Positive and Negative Social Support and HPA-axis Hyperactivity:

Evidence from Glucocorticoids in Human Hair

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Abstract

Introduction. While positive social support is associated with lower prevalence of disease and better treatment outcomes, negative social relationships can instead have unfavourable consequences for several physical and mental health conditions. However, the specific mechanisms by which this nexus might operate remain poorly understood. Hypothalamic–pituitary–adrenal (HPA) axis hyperactivity owing to psychosocial stress has been proposed as a potential pathway underlying the link between social support and health. Hair glucocorticoids such as cortisol and cortisone are emerging as promising biomarkers of long-term retrospective HPA activation. Therefore, the aim of this investigation was to examine the effects of positive and negative experiences of social support within key relationships (i.e. spouse/partner, children, other family members, and friends) on cortisol and cortisone.

Methods. These associations were tested in a sample of 2,520 older adults (mean age 68.1) from the English Longitudinal Study of Ageing. Hair samples were collected in wave 6 (2012/13). To understand the impact of cumulative exposure to poor social support, the analysis used self-reported data from waves 4 (2008/09) and 6. Covariates included demographic, socioeconomic, lifestyle, and hair characteristics.

Results. In cross sectional analyses, lower positive support from all sources and specifically from children were associated with higher cortisol. Additionally, lower positive support from children was positively associated with cortisone. Similarly, higher overall negative support was related to higher cortisol, and greater negative support from children was also positively associated with cortisone. In longitudinal analyses, there was evidence for positive associations between hair glucocorticoids and cumulative exposure to poorer social support.

Conclusions. Experiences of low positive and high negative social support, particularly from children, were both related to higher hair glucocorticoids. Hence, social relationships of

poorer quality in later life may have adverse effects on the HPA axis thereby increasing the individual's susceptibility to poor health.

Key words: cortisol; cortisone; social support; HPA axis; stress.

1. Introduction

Social support can be defined as the social resources perceived by individuals to be available to them as well as those that are actually provided in the context of helping relationships (Gottlieb and Bergen, 2010). There is convincing evidence that social support is a crucial factor in the maintenance of health and an essential component of human wellbeing (Cohen et al., 2000; Uchino, 2006). Several prospective studies have demonstrated how both functional and structural aspects of social support can affect morbidity and mortality from a wide range of diseases (Holt-Lunstad et al., 2010). A better understanding of this relationship between social support and health is particularly important in contemporary industrialised societies. Indeed, despite huge advances in contemporary communication technology in an epoch of mass-globalisation, both the *quality* and *quantity* of subjective social connections appear to be decreasing (McPherson et al., 2006; Office for National Statistics, 2016).

Social interactions are not inherently positive in nature, and instead entail both rewards and costs (Rook, 1997). For instance, having a larger social network could lead to higher interpersonal conflict in the context of unhealthy social exchanges (Cohen et al., 2000). Therefore, over the last two decades, researchers have devoted increasingly more attention to the negative (e.g. criticism and demands), as well as positive (e.g. affection and understanding) aspects of social support. The dual focus on positive and negative social support rests on the finding that they are two relatively distinct constructs (Fiori and Consedine, 2013). In this vein recent evidence indicates that, whilst positive social support can promote health and wellbeing, negative social interactions can predispose the individual to poorer health outcomes (Newsom et al., 2005; Croezen, 2012; Khondoker et al., 2017). Nevertheless, it remains unclear which dimension or source of social support has the greatest impact on health.

Notwithstanding these limitations, the nexus between social support and health is now well established in the research literature. However, the specific pathways by which this might operate remain poorly understood (Holt-Lunstad et al., 2010). There are two broad sets of mechanisms through which psychosocial factors may influence health – namely, the *behavioural* and the *psychobiological* (Steptoe et al., 2005). With respect to behavioural factors, there is some evidence that negative social support is associated with current smoking, physical inactivity, overweight, and excessive alcohol consumption (Croezen et al., 2012). However, the association between social support and health appears to be partly independent of behavioural risk factors (Berkman and Krishna, 2015), and there also are instances of supportive relationships which ultimately promote damaging health behaviours (Uchino, 2006).

An alternative pathway is represented by psychobiological processes, where hypothalamic-pituitary-adrenal (HPA) axis hyperactivity owing to psychosocial stress might be a key mediator (DeVries, et al., 2003; Hostinar and Gunnar, 2013). According to the stress-buffering hypothesis, social support can either provide a buffer against stress, serving as a coping resource against the negative effects of adverse life events, or be itself a source of stress (Cohen et al., 2000). Activation of the HPA axis is one of the most thoroughly characterised neuroendocrine response to stress (McEwen, 1998). Consequently, the glucocorticoid hormone cortisol, a primary product of the HPA axis, has been proposed as a key biomarker underlying the relationship between health and psychosocial factors.

Cortisol is produced in the adrenal glands via the enzyme 11-beta-hydroxysteriod dehydrogenase (11B-HSD) type 1. Higher levels of this hormone are implicated in the aetiology of numerous cardiometabolic, inflammatory, endocrine, and neural disorders (Girod and Brotman, 2004; McEwen, 2007; Hackett et al., 2016; Jackson et al., 2017), as well as mental health problems (Adam et al., 2017). Cortisone is another glucocorticoid hormone

which is metabolised from cortisol in the peripheral tissue by the enzyme 11B-HSD type 2, and is typically considered as an inactive metabolite because it has much lower glucocorticoid activity than cortisol (Raul et al., 2004). In addition, the ratio of cortisol to cortisone can be used as an indirect measurement of 11B-HSD enzymatic activity, which is responsible for regulating overall glucocorticoid action (Weber et al., 2000). Similarly to cortisol, elevated levels of cortisone and cortisol/cortisone ratio have been found to be associated with different mental and physical health factors, including depression, self-reported stress, body mass index, obesity, and hypertension (Quinkler and Stewart, 2003; Romer et al., 2009; Vanaelst et al., 2013; Rippe et al., 2016; Scharlau et al., 2018). Moreover, the importance of assessing cortisone and the ratio in stress-related research has been reinforced by evidence showing altered 11B-HSD activity under stress conditions (Quinete et al., 2015).

A number of studies have found evidence for positive associations between cortisol and measures of social isolation, loneliness, and perceived social support (Steptoe et al., 2004; Adam et al., 2006; Stafford et al., 2013; Staufenbiel et al., 2014). However, no research has yet addressed the effects of both positive and negative social relationships on cortisol, cortisone, and their ratio. Moreover, until recently glucocorticoid hormones have been predominantly measured in saliva, serum, or urine, which can only represent the dynamics of glucocorticoid output over short periods up to 24 hours (Staufenbiel et al., 2015). In contrast, measurements in hair provide quantification of glucocorticoid output over several weeks, and are not influenced by the acute variations related to momentary events and moods. As a result, hair concentrations of cortisol and cortisone are emerging as promising biomarkers of long-term HPA activation (Stalder and Kirschbaum, 2012; Stalder et al., 2017).

Therefore, the aim of this study was to determine the relative influence of positive and negative experiences of social support on hair cortisol, cortisone, and their ratio (R_{hcc}) in a

sample of older men and women. Since different relationships may perform different functions in the social networks of older people (Khondoker et al., 2017), the associations between positive and negative support and hair glucocorticoids were analysed separately according to source type (i.e. partner/spouse, children, other immediate family members, and friends). Furthermore, in order to understand the impact of cumulative exposure to poor social support, the analysis used data on the participants' quality of social relationships evaluated in retrospect over four years. We hypothesised that: 1) positive social support would be related to lower cortisol, cortisone, and R_{hcc}, whereas negative social support would be associated with higher levels of hair glucocorticoids; 2) these associations would be larger for emotionally-closer relationships such as partner/spouse and children; and 3) cumulative exposure to low positive/high negative social support over a four-year period would be associated with higher glucocorticoids.

2. Methods

2.1. Study sample

The data came from the English Longitudinal Study of Ageing (ELSA), a prospective study of women and men aged 50 years and over living in England. The study began in 2002 with an original sample of 12,099 participants, who were drawn from the Health Survey for England. The methods of data collection and sample design are detailed at www.elsa-project.ac.uk. Comparisons of the sample's sociodemographic features with the national census suggest that it is representative of the general English population (Steptoe et al., 2013). During the assessment by study nurses in wave 6 (2012/13), hair samples were collected to measure cortisol and cortisone. Out of the 7,699 participants who participated in the nurse interview, hair samples were collected from 5,451 individuals. However, owing to financial constraints, hormone levels were assayed only from 2,685 participants, prioritising

those who had participated in the maximum number of previous waves of data collection (Steptoe et al., 2017). There were 84 individuals who were excluded from the study because they had hormone levels too low to be detected or too extreme, resulting in a sample of 2,601 participants. In addition, to examine the effect of cumulative exposure to poor social support, the analysis used data from the self-completion questionnaire in waves 4 (2008/09) and 6. In the sample with detectable hair glucocorticoids, there were 80 individuals who did not return the self-completed interview in wave 4. Thus, the final analytical sample included 2,520 respondents. All respondents provided informed consent. Ethical approval was obtained from the National Research Ethics Service.

2.2.   Measurements

2.2.1. Hair Cortisol and Cortisone

During the nurse visit, hair strands of approximately 3 cm were collected from the posterior vertex as close to the scalp as possible. Participants were excluded from the hair sample in the following circumstances: pregnancy, breastfeeding, certain scalp conditions, having less than two cm of hair length, and inability to sit with head remaining still. A more detailed description of the hair sampling process can be found at http://www.elsa-project.ac.uk/uploads/elsa/docs_w6/project_instructions_nurse.pdf. The hair analysis was conducted by the Technische Universität Dresden in Germany. As described in Gao et al. (2016), following a standard wash and steroid extraction procedure, glucocorticoid levels were quantified by high performance liquid chromatography-mass spectrometry (LC/MS). Cortisol and cortisone concentrations were expressed in pg/mg. Based on an average hair growth of approximately 1 cm per month (Kirschbaum et al., 2009), the 3 cm hair segment closest to the scalp represents average glucocorticoid concentrations accumulated over three months prior to sampling. Hair specific characteristics that could affect hormonal levels (e.g.

dyeing or chemical treatments) were assessed by self-reports. The R_{hcc} was calculated by dividing hair cortisol levels by cortisone concentrations.

2.2.2. *Positive and negative social support*

Positive and negative experiences of social support were measured based on items administered in a self-completion questionnaire. A set of three items were used to measure positive support, while four items were used to represent negative social exchanges (Appendix A). The same sets of items were used to measure the quality of each of four types of close relationship separately (Spouse/partner, children…). Responses were measured on a 4-point scale ranging from 1 ('not at') to 4 ('a lot'). For each relationship, positive and negative scores were then averaged and categorised into 'low' (1-2), 'medium' (3), 'high' (4), or 'no source' (positive support), and 'low' (1), 'medium' (2), 'high' (3-4), or 'no source' (negative support). This approach minimised the amount of missing data because some relationships were not available for all participants, and allowed us to examine the effect of not having a specific source of support compared with having a poor relationship. In addition, we calculated overall scores for low positive and high negative support across all four sources, where respondents were assigned a score of one if they reported low positive/high negative support for each relationship. Furthermore, a combined measure of positive and negative support was calculated by summing together the overall low positive and high negative scores. Cross-sectional analyses were based on responses in wave 6, while in longitudinal analyses, the effect of cumulative exposure to low positive/high negative social support was evaluated based on responses from waves 4 (2008/09) and 6. For each source and dimension of social support, a categorical variable was created for whether the participant had been exposed to low positive/high negative social support two, one, or no

times across the two time points. Overall scores were also computed by summing together the overall positive, negative, and combined scores from waves 4 and 6.

2.2.3. *Sociodemographic variables, lifestyle factors, and hair characteristics*

The analyses were adjusted for sociodemographic, lifestyle, and hair characteristics. Sex was a dichotomous variable, while age was measured on a continuous scale. Wealth and educational attainment were used as indicators of socioeconomic position. Wealth was derived from a comprehensive assessment of the respondent's economic resources, excluding pension wealth, and was categorised into quintiles across all ELSA respondents who participated in wave 6. Educational attainment was a categorical variable coded as 'graduate', 'primary/secondary school', or 'no qualifications'. Body Mass Index (BMI) was derived from measures of height and body weight collected during the nurse assessment in wave 6. Current smoking status was represented by a dichotomous variable (yes/no). Physical activity was measured using data about mild intensity (e.g. laundry, home repairs), moderate intensity (e.g. walking, cleaning the car), and vigorous activity (e.g. cycling, aerobics). Participants indicated the frequency of participation based on a four-point scale ranging from 'hardly ever or never' to 'more than once a week'. In the current analysis, people were classified as sedentary if they reported no light, moderate or vigorous intensity activity hardly ever. Lastly, we also controlled for a number hair characteristics which may influence hormonal concentrations. These were: hair colour (brunette, red/ginger, blonde, white/grey, mix grey/other colour) and chemical treatments (yes/no).

2.3. *Statistical Analyses*

RStudio version 1.0.136 for Windows was used in all statistical analyses. Cortisol and cortisone were positively skewed, and therefore logarithmic transformation was applied to

achieve normal distribution. The associations between glucocorticoid concentrations and social support were tested using multiple linear regression analysis. Each outcome variable (i.e. cortisol, cortisone, R_{hcc}) was modelled in separate regression models. In a first step, partially-adjusted models were performed examining the effects of each social support variable on hair glucocorticoid levels separately, with adjustment for sex and age (Model 1). In the next step, fully-adjusted regression models were run including all covariates used in the analysis (Model 2). Lastly, the independent effects of each social relationship were tested entering all source-specific social support variables simultaneously, but separately for positive and negative experiences due to potential multicollinearity issues (Model 3). Missing data were accounted for by multiple imputation by chained equations using the R's package '*Mice*' (Van Buuren and Groothuis-Oudshoorn, 2011). Missing information was imputed on all variables for those respondents with available glucocorticoid values. All analysis variables were used as predictors in the imputation models. Missing data is estimated under the Missing at Random Assumption (MAR) (Little and Rubin, 2002). In the present analysis, MAR implies that if all the variables that are associated with the missing data generating mechanism are used in the imputation models, then estimates can be reliably computed for all participants with missing data (Ploubidis et al., 2014). Therefore, since socioeconomic position and age are the main drivers of attrition in ELSA (Steptoe et al., 2013) and were used as predictors in the imputation models, this assumption is likely to be met. Twenty imputed datasets were created and the pooled estimates from the regression models are reported. A comparison of observed and imputed data demonstrated that these values were very similar (Appendix B), thus suggesting that the imputation process was conducted appropriately.

3. Results

3.1. Sample characteristics

The characteristics of the study sample are summarised in Table 1. Participants were on average 68.1 years old, and 58.7 % were women. The majority had primary or secondary school qualifications, and there was a higher proportion of participants in the highest wealth quintile. The sample was on average overweight, only 10.1 % were current smokers, and most of them did not have a sedentary lifestyle. Cortisone concentrations were considerably higher than cortisol, and they showed a significant positive correlation with each other ($r = 0.279$, $p < .001$). Descriptive statistics of the negative and positive social support measures are shown in Table 2. For all relationships, the majority of participants reported high positive/low negative social support in wave 6, and only a small proportion of them had experienced low positive/high negative social support twice across waves 4 and 6. There was a moderate positive correlation between overall low positive and high negative social support scores ($r = 0.137$, $p < .001$). Chi-square tests of independence indicated that positive and negative support variables within each relationship were significantly correlated to each other. Furthermore, significant associations were also found between positive/negative support variables across different relationships (e.g. positive support from partner and children).

3.2. Associations with hair cortisol

The regressions of hair cortisol on positive and negative experiences on social support are reported in Table 3. In cross-sectional analyses, the overall score for low positive support was significantly associated with cortisol, an effect which was sustained also after adjustment for the other covariates as indicated in Model 2 ($\beta = 0.048$, $p = 0.018$). This suggests that for every one point increase in the low positive support score the expected log transformed

cortisol value increased by 0.05 standard deviation units on average. Similarly, the overall score for high negative support was positively associated with cortisol concentrations both in partially and fully adjusted models (Model 2: $\beta = 0.039$, $p = 0.051$). In addition, the combined positive + negative score was also associated with higher cortisol levels independently of all covariates (Model 2: $\beta = 0.058$, $p = 0.004$), and its effect size was larger than those observed for the two scores separately. When social support was tested separately for each social relationship, evidence was found for a significant association between social support from children and hair cortisol, which was robust to full adjustment for all covariates and independent from the other sources of positive support. Specifically, participants who reported high and medium positive support from children had on average a log transformed cortisol value of 0.081 ($p = 0.050$) and 0.084 ($p = 0.023$) standard deviations lower than those with low children support respectively (Model 3).

Cortisol was also associated with cumulative exposure to poor social support over a four-year period. Higher scores on overall low positive ($\beta = 0.055$, $p = 0.006$) and positive + negative ($\beta = 0.062$, $p = 0.002$) scores across waves 4 and 6 were both positively associated with cortisol independently of all covariates (Model 2). Importantly, the magnitude of their effects was somewhat larger than in cross-sectional analyses. Overall negative support was found to be positively associated with cortisol. However, this effect no longer reached statistical significance in fully adjusted analysis (Model 2: $\beta = 0.038$, $p = 0.060$). Source-specific analyses (see Supplementary tables online; Appendix C) demonstrated that participants who had been exposed to low positive support from children twice had an average cortisol value of 0.038 standard deviations higher than those who reported high or medium positive support from children at both time points independently from all covariates ($p = 0.050$).

3.3.   Associations with hair cortisone

The regressions of cortisone on positive and negative experiences of social support are shown in Table 4. In cross-sectional analyses, the overall scores for positive and negative support, as well as their combination, were not significantly associated with cortisone. However, source-specific effects of positive and negative support from children demonstrated significant associations with cortisone levels. Participants who reported high or medium positive support from children had an average log transformed cortisone value of 0.010 ($p =$ 0.012) and 0.083 ($p = 0.016$) standard deviation units lower than those with low positive support respectively, independently of the other covariates and sources of social support (Model 3). Furthermore, low and medium negative support from children, as well as having no children, were all significantly associated with a decrease in cortisone of 0.177 ($p =$ 0.002), 0.127 ($p = 0.008$), and 0.092 ($p = 0.027$) standard deviations respectively, compared to the group of respondents with high negative support (Model 3).

Similarly, longitudinal analyses provided no evidence for significant associations between cortisone and cumulative exposure to overall positive and negative support. Nevertheless, there was a significant effect of children support in source-specific analyses (Appendix C). In particular, participants reporting low positive children support at both or one time point had on average a log transformed cortisone score of 0.041 ($p = 0.049$) and 0.038 ($p = 0.046$) standard deviations higher than their counterparts independently of all covariates.

3.4.   Associations with the R_{hcc}

In cross-sectional analyses, the R_{hcc} showed significant associations with the overall support scores after adjustment for all covariates (Table 5; Model 2). For every one point increase in the low positive, high negative, and positive + negative scores, the mean R_{hcc} was

expected to increase on average by 0.039 ($p = 0.048$), 0.053, ($p = 0.008$), and 0.059 ($p = 0.003$) standard deviations respectively. Similar associations were also found in longitudinal analyses. In fact, cumulative exposure to overall low positive ($\beta = 0.048$, $p = 0.015$) and high negative ($\beta = 0.055$, $p = 0.08$) social support, as well as their combination ($\beta = 0.066$, $p = 0.001$), were all positively related to the R_{hcc} independently of the other study covariates, and with larger effect sizes than those observed in cross-sectional analyses (Model 2). However, the favourable effect of higher quality support from children on cortisol and cortisone was not observed for their ratio (Appendix C).

3.5.   Effects of sociodemographic, lifestyle, and hair characteristics

Lastly, we found evidence for significant associations between hair glucocorticoid hormones and a number of demographic, socioeconomic, lifestyle, and hair characteristics which were used as covariates in the main analysis (Appendix D). In fully adjusted models, higher BMI and lower wealth were associated with higher cortisol and cortisone. Elevated cortisone concentrations were also observed for males, smokers, and participants with darker or not chemically treated hair. In addition, the R_{hcc} was positively associated with female sex, age, and lighter or chemically treated hair.

3.6.   Sensitivity analyses

In order to assess potential bias due to missing data, all models were rerun applying list-wise deletion on all variables. This resulted in a sample of 1,524 participants. The pattern of associations between positive and negative social support and glucocorticoid levels remained almost unchanged. There were some variations in the significance level of the source-specific social support measures. However, this is likely to be due to the reduced sample size, and therefore power of the analysis to detect significant differences between

subgroups. Supplementary tables for these analyses can be found in the online version of the article (Appendix E).

4. Discussion

4.1. Summary of main findings

This study investigated the associations of hair cortisol, cortisone, and their ratio with both positive and negative experiences of social support within key relationships (i.e. partner/spouse, children, other family members, and friends) in a sample of older adults from ELSA. The first hypothesis proposed that positive support would have a favourable effect on hair glucocorticoids, whilst negative social relationships would lead to higher hormone levels. The results confirmed that participants who reported lower positive or greater negative social support across all sources had higher levels of cortisol, as well as an elevated R_{hcc}. In addition, lower overall positive support was associated with higher negative support, and their combination led to an even higher level of glucocorticoid concentrations as compared with their individual effects. According to the second hypothesis, the association between social support and hair glucocorticoids would be larger for emotionally-closer relationships such as partner/spouse and children. The results supported this prediction in relation to children support, since this was the source-specific measure exhibiting the largest effects on both hormones. Lastly, the third hypothesis proposed an adverse effect of cumulative exposure to poor social support on hormone levels. In line with this prediction, overall low positive and high negative social support evaluated in retrospect over a four-year period were associated with an increase in both cortisol and the R_{hcc}. Furthermore, greater hormone concentrations were observed in participants reporting low positive support from children at both measurement points, a finding which further corroborates the second study prediction. These

associations were also independent of relevant demographic, socioeconomic, lifestyle, and hair characteristics.

4.2.   *Interpretation of the results in relation to previous work*

To our knowledge, this is the first study to investigate the influence of positive and negative social support on hair cortisol, cortisone, and their ratio. Although associations between cortisol and other aspects of social relationships such as isolation and loneliness have been documented in previous studies (e.g. Steptoe et al., 2004; Adam et al., 2006; Stafford et al., 2013), no research has yet investigated the positive, as well as negative, qualitative dimensions of social support in relation to the HPA axis. Moreover, the majority of studies have assessed cortisol using salivary or blood measurements which can fluctuate considerably over the day and in response to different activities or moods. Scalp hair cortisol instead allows to measure long-term HPA activity (Stalder and Kirschbaum, 2012). It may therefore be well suited to the analysis of the psychobiological pathways linking social support and health which may take time to unfold. Consequently, this study makes a fundamental contribution to the current state of knowledge. Specifically, it demonstrated that, while higher positive support within close relationships was associated with lower concentrations of hair cortisol, conversely, higher negative social support led to an increase in hormone levels. In addition, it showed that chronically elevated cortisol concentrations were associated with cumulative measures of poor social support, thus providing a more comprehensive characterisation of the interplay between social relationships and HPA function over time. HPA axis hyperactivity is one of the best characterised neuroendocrine response to stress (DeVries et al., 2003), which also plays a critical role for physical and mental health (Girod and Brotman, 2004; Hackett et al., 2016; Adam et al, 2017). Thus, this provides further support for the stress-buffering hypothesis of social support (Cohen et al.,

2000), as well as convincing evidence for the possible presence of a specific psychobiological

pathway underlying the nexus between social support and health. The relationships between

hair glucocorticoids and social support were also independent of a number of behavioural and

lifestyle factors (i.e. adiposity, smoking, and physical inactivity) which are associated with

both cortisol (Stalder et al., 2017; Steptoe et al., 2017) and social support (Croezen et al.,

2012). This therefore indicates that the psychobiological and behavioural pathways through

which social relationships may influence health are partly independent from each other.

Another original aspect of this study was the assessment of hair cortisone and the R_{hcc}

as potential biomarkers of HPA axis activity along with cortisol. Previous research

demonstrated that both cortisone and the R_{hcc} are related to various aspects of physical and

mental health, which are also associated with cortisol (Quinkler and Stewart, 2003; Romer et

al., 2009; Vanaelst et al., 2013; Rippe et al., 2016; Scharlau et al., 2018). Nevertheless, there

are virtually no studies that have investigated the effect of social support on cortisone and the

R_{hcc}. The current study demonstrated that the aggregated scales of positive and negative

social support were significantly associated with both cortisol and the ratio, whilst only poor

children support had an adverse link with cortisone. Such different patterns of associations of

social support with cortisol and cortisone remain difficult to interpret owing to the relatively

limited number of studies which have used both hormones as biomarkers of stress. Recent

research suggested that salivary cortisone may provide a better reflection of systemic cortisol

levels because it represents more accurately free serum cortisol levels after adrenal

stimulation (Stalder et al., 2013). Furthermore, cortisone seems to be more stable over time

(Vanaelst et al., 2013), and it may also be more readily measurable in hair since it has a

concentration approximately 3 times higher than cortisol (Staufenbiel et al., 2015). A number

of studies reported similar associations of socioeconomic adversity and various stress-related

physical conditions (e.g. overweight, diabetes, and cardiometabolic syndrome) with both hair

cortisol and cortisone (Stalder et al., 2013; Staufenbiel et al., 2015; Noppe et al., 2016; Rippe et al., 2016; Vliegenthart et al., 2016). However, the strength of these relationships was somewhat larger for cortisol as compared with cortisone, a finding which is consistent with the effect of social support observed in this study. This difference may be attributable to a greater influence of biological rather than environmental factors on the levels of cortisone found in human hair. Cortisone is in fact built later in the corticosteroid chain, and is not solely related to cortisol levels (Rippe et al., 2016). For instance, cortisol binds mainly to cortisol binding globulin (CBG) and albumin, whilst only the remaining free fraction (3-10%) constitutes the bio-active hormone. However, also cortisone binds to CBG, and it is unclear whether only free cortisol or a combination of cortisol and cortisone is built in hair (Raul et al., 2004). Thus, CBG action may influence the strength of the associations of cortisol and cortisone with other environmental factors. Furthermore, it is important to note that age appears to have a curvilinear effect on hair cortisol, where elevated hormone levels are found in young children and older adults (Dettenborn et al., 2012). In contrast, there is no evidence documenting how cortisone and the R_{hcc} change across the different stages of the lifespan. Thus, the impact of other biological as well as environmental factors on these biomarkers could differ according to the particular age group examined. Moreover, it also remains unclear whether there is a finite conversion rate which limits the capacity to convert cortisol into cortisone in hair. Notwithstanding these issues, our results clearly suggest that hair cortisone and the R_{hcc} may provide useful information about HPA activity, and should therefore be assessed in future research along with cortisol.

In relation to the issue of which dimension of social support has the strongest impact on health, the results appear to suggest that the absence of positive social relationships has a more detrimental effect on the HPA axis than negative social support, particularly in the case of cortisol. Thus, this could indicate that the lack of a warm, reliable, and understanding

relationship could be more harmful than being exposed to greater criticism and demands from key members of one's own social network. This is in contradiction to previous research indicating a disproportionate impact of negative social support on health and wellbeing (e.g. Rook, 1997; Khondoker et al., 2017). However, it should be noted that the overall quality of social support in this sample was particularly high, which might have limited the ability of this study to detect larger effects of negative social support on hair glucocorticoids. Nevertheless, the benefits of positive social relationships on health have been widely documented (Newsom, 2005). For instance, Okun and Keith (1998) found that positive social exchanges exerted a stronger unique effect on wellbeing and depressive symptoms than negative relationships in older adults, while other researchers reported comparable effects (e.g. Manne and Zautra, 1989). Hence, our results further corroborate such findings.

Lastly, in terms of the effect of different components of social support, children appear to be the most influential source in this sample of older adults. This is consistent with the results of previous studies indicating that positive support from children in particular was associated with fewer depressive symptoms and lower risk of dementia in later life (Okun and Keith, 1998; Khondoker et al., 2017). Such findings could be explained by the fact that the parent-child tie is a unique source of social attachment and solidarity (Umberson, 1992), which has been proposed to affect well-being through supports that meet the needs of both parents and children (Ward, 2008). Furthermore, the parent-child tie plays an increasingly important role as individuals age, since social networks tend to become smaller and focused on emotionally close kin (Ajrouch, et al., 2001).

4.3.   *Limitations and suggestions for further research*

This study has a number of limitations which should be carefully considered. First, although the effect of social support was assessed in retrospect over a four-year period, no

causal conclusions can be drawn because cortisol was measured only once. Second, not all people with detectable hair glucocorticoid concentrations were included in the analysis because some of them did not take part in the self-completion survey in wave 4. Since the excluded participants were older and had lower socioeconomic position, the sample might not be representative of the general population. Third, another important limitation pertains to the social support scales. In fact, since only a minority of the sample reported low positive or high negative social support, the aggregated scores were not equally representative of all participants with more favourable experiences. Similarly, the source-specific categorical measures of cumulative exposure were based on unbalanced group comparisons. For instance, only about 3% of the participants reported low positive/high negative partner support twice across the 4-year period of the study, which might have adversely affected the statistical power of the analysis. Furthermore, the 'no source' category and the other non-extreme responses were both assigned a score of zero in the aggregated scales, hence considering them as the same experiences. Nevertheless, including also participants without a particular type of relationship allowed to reduce the amount of missing data. In addition, potential differences between the 'no source' group and the other respondents were addressed in the source-specific analyses. Thus, the use of both categorical and aggregated measures of social support helped to minimise the limitations associated with each approach. Fourth, all social support variables, as well as some of the lifestyle indicators, were measured using self-report which may be prone to measurement error due to the sensitivity of the information required.

Further research is required to determine the causal effects of social support on the HPA axis using longitudinal assessments of cortisol and cortisone. It would also be interesting to assess the effects of positive and negative experiences of social support on the HPA axis in younger adults to understand whether different sources and dimensions of social

support may have a different impact on stress throughout the various stages of the lifespan. Additionally, future research should address the relative lack of empirical evidence on the associations of other aspects of social relationships (e.g. social isolation and loneliness) on hair glucocorticoids. Genetic background and early life environment appear to be the main determinants of HPA axis activity along with current life stress (Stephens and Wand, 2012). Thus, given the growing availability of such data in epidemiological surveys, it should be established how the relationships between current social environment, HPA axis, and health are influenced by these characteristics. Lastly, since the current knowledge on hair cortisone and the R_{hcc} is still very limited, more methodological research is required to provide a more detailed characterisation of these biomarkers across the various stages of the life course.

4.4. Conclusions

To conclude, the current investigation demonstrates that, whilst positive social support within key social relationships is associated with lower hair glucocorticoid concentrations, negative social exchanges may instead increase the risk of HPA axis hyperactivity. Amongst the various sources of social support, children appear to be particularly crucial, whilst associations with other components of social support are weaker. This suggests that it is important to consider multiple sources of support because their aggregated effect may have a larger influence on hormone levels. Given the key role of the HPA axis for several health outcomes, these results therefore provide convincing evidence for the existence of a specific psychobiological pathway underlying the nexus between social support and health. Moreover, they have important implications for health and social care practice. Specifically, they highlight the value of improving the quality of social relationships, rather than merely enhancing social interactions, in order to reduce stress and ameliorate health.

Contributors

All authors contributed significantly to the conception, design, analyses or interpretation of data and were involved in revising it critically for intellectual context. The submission of this paper was approved by all researchers.

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85(3), 1133-1136.

Table 1. Sample characteristics.

		% missing	*Mean (sd)*	*Frequency (%)*
Age		0	68.1 (7.4)	
Sex	Female	0		1480 (58.7)
Education	Graduate	0.3		448 (17.8)
	Primary/secondary school			1506 (59.9)
	No qualifications			559 (22.2)
Wealth	1 = lowest	1.5		399 (16.1)
	2			473 (19.1)
	3			510 (20.5)
	4			525 (21.2)
	5 = highest			575 (23.1)
Cortisol (log, pg/mg)		0	0.91 (0.63)	
Cortisone (log, pg/mg)		0	1.84 (0.77)	
R_{hcc} (log, pg/mg)		0	0.27 (1.43)	
BMI		10.4	27.9 (5.05)	
Current Smoking	Yes	0		255 (10.1)
Sedentary Activity	Yes	0		95 (3.8)
Hair colour	Brunette	0		608 (24.2)
	Red/ginger			61 (2.4)
	Blonde			316 (12.5)
	White/grey			1459 (57.9)
	Mix grey/other colour			76 (3.1)
Hair treatment	Yes	0		888 (35.2)
	No			1632 (64.8)

Notes. ELSA, wave 6; N=2,520; sd = standard deviation; R_{hcc} = ratio of hair cortisol to cortisone.

Table 2. Summary statistics of positive and negative social support.

Social support (wave 6)		Positive experiences		Negative experiences	
		% missing	*Frequency (%)*	*% missing*	*Frequency (%)*
Partner	High	5.6	1485 (62.5)	6.0	117 (4.9)
	Medium		195 (8.2)		622 (26.1)
	Low		63 (2.7)		1007 (42.3)
	No source		633 (26.6)		633 (26.6)
Children	High	5.7	1448 (60.9)	6.3	70 (3.0)
	Medium		478 (20.1)		519 (22.0)
	Low		144 (6.1)		1466 (62.1)
	No source		306 (12.9)		306 (13.0)
Family	High	6.8	872 (37.1)	15.2	78 (3.5)
	Medium		779 (33.2)		399 (18.1)
	Low		537 (22.9)		1574 (71.5)
	No source		160 (6.8)		160 (6.8)
Friends	High	5.7	1200 (50.5)	12.9	197 (8.5)
	Medium		796 (33.5)		544 (23.5)
	Low		248 (10.4)		1445 (62.3)
	No source		132 (5.6)		132 (5.7)
Overall scores		*Mean (sd)*			
Low positive		0.65(0.72)			
High negative		0.36(0.55)			
Pos. + Neg.		1.0(1.0)			

Cumulative Exposure (waves 4 & 6)		Low Positive		High Negative	
		% missing	*Frequency (%)*	*% missing*	*Frequency (%)*
Partner	0 times	12.1	1497 (67.6)	12.1	1402 (65.2)
	1 time		65 (2.9)		143 (6.5)
	2 times		20 (2.8)		37 (2.7)
	No source		633 (26.6)		633 (26.6)
Children	0 times	11.9	1702 (76.7)	12.7	1773(81.7)
	1 time		152 (6.8)		106 (4.8)
	2 times		59 (2.7)		16 (0.7)
	No source		306 (13.8)		306 (12.8)
Family	0 times	13.5	1333 (61.1)	21.7	1658 (84.0)
	1 time		415 (19.0)		123(6.2)
	2 times		273 (12.5)		32 (1.6)
	No source		160 (7.3)		160 (8.1)
Friends	0 times	12.1	1741 (78.6)	19.4	1698 (83.6)
	1 time		258 (11.6)		180 (8.9)
	2 times		85(3.8)		22(1.1)
	No source		132 (6.0)		132 (6.5)
Overall scores		*Mean (sd)*			
Positive		1.3(1.20)			
Negative		0.7(1.10)			
Pos. + Neg.		2.0(1.70)			

Notes. Data source: ELSA, waves 4 & 6; N = 2,520; sd = standard deviation.

Table 3. Associations between hair cortisol and positive and negative experiences of social support.

Outcome: *Cortisol (log)*		**Model 1**			**Model 2**			**Model 3**		
		B(SE)	β	*p*-value	B(SE)	β	*p*-value	B(SE)	β	*p*-value
Social Support: cross-sectional										
Overall	Low Pos.	**0.043 (0.017)**	**0.049**	**0.014**	**0.041 (0.017)**	**0.048**	**0.018**			
scores	High Neg.	**0.054 (0.023)**	**0.047**	**0.019**	**0.044 (0.021)**	**0.039**	**0.051**			
	Pos. + Neg.	**0.041 (0.013)**	**0.064**	**0.002**	**0.037 (0.013)**	**0.058**	**0.004**			
Source – specific: Positive										
Partner	High	0.054 (0.078)	0.041	0.494	0.065 (0.079)	0.050	0.406	0.065 (0.080)	0.050	0.416
(ref: low)	Medium	0.031 (0.088)	0.014	0.721	0.038 (0.088)	0.017	0.666	0.025 (0.089)	0.011	0.775
	No source	0.037 (0.080)	0.026	0.649	0.025 (0.081)	0.017	0.761	0.011 (0.082)	0.008	0.894
Children	High	**-0.117 (0.053)**	**-0.092**	**0.026**	-0.097 (0.053)	-0.076	0.065	**-0.104 (0.053)**	**-0.081**	**0.050**
(ref: low)	Medium	**-0.142 (0.057)**	**-0.091**	**0.012**	**-0.127 (0.057)**	**-0.081**	**0.026**	**-0.131 (0.058)**	**-0.084**	**0.023**
	No source	-0.096 (0.061)	-0.051	0.114	-0.066 (0.061)	-0.035	0.280	-0.057 (0.063)	-0.030	0.364
Other	High	-0.046 (0.034)	-0.035	0.170	-0.041 (0.033)	-0.031	0.225	-0.046 (0.035)	-0.036	0.191
Family	Medium	-0.064 (0.034)	-0.049	0.059	-0.053 (0.034)	-0.040	0.116	-0.058 (0.034)	-0.044	0.093
(ref: low)	No source	-0.075 (0.054)	-0.030	0.167	-0.062 (0.054)	-0.025	0.255	-0.071 (0.055)	-0.029	0.196
Friends	High	0.001 (0.043)	0.001	0.988	0.011 (0.042)	0.009	0.801	0.023 (0.044)	0.018	0.604
(ref: low)	Medium	0.027 (0.044)	0.020	0.543	0.041 (0.044)	0.031	0.348	0.052 (0.045)	0.039	0.243
	No source	-0.027 (0.065)	-0.010	0.680	-0.050 (0.066)	-0.018	0.448	-0.047 (0.066)	-0.017	0.470
Source-specific: Negative										
Partner	Low	-0.079 (0.060)	-0.062	0.187	-0.046 (0.060)	-0.036	0.442	-0.037 (0.063)	-0.029	0.560
(ref: high)	Medium	-0.088 (0.062)	-0.062	0.153	-0.061 (0.062)	-0.043	0.323	-0.047 (0.063)	-0.033	0.459
	No source	-0.089 (0.062)	-0.063	0.149	-0.082 (0.062)	-0.058	0.184	-0.074 (0.064)	-0.052	0.250
Children	Low	-0.020 (0.072)	-0.015	0.786	0.015 (0.073)	0.012	0.838	0.026 (0.078)	0.020	0.741
(ref: high)	Medium	-0.034 (0.075)	-0.023	0.651	-0.008 (0.075)	-0.006	0.912	-0.004 (0.078)	-0.002	0.962
	No source	-0.004 (0.079)	-0.002	0.956	0.039 (0.079)	0.021	0.621	0.069 (0.084)	0.037	0.412
Other	Low	-0.022 (0.068)	-0.016	0.741	-0.008 (0.068)	-0.006	0.902	-0.010 (0.071)	-0.007	0.894
Family	Medium	-0.013 (0.072)	-0.008	0.852	-0.005 (0.073)	-0.003	0.942	-0.004 (0.074)	-0.002	0.960
(ref: high)	No source	-0.052 (0.082)	-0.021	0.521	-0.033 (0.082)	-0.014	0.688	-0.036 (0.085)	-0.015	0.671
Friends	Low	-0.010 (0.076)	-0.008	0.894	0.031 (0.046)	0.024	0.501	0.017 (0.048)	0.013	0.719
(ref high)	Medium	0.063 (0.078)	0.043	0.801	0.094 (0.050)	0.064	0.059	0.082 (0.051)	0.056	0.105
	No source	-0.001 (0.094)	-0.000	0.995	-0.002 (0.072)	-0.001	0.968	0.003 (0.075)	0.001	0.970
Social support: cumulative exposure										
Overall	Low Pos.	**0.030 (0.010)**	**0.058**	**0.004**	**0.028 (0.010)**	**0.055**	**0.006**			
scores	High Neg.	**0.027 (0.012)**	**0.046**	**0.021**	0.022 (0.012)	0.038	0.060			
	Pos. + Neg.	**0.025 (0.007)**	**0.069**	**0.001**	**0.022 (0.007)**	**0.062**	**0.002**			

Notes. ELSA, waves 4 and 6; B = regression coefficients; SE = standard errors; β = standardised coefficients; bold values are statistically significant at $p \leq 0.05$.

Table 4. Associations between hair cortisone and positive and negative experiences of social support.

Outcome: *Cortisone (log)*		**Model 1**			**Model 2**			**Model 3**		
		B(SE)	β	*p*-value	B(SE)	β	*p*-value	B(SE)	β	*p*-value
Social Support: cross-sectional										
Overall	Low Pos.	0.023 (0.021)	0.022	0.261	0.016 (0.020)	0.015	0.421			
scores	High Neg.	-0.007 (0.027)	-0.005	0.789	-0.035 (0.026)	-0.025	0.179			
	Pos.+ Neg.	0.011 (0.015)	0.013	0.493	-0.002 (0.015)	-0.003	0.871			
Source specific: Positive										
Partner	High	0.035 (0.093)	0.022	0.703	0.062 (0.091)	0.039	0.493	0.078 (0.092)	0.049	0.392
(ref: low)	Medium	-0.005 (0.104)	-0.002	0.964	0.006 (0.101)	0.002	0.950	-0.009 (0.102)	-0.003	0.929
	No source	0.142 (0.095)	0.081	0.136	0.125 (0.093)	0.071	0.180	0.126 (0.094)	0.071	0.182
Children	High	**-0.196 (0.062)**	**-0.124**	**0.002**	**-0.159 (0.061)**	**-0.100**	**0.009**	**-0.158 (0.063)**	**-0.100**	**0.012**
(ref: low)	Medium	**-0.190 (0.068)**	**-0.099**	**0.005**	**-0.160 (0.066)**	**-0.083**	**0.015**	**-0.159 (0.066)**	**-0.083**	**0.016**
	No source	**-0.141 (0.072)**	**-0.061**	**0.050**	-0.099 (0.070)	-0.043	0.159	-0.112 (0.072)	-0.048	0.120
Other	High	-0.054 (0.040)	-0.034	0.175	-0.045 (0.038)	-0.027	0.245	-0.032 (0.041)	-0.020	0.425
Family	Medium	-0.058 (0.040)	-0.035	0.152	-0.034 (0.039)	-0.021	0.384	-0.024 (0.039)	-0.015	0.538
(ref: low)	No source	-0.066 (0.064)	-0.022	0.304	-0.049 (0.062)	-0.016	0.428	-0.049 (0.063)	-0.016	0.444
Friends	High	**-0.101 (0.051)**	**-0.065**	**0.047**	-0.067 (0.049)	-0.043	0.172	-0.060 (0.051)	-0.039	0.237
(ref: low)	Medium	**-0.112 (0.052)**	**-0.069**	**0.032**	-0.085 (0.051)	-0.052	0.092	-0.076 (0.051)	-0.046	0.138
	No source	-0.054 (0.078)	-0.016	0.487	-0.115 (0.075)	-0.034	0.127	-0.102 (0.076)	-0.030	0.179
Source-specific: Negative										
Partner	Low	-0.077 (0.071)	0.050	0.273	-0.026 (0.069)	-0.017	0.705	0.017 (0.072)	0.011	0.812
(ref:	Medium	0.007 (0.073)	0.004	0.925	0.040 (0.071)	0.023	0.575	0.079 (0.072)	0.046	0.269
high)	No source	0.071 (0.073)	0.040	0.333	0.072 (0.071)	0.041	0.314	0.112 (0.073)	0.064	0.127
Children	Low	**-0.261 (0.086)**	**-0.164**	**0.002**	**-0.238 (0.083)**	**-0.149**	**0.004**	**-0.274 (0.089)**	**-0.177**	**0.002**
(ref:	Medium	**-0.218 (0.089)**	**-0.117**	**0.015**	**-0.216 (0.086)**	**-0.116**	**0.013**	**-0.235 (0.089)**	**-0.127**	**0.008**
high)	No source	**-0.201 (0.093)**	**-0.087**	**0.031**	-0.175 (0.090)	-0.076	0.053	**-0.211 (0.095)**	**-0.092**	**0.027**
Other	Low	0.080 (0.080)	0.047	0.319	0.106 (0.079)	0.063	0.173	0.151 (0.081)	0.090	0.068
Family	Medium	0.094 (0.085)	0.047	0.273	0.094 (0.083)	0.047	0.256	0.125 (0.084)	0.063	0.138
(ref:	No source	0.054 (0.096)	0.018	0.578	0.083 (0.094)	0.028	0.377	0.115 (0.096)	0.039	0.233
high)										
Friends	Low	0.030 (0.054)	0.018	0.581	0.070 (0.052)	0.044	0.185	0.080 (0.054)	0.050	0.142
(ref high)	Medium	0.022 (0.059)	0.012	0.713	0.032 (0.057)	0.018	0.577	0.019 (0.058)	0.011	0.744
	No source	**0.188 (0.085)**	**0.051**	**0.028**	0.137 (0.083)	0.037	0.098	**0.179 (0.085)**	**0.048**	**0.036**
Social Support - cumulative exposure										
Overall	Low Pos.	0.015 (0.012)	0.023	0.235	0.008 (0.012)	0.013	0.484			
scores	High Neg.	-0.005 (0.014)	-0.007	0.709	-0.020 (0.014)	-0.028	0.139			
	Pos.+ Neg.	0.005 (0.009)	0.012	0.551	-0.004 (0.008)	-0.009	0.674			

Notes. ELSA, waves 4 and 6; B = regression coefficients; SE = standard errors; β = standardised coefficients; bold values are statistically significant at p ≤ 0.05.

Table 5. Associations between the ratio of hair cortisol to cortisone (R_{hcc}) and positive and negative experiences of social support.

Outcome : R_{hcc} (log)		Model 1			Model 2			Model 3		
		B(SE)	β	p-value	B(SE)	β	p-value	B(SE)	β	p-value
Social Support - cross-sectional										
Overall scores	Low Pos.	0.074 (0.039)	0.038	0.059	**0.078 (0.039)**	**0.039**	**0.048**			
	High Neg.	**0.130 (0.052)**	**0.050**	**0.012**	**0.136 (0.051)**	**0.053**	**0.008**			
	Pos.+Neg.	**0.084 (0.029)**	**0.057**	**0.004**	**0.088 (0.029)**	**0.059**	**0.003**			
Source-specific: Positive										
Partner	High	0.087 (0.177)	0.029	0.623	0.088 (0.178)	0.030	0.621	0.070 (0.180)	0.024	0.697
(ref: low)	Medium	0.076 (0.200)	0.015	0.705	0.079 (0.200)	0.015	0.692	0.065 (0.201)	0.013	0.745
	No source	-0.058 (0.182)	-0.019	0.751	-0.068 (0.183)	-0.021	0.709	-0.102 (0.186)	-0.031	0.584
Children	High	-0.074 (0.119)	-0.025	0.534	-0.065 (0.119)	-0.022	0.586	-0.083 (0.124)	-0.028	0.500
(ref: low)	Medium	-0.141 (0.129)	-0.039	0.277	-0.134 (0.129)	-0.038	0.298	-0.144 (0.130)	-0.041	0.267
	No source	-0.077 (0.138)	-0.018	0.575	-0.051 (0.138)	-0.012	0.712	-0.018 (0.142)	-0.004	0.901
Other Family	High	-0.051 (0.076)	-0.017	0.505	-0.048 (0.076)	-0.016	0.528	-0.074 (0.080)	-0.025	0.357
(ref: low)	Medium	-0.093 (0.077)	-0.031	0.230	-0.091 (0.077)	-0.030	0.236	-0.111 (0.078)	-0.037	0.154
	No source	-0.104 (0.123)	-0.019	0.396	-0.091 (0.123)	-0.016	0.459	-0.115 (0.125)	-0.020	0.359
Friends	High	0.103 (0.097)	0.036	0.287	-0.067 (0.049)	-0.043	0.172	0.113 (0.100)	0.040	0.261
(ref: low)	Medium	0.172 (0.100)	0.057	0.084	-0.085 (0.051)	-0.052	0.092	0.194 (0.101)	0.064	0.055
	No source	-0.008 (0.148)	-0.001	0.956	-0.115 (0.075)	-0.034	0.127	-0.008 (0.149)	-0.001	0.955
Source-specific: Negative										
Partner	Low	-0.105 (0.135)	-0.036	0.439	-0.081 (0.136)	-0.028	0.552	-0.103 (0.142)	-0.036	0.469
(ref: high)	Medium	-0.212 (0.139)	-0.065	0.127	-0.183 (0.139)	-0.057	0.189	-0.190 (0.142)	-0.059	0.181
	No source	**-0.276 (0.139)**	**-0.085**	**0.048**	-0.263 (0.140)	-0.081	0.061	**-0.284 (0.145)**	**-0.088**	**0.050**
Children	Low	0.215 (0.164)	0.073	0.191	0.272 (0.164)	0.092	0.098	0.332 (0.176)	0.113	0.059
(ref: high)	Medium	0.137 (0.171)	0.040	0.424	0.193 (0.170)	0.056	0.257	0.223 (0.176)	0.065	0.209
	No source	0.193 (0.178)	0.045	0.279	0.266 (0.178)	0.062	0.136	**0.370 (0.189)**	**0.086**	**0.050**
Other Family	Low	-0.131 (0.154)	-0.042	0.393	-0.126 (0.154)	-0.040	0.416	-0.173 (0.160)	-0.055	0.281
(ref: high)	Medium	-0.131 (0.163)	-0.036	0.422	-0.113 (0.164)	-0.031	0.490	-0.140 (0.166)	-0.038	0.401
	No source	-0.173 (0.184)	-0.032	0.393	-0.158 (0.185)	-0.029	0.395	-0.197 (0.190)	-0.036	0.301
Friends	Low	0.003 (0.103)	0.001	0.974	0.001 (0.103)	0.000	0.992	-0.042 (0.107)	-0.014	0.695
(ref high)	Medium	0.173 (0.112)	0.052	0.122	0.183 (0.112)	0.055	0.103	0.168 (0.114)	0.050	0.142
	No source	-0.138 (0.162)	-0.020	0.396	-0.144 (0.163)	-0.021	0.377	-0.174 (0.168)	-0.025	0.301
Social Support - cumulative exposure										
Overall scores	Low Pos.	**0.055 (0.024)**	**0.046**	**0.021**	**0.057 (0.023)**	**0.048**	**0.015**			
	High Neg.	**0.067 (0.027)**	**0.050**	**0.012**	**0.070 (0.027)**	**0.055**	**0.008**			
	Pos.+Neg.	**0.052 (0.016)**	**0.063**	**0.002**	**0.056 (0.016)**	**0.066**	**0.001**			

Notes. ELSA, waves 4 and 6; B = regression coefficients; SE = standard errors; β = standardised coefficients; bold values are statistically significant at p ≤ 0.05.

Appendix A

Items		Original Scale			
		1 (a lot)	2 (some)	3 (a little)	4 (not at all)
Positive social support	(a) How much do they really understand the way you feel about things? (b) How much can you rely on them if you have a serious problem? (c) How much can you open up to them if you need if you need to talk about your worries?				
Negative social support	(a) How much do they criticise you? (b) How much do they let you down when you are counting on them? (c) How much do they get on your nerves (d) How often do they make too many demands on you?				

Appendix A. Questionnaire and scale measuring positive and negative experiences of social support.

Appendix B

Appendix B.1. Sample characteristics and a comparison of observed and imputed data.

		Observed			Imputed	
		% missing	Mean (sd)	Frequency (%)	Mean (sd)	%
Age		0	68.1 (7.4)		68.1 (7.4)	
Sex	Male	0		1040 (41.3)		41.3
	Female			1480 (58.7)		58.7
Education	Graduate	0.3		448 (17.8)		17.8
	Primary/secondary school			1506 (59.9)		59.8
	No qualifications			559 (22.2)		22.2
Wealth	1 = lowest	1.5		399 (16.1)		15.9
	2			473 (19.1)		19.0
	3			510 (20.5)		20.6
	4			525 (21.2)		21.2
	5 = highest			575 (23.1)		23.3
Cortisol (log, pg/mg)		0	0.91 (0.63)		0.91 (0.63)	
Cortisone (log, pg/mg)		0	1.84 (0.77)		1.84 (0.77)	
R_{hcc} (log, pg/mg)		0	0.27 (1.43)		0.27 (1.43)	
BMI		10.4	27.9 (5.05)		28.0 (5.08)	
Current Smoking	Yes	0		255 (10.1)		10.1
	No			2265 (89.9)		89.9
Sedentary Activity	Yes	0		95 (3.8)		3.8
	No			2425 (96.2)		96.2
Hair colour	Brunette	0		608 (24.2)		24.2
	Red/ginger			61 (2.4)		2.4
	Blonde			316 (12.5)		12.5
	White/grey			1459 (57.9)		57.9
	Mix grey/other colour			76 (3.1)		3.1
Hair treatment	Yes	0		888 (35.2)		35.2
	No			1632 (64.8)		64.8

Notes. Data source: ELSA, wave 6; N=2,520; only percentages are given for the imputed data as frequencies vary across the 20 imputed datasets.

Appendix B.2. Summary statistics of positive and negative social support and a comparison of observed and imputed data.

Social support (wave 6)		Positive experiences			Negative experiences		
			Observed	Imputed		Observed	Imputed
		% missing	*Frequency (%)*	*%*	*% missing*	*Frequency (%)*	*%*
Partner	High	5.6	1485 (62.5)	62.6	6.0	117 (4.9)	4.9
	Medium		195 (8.2)	8.3		622 (26.1)	26.5
	Low		63 (2.7)	2.7		1007 (42.3)	42.1
	No source		633 (26.6)	26.4		633 (26.6)	26.5
Children	High	5.7	1448 (60.9)	60.8	6.3	70 (3.0)	3.1
	Medium		478 (20.1)	20.1		519 (22.0)	22.0
	Low		144 (6.1)	6.3		1466 (62.1)	62.1
	No source		306 (12.9)	12.8		306 (13.0)	12.8
Family	High	6.8	872 (37.1)	36.9	15.2	78 (3.5)	3.7
	Medium		779 (33.2)	33.6		399 (18.1)	18.2
	Low		537 (22.9)	22.5		1574 (71.5)	70.8
	No source		160 (6.8)	6.9		160 (6.8)	7.2
Friends	High	5.7	1200 (50.5)	50.4	12.9	197 (8.5)	8.6
	Medium		796 (33.5)	33.4		544 (23.5)	24.4
	Low		248 (10.4)	10.7		1445 (62.3)	62.3
	No source		132 (5.6)	5.5		132 (5.7)	4.7
Overall scores		*Mean (sd)*					
Low positive		0.65(0.72)					
High negative		0.36(0.55)					
Pos. + Neg.		1.0(1.0)					

Cumulative exposure to social support (waves 4 & 6)		Low Positive			High Negative		
			Observed	Imputed		Observed	Imputed
		% missing	*Frequency (%)*	*%*	*% missing*	*Frequency (%)*	*%*
Partner	0 times	12.1	1497 (67.6)	67.7	12.1	1402 (65.2)	65.2
	1 time		65 (2.9)	3.0		143 (6.5)	7.1
	2 times		20 (2.8)	2.8		37 (2.7)	2.6
	No source		633 (26.6)	26.5		633 (26.6)	26.1
Children	0 times	11.9	1702 (76.7)	76.0	12.7	1773 (81.7)	81.2
	1 time		152 (6.8)	7.4		106 (4.8)	5.2
	2 times		59 (2.7)	2.8		16 (0.7)	0.8
	No source		306 (13.8)	13.8		306 (12.8)	12.8
Family	0 times	13.5	1333 (61.1)	61.0	21.7	1658 (84.0)	83.4
	1 time		415 (19.0)	19.7		123 (6.2)	7.2
	2 times		273 (12.5)	12.3		32 (1.6)	1.4
	No source		160 (7.3)	7.0		160 (8.1)	8.0
Friends	0 times	12.1	1741 (78.6)	78.5	19.4	1698 (83.6)	83.2
	1 time		258 (11.6)	11.9		180 (8.9)	9.2
	2 times		85 (3.8)	3.7		22 (1.1)	1.1
	No source		132 (6.0)	5.9		132 (6.5)	6.5
Overall scores		*Mean (sd)*					
Positive		1.3 (1.20)					
Negative		0.7 (1.10)					
Pos. + Neg.		2.0 (1.70)					

Notes. Data source: ELSA, waves 4 & 6; N = 2,520; only percentages are given for the imputed data as frequencies vary across the 20 imputed datasets. Overall scores were only calculated for the imputed datasets.
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Appendix C

Appendix C.1. Associations between hair cortisol and source-specific measures of cumulative exposure to low positive/high negative social support.

Outcome: *cortisol (log)*		Model 1			Model 2			Model 3		
		B(SE)	β	*p*-value	B(SE)	β	*p*-value	B(SE)	β	*p*-value
Social support - cumulative exposure										
Low positive										
Partner	2	0.169 (0.141)	0.024	0.232	0.139 (0.141)	0.020	0.322	0.132 (0.142)	0.019	0.352
(ref: 0)	1	-0.078 (0.073)	-0.021	0.287	-0.080 (0.074)	-0.023	0.256	-0.091 (0.074)	-0.025	0.218
	No source	-0.014 (0.029)	-0.010	0.630	-0.037 (0.031)	-0.026	0.226	-0.051 (0.031)	-0.036	0.103
Children	2	**0.182 (0.076)**	**0.048**	**0.017**	**0.147 (0.075)**	**0.038**	**0.050**	0.147 (0.076)	0.039	0.056
(ref: 0)	1	0.024 (0.048)	0.010	0.621	0.009 (0.048)	0.004	0.856	0.008 (0.049)	0.003	0.869
	No source	0.027 (0.038)	0.014	0.477	0.037 (0.038)	0.020	0.334	0.053 (0.039)	0.028	0.179
Other Family	2	0.048 (0.039)	0.025	0.222	0.041 (0.039)	0.021	0.298	0.043 (0.040)	0.023	0.282
(ref: 0)	1	**0.079 (0.032)**	**0.050**	**0.015**	**0.069 (0.032)**	**0.044**	**0.031**	**0.073 (0.032)**	**0.047**	**0.024**
	No source	-0.010 (0.050)	-0.004	0.837	-0.006 (0.050)	-0.002	0.904	-0.012 (0.050)	-0.005	0.807
Friends	2	-0.003 (0.067)	-0.001	0.969	-0.016 (0.067)	-0.005	0.817	-0.037 (0.068)	-0.011	0.583
(ref: 0)	1	-0.007 (0.038)	-0.004	0.853	-0.021 (0.039)	-0.011	0.592	-0.034 (0.039)	-0.018	0.381
	No source	-0.038 (0.055)	-0.014	0.487	-0.074 (0.056)	-0.027	0.183	-0.092 (0.056)	-0.034	0.101
High Negative										
Partner	2	0.166 (0.100)	0.033	0.098	0.147 (0.100)	0.029	0.143	0.161 (0.101)	0.032	0.113
(ref: 0)	1	0.017 (0.050)	0.007	0.732	-0.016 (0.050)	-0.006	0.751	-0.003 (0.051)	-0.013	0.950
	No source	-0.006 (0.030)	-0.004	0.846	-0.028 (0.031)	-0.019	0.377	-0.035 (0.032)	-0.025	0.270
Children	2	0.029 (0.141)	0.004	0.838	0.016 (0.141)	0.002	0.117	0.005 (0.143)	0.001	0.970
(ref: 0)	1	-0.014 (0.057)	-0.005	0.811	-0.050 (0.057)	-0.018	0.379	-0.054 (0.059)	-0.019	0.361
	No source	0.018 (0.038)	0.009	0.637	0.028 (0.038)	0.015	0.458	0.039 (0.039)	0.021	0.320
Other Family	2	0.016 (0.106)	0.003	0.880	-0.005 (0.107)	-0.001	0.966	-0.000 (0.110)	-0.000	0.998
(ref: 0)	1	-0.002(0.049)	-0.001	0.974	-0.024 (0.049)	-0.010	0.628	-0.015 (0.050)	-0.006	0.771
	No source	0.004 (0.052)	0.001	0.942	-0.005 (0.052)	-0.002	0.925	-0.005 (0.052)	-0.002	0.922
Friends	2	0.046 (0.119)	0.008	0.700	0.018 (0.119)	0.003	0.878	0.025 (0.121)	0.004	0.835
(ref: 0)	1	-0.049 (0.043)	-0.023	0.259	-0.063 (0.044)	-0.030	0.148	-0.061 (0.044)	-0.028	0.166
	No source	-0.014 (0.060)	-0.005	0.815	-0.054 (0.060)	-0.018	0.365	-0.061 (0.060)	-0.021	0.312

Notes. Source: ELSA, waves 4 and 6; B = regression coefficients; SE = standard errors; β = standardised regression coefficients; bold values are statistically significant at p ≤ 0.05.

Appendix C.2. Associations between hair cortisone and source-specific measures of cumulative exposure to low positive/high negative social support.

Outcome: *Cortisone (log)*		Model 1			Model 2			Model 3		
		B(SE)	β	*p*-value	B(SE)	β	*p*-value	B(SE)	β	*p*-value
Social Support - cumulative exposure										
Low positive										
Partner	2	0.088 (0.167)	0.010	0.599	0.078 (0.162)	0.009	0.631	0.049 (0.006)	0.049	0.298
(ref: 0)	1	-0.035 (0.087)	-0.008	0.684	-0.062 (0.085)	-0.014	0.464	-0.086 (0.085)	-0.019	0.313
	No source	**0.112 (0.035)**	**0.064**	**0.001**	**0.070 (0.035)**	**0.040**	**0.046**	0.058 (0.036)	0.033	0.109
Children	2	**0.207 (0.091)**	**0.044**	**0.022**	**0.187 (0.088)**	**0.041**	**0.049**	0.157 (0.089)	0.033	0.086
(ref: 0)	1	**0.163 (0.057)**	**0.055**	**0.004**	**0.111 (0.056)**	**0.038**	**0.046**	0.102 (0.056)	0.035	0.070
	No source	0.061 (1.354)	0.004	0.176	0.064 (0.044)	0.028	0.142	0.049 (0.045)	0.021	0.277
Other Family	2	0.065 (0.047)	0.028	0.161	0.044 (0.045)	0.019	0.332	0.017 (0.046)	0.007	0.706
(ref: 0)	1	0.037 (0.038)	0.019	0.336	0.024 (0.037)	0.012	0.525	0.012 (0.037)	0.006	0.746
	No source	-0.007 (0.059)	-0.002	0.900	-0.009 (0.058)	-0.003	0.880	-0.022 (0.058)	-0.007	0.706
Friends	2	**0.166 (0.080)**	**0.040**	**0.038**	0.113 (0.077)	0.027	0.144	0.098 (0.078)	0.024	0.210
(ref: 0)	1	0.081 (0.046)	0.034	0.077	0.048 (0.044)	0.020	0.281	0.039 (0.045)	0.017	0.388
	No source	0.057 (0.065)	0.017	0.383	-0.037 (0.064)	-0.011	0.561	-0.039 (0.065)	-0.012	0.546
High Negative										
Partner	2	0.129 (0.119)	0.021	0.279	0.091 (0.115)	0.015	0.427	0.070 (0.116)	0.011	0.550
(ref: 0)	1	-0.019 (0.059)	-0.006	0.747	-0.068 (0.058)	-0.022	0.237	-0.062 (0.058)	-0.020	0.289
	No source	**0.114 (0.035)**	**0.065**	**0.001**	0.069 (0.036)	0.039	0.053	0.065 (0.037)	0.037	0.074
Children	2	0.318 (0.167)	0.037	0.057	0.283 (0.162)	0.033	0.080	0.302 (0.164)	0.035	0.066
(ref: 0)	1	0.091 (0.067)	0.026	0.174	0.041 (0.066)	0.012	0.530	0.078 (0.068)	0.022	0.247
	No source	0.048 (0.045)	0.021	0.286	0.054 (0.043)	0.023	0.217	0.036 (0.045)	0.016	0.420
Other Family	2	-0.069 (0.125)	-0.011	0.579	-0.151 (0.123)	-0.023	0.220	-0.177 (0.126)	-0.027	0.160
(ref: 0)	1	-0.001 (0.058)	-0.001	0.988	-0.036 (0.056)	-0.012	0.526	-0.032 (0.058)	-0.011	0.582
	No source	0.033 (0.061)	0.010	0.591	0.035 (0.060)	0.011	0.555	0.033 (0.060)	0.010	0.586
Friends	2	-0.075 (0.142)	-0.010	0.596	-0.164 (0.137)	-0.022	0.231	-0.162 (0.139)	-0.022	0.244
(ref: 0)	1	-0.066 (0.051)	-0.020	0.197	-0.092 (0.050)	-0.034	0.067	-0.089 (0.050)	-0.033	0.079
	No source	**0.155 (0.070)**	**0.043**	**0.028**	0.073 (0.068)	0.020	0.292	0.072 (0.069)	0.020	0.299

Notes. Source: ELSA, waves 4 and 6; B = regression coefficients; SE = standard errors; β = standardised regression coefficients; bold values are statistically significant at p ≤ 0.05.

Appendix C.3. Associations between the ratio of hair cortisol to cortisone (R_{hcc}) and source-specific measures of cumulative exposure to low positive/high negative social support.

Outcome: $R_{hcc}(log)$		Model 1			Model 2			Model 3		
		B(SE)	β	*p*-value	B(SE)	β	*p*-value	B(SE)	β	*p*-value
Social Support - cumulative exposure										
Low positive										
Partner	2	0.301 (0.319)	0.019	0.346	0.244 (0.319)	0.015	0.444	0.256 (0.322)	0.016	0.425
(ref: 0)	1	-0.144 (0.167)	-0.017	0.387	-0.131 (0.167)	-0.016	0.435	-0.124 (0.168)	-0.015	0.461
	No source	**-0.144 (0.066)**	**-0.044**	**0.030**	**-0.155 (0.069)**	**-0.048**	**0.025**	**-0.176 (0.071)**	**-0.054**	**0.013**
Children	2	0.212 (0.173)	0.024	0.221	0.173 (0.174)	0.020	0.320	0.187 (0.176)	0.021	0.288
(ref: 0)	1	-0.107 (0.109)	-0.020	0.327	-0.090 (0.110)	-0.016	0.413	-0.083 (0.111)	-0.015	0.457
	No source	0.005 (0.086)	0.001	0.955	0.023 (0.086)	0.005	0.788	0.075 (0.089)	0.017	0.399
Other Family	2	0.045 (0.089)	0.010	0.616	0.050 (0.088)	0.012	0.570	0.082 (0.091)	0.019	0.368
(ref: 0)	1	**0.142 (0.073)**	**0.040**	**0.053**	0.134 (0.073)	0.037	0.067	**0.155 (0.074)**	**0.043**	**0.036**
	No source	-0.015 (0.113)	-0.003	0.898	-0.003 (0.113)	-0.001	0.975	-0.005 (0.114)	-0.001	0.963
Friends	2	-0.172 (0.152)	-0.022	0.260	0.113 (0.077)	0.027	0.144	-0.183 (0.154)	-0.024	0.232
(ref: 0)	1	-0.097 (0.087)	-0.022	0.266	0.048 (0.044)	0.020	0.281	-0.117 (0.089)	-0.027	0.187
	No source	-0.145 (0.125)	-0.023	0.245	-0.037 (0.064)	-0.011	0.561	-0.173 (0.127)	-0.028	0.174
High Negative										
Partner	2	0.254 (0.022)	0.254	0.265	0.246 (0.227)	0.022	0.278	0.300 (0.230)	0.026	0.192
(ref: 0)	1	0.052 (0.113)	0.009	0.644	0.026 (0.113)	0.005	0.819	0.049 (0.115)	0.007	0.672
	No source	-0.128 (0.067)	-0.039	0.058	-0.133 (0.070)	-0.041	0.059	**-0.148 (0.072)**	**-0.045**	**0.041**
Children	2	-0.250 (0.319)	-0.016	0.434	-0.244 (0.319)	-0.015	0.444	-0.289 (0.324)	-0.018	0.373
(ref: 0)	1	-0.121 (0.129)	-0.019	0.344	-0.156 (0.129)	-0.024	0.229	-0.201 (0.134)	-0.031	0.133
	No source	-0.003 (0.085)	-0.001	0.971	0.014 (0.085)	0.003	0.874	0.056 (0.088)	0.013	0.526
Other Family	2	0.107 (0.239)	0.009	0.654	0.142 (0.242)	0.012	0.559	0.177 (0.248)	0.015	0.474
(ref: 0)	1	-0.002 (0.110)	-0.000	0.987	-0.018 (0.111)	-0.003	0.873	-0.001 (0.114)	-0.000	0.996
	No source	-0.025 (0.117)	-0.004	0.834	-0.047 (0.117)	-0.008	0.691	-0.045 (0.118)	-0.008	0.702
Friends	2	0.182 (0.270)	0.013	0.502	0.207 (0.270)	0.015	0.444	0.220 (0.274)	0.016	0.422
(ref: 0)	1	-0.046 (0.098)	-0.009	0.640	-0.053 (0.099)	-0.011	0.590	-0.051 (0.099)	-0.010	0.607
	No source	-0.187 (0.135)	-0.028	0.165	-0.197 (0.136)	-0.029	0.146	-0.212 (0.136)	-0.031	0.121

Notes. Source: ELSA, waves 4 and 6; B = regression coefficients; SE = standard errors; β = standardised regression coefficients; bold values are statistically significant at p ≤ 0.05.

Appendix D

Appendix D. Associations of hair cortisol, cortisone, and cortisol/cortisone ratio (R_{hcc}) with the other covariates.

		Unadjusted			Mutually adjusted		
		B(SE)	β	p-value	B(SE)	β	p-value
Cortisol							
Female (ref: male)		-0.014 (0.025)	-0.011	0.592	-0.031 (0.032)	-0.024	0.340
Age		0.001 (0.002)	0.015	0.449	0.002 (0.002)	0.026	0.233
Wealth quintiles	2	-0.078 (0.042)	-0.049	0.065	-0.062 (0.043)	-0.039	0.147
(ref: 1 = lowest)	3	**-0.099 (0.042)**	**-0.064**	**0.018**	**-0.082 (0.043)**	**-0.053**	**0.053**
	4	**-0.108 (0.041)**	**-0.070**	**0.009**	-0.075 (0.043)	-0.049	0.082
	5 (= highest)	**-0.109 (0.041)**	**-0.074**	**0.007**	-0.068 (0.043)	-0.046	0.119
Education	No qualifications	0.059 (0.040)	0.039	0.136	0.017 (0.044)	0.011	0.703
(ref: Graduate)	Primary/secondary	0.026 (0.034)	0.020	0.447	0.008 (0.035)	0.006	0.828
BMI		**0.011 (0.002)**	**0.093**	**<0.001**	**0.011 (0.003)**	**0.092**	**< 0.001**
Smoking	Yes	0.032 (0.041)	0.016	0.435	0.029 (0.043)	0.014	0.497
Sedentary life	Yes	**0.134 (0.065)**	**0.041**	**0.040**	0.097 (0.067)	0.029	0.146
Hair colour	Red/ginger	-0.032 (0.043)	-0.017	0.464	-0.030 (0.045)	-0.016	0.509
(ref: Brunette)	Blonde	0.057 (0.079)	0.015	0.467	0.057 (0.079)	0.015	0.470
	White/grey	0.021 (0.084)	0.005	0.806	0.013 (0.084)	0.003	0.875
	Mix/other colour	-0.010 (0.030)	-0.008	0.738	-0.030 (0.034)	-0.024	0.375
Hair treatment	Yes	-0.003 (0.026)	-0.002	0.901	0.013 (0.037)	0.010	0.719
Cortisone							
Female (ref: male)		**-0.420 (0.030)**	**-0.268**	**< 0.001**	**-0.234 (0.037)**	**-0.149**	**< 0.001**
Age		**-0.004 (0.002)**	**-0.042**	**0.035**	-0.003 (0.002)	-0.027	0.187
Wealth quintiles	2	**-0.225 (0.052)**	**-0.114**	**< 0.001**	**-0.166 (0.049)**	**-0.085**	**0.001**
(ref: 1 = lowest)	3	**-0.180 (0.051)**	**-0.095**	**< 0.001**	**-0.128 (0.049)**	**-0.067**	**0.009**
	4	**-0.254 (0.051)**	**-0.134**	**< 0.001**	**-0.180 (0.050)**	**-0.095**	**< 0.001**
	5	**-0.179 (0.050)**	**-0.098**	**< 0.001**	**-0.127 (0.050)**	**-0.070**	**0.011**
Education	No qualifications	-0.046 (0.049)	-0.025	0.344	0.017 (0.050)	0.009	0.740
(ref: Graduate)	Primary/secondary	-0.057 (0.042)	-0.036	0.174	-0.016 (0.040)	-0.010	0.699
BMI		**0.017 (0.003)**	**0.114**	**< 0.001**	**0.016 (0.003)**	**0.107**	**< 0.001**
Smoking	Yes	**0.289 (0.051)**	**0.113**	**< 0.001**	**0.297 (0.049)**	**0.116**	**< 0.001**
Sedentary life	Yes	0.151 (0.081)	0.037	0.061	0.050 (0.076)	0.012	0.515
Hair colour	Red/ginger	**-0.514 (0.052)**	**-0.221**	**< 0.001**	**-0.348 (0.052)**	**-0.150**	**< 0.001**
(ref: Brunette)	Blonde	0.092 (0.095)	0.020	0.332	0.064 (0.091)	0.014	0.479
	White/grey	**-0.425 (0.101)**	**-0.085**	**< 0.001**	**-0.308 (0.097)**	**-0.061**	**0.002**
	Mix/other colour	0.029 (0.036)	0.018	0.426	**-0.103 (0.039)**	**-0.066**	**0.009**
Hair treatment	Yes	**-0.454 (0.031)**	**-0.281**	**< 0.001**	**-0.243 (0.043)**	**-0.151**	**< 0.001**
R_{hcc}							
Female (ref: male)		**0.387 (0.057)**	**0.133**	**< 0.001**	**0.164 (0.073)**	**0.056**	**0.025**
Age		**0.008 (0.004)**	**0.039**	**0.051**	**0.008 (0.004)**	**0.042**	**0.054**
Wealth quintiles	2	0.045 (0.097)	0.012	0.645	0.023 (0.097)	0.006	0.810
(ref: 1 = lowest)	3	-0.047 (0.095)	-0.013	0.622	-0.062 (0.096)	-0.018	0.517
	4	0.006 (0.095)	0.002	0.946	0.006 (0.098)	0.002	0.949
	5	-0.075 (0.093)	-0.022	0.422	-0.032 (0.098)	-0.009	0.745
Education	No qualifications	**0.179 (0.091)**	**0.052**	**0.048**	0.017 (0.099)	0.005	0.866
(ref: Graduate)	Primary/secondary	0.111 (0.077)	0.038	0.150	0.028 (0.080)	0.010	0.727
BMI		0.009 (0.006)	0.031	0.116	0.010 (0.006)	0.035	0.082
Smoking	Yes	**-0.215 (0.095)**	**-0.045**	**0.023**	**-0.229 (0.097)**	**-0.048**	**0.018**
Sedentary life	Yes	0.158 (0.150)	0.021	0.292	0.173 (0.151)	0.023	0.251
Hair colour	Red/ginger	**0.444 (0.099)**	**0.103**	**< 0.001**	**0.283 (0.102)**	**0.066**	**0.006**
(ref: Brunette)	Blonde	0.043 (0.180)	0.005	0.810	0.070 (0.179)	0.008	0.696
	White/grey	**0.475 (0.191)**	**0.051**	**0.013**	0.342 (0.191)	0.037	0.074
	Mix/other colour	-0.049 (0.069)	-0.017	0.477	0.036 (0.077)	0.012	0.644
Hair treatment	Yes	**0.445 (0.059)**	**0.148**	**< 0.001**	**0.273 (0.084)**	**0.091**	**0.001**

Notes. Source: ELSA, waves 6; B = regression coefficients; SE = standard errors; β = standardised regression coefficients; bold values are statistically significant at p ≤ 0.05.

Appendix E

Appendix E.1. Associations between hair cortisol and positive and negative experiences of social support in complete-case analyses (N = 1,524).

Outcome: *Cortisol (log)*		**Model 1**			**Model 2**			**Model 3**		
		B(SE)	β	*p*-value	B(SE)	β	*p*-value	B(SE)	β	*p*-value
Social Support – cross-sectional										
Positive										
Overall	Low Pos.	**0.062 (0.024)**	**0.071**	**0.009**	**0.057 (0.024)**	**0.064**	**0.017**			
scores	High Neg.	0.061 (0.032)	0.051	0.058	0.052 (0.032)	0.043	0.104			
	Pos.+Neg.	**0.054 (0.018)**	**0.081**	**0.002**	**0.049 (0.018)**	**0.072**	**0.006**			
Partner	High	0.093 (0.121)	0.069	0.446	0.158 (0.122)	0.117	0.193	0.146 (0.123)	0.108	0.234
(ref: low)	Medium	0.130 (0.134)	0.054	0.332	0.175 (0.134)	0.073	0.191	0.165 (0.134)	0.068	0.221
	No source	0.044 (0.124)	0.029	0.726	0.078 (0.125)	0.053	0.531	0.050 (0.126)	0.034	0.688
Children	High	-0.112 (0.078)	-0.084	0.154	-0.097 (0.078)	-0.072	0.216	-0.108 (0.080)	-0.081	0.177
(ref: low)	Medium	-0.141 (0.085)	-0.085	0.097	-0.137 (0.084)	-0.082	0.104	-0.141(0.085)	-0.085	0.095
	No source	-0.055 (0.088)	-0.029	0.536	-0.043 (0.088)	-0.022	0.622	-0.023 (0.090)	-0.012	0.793
Other Family	High	0.017 (0.046)	0.011	0.709	0.008 (0.045)	0.005	0.855	0.019 (0.048)	0.012	0.677
(ref: low)	Medium	-0.034 (0.040)	-0.026	0.386	-0.035 (0.039)	-0.026	0.368	-0.032 (0.041)	-0.024	0.428
	No source	0.089 (0.103)	0.024	0.385	0.073 (0.103)	0.019	0.472	0.068 (0.102)	0.018	0.507
Friends	High	-0.049 (0.064)	-0.021	0.440	-0.049 (0.063)	-0.021	0.439	-0.053 (0.066)	-0.023	0.423
(ref: low)	Medium	0.025 (0.037)	0.018	0.508	0.024 (0.037)	0.018	0.509	0.021 (0.038)	0.015	0.596
	No source	0.066 (0.143)	0.012	0.647	0.065 (0.143)	0.012	0.646	0.063 (0.143)	0.011	0.658
Negative										
Partner	Low	-0.160 (0.089)	-0.124	0.073	-0.116 (0.090)	-0.090	0.198	-0.114 (0.092)	-0.088	0.215
(ref: high)	Medium	**-0.183 (0.092)**	**-0.125**	**0.048**	-0.146 (0.093)	-0.100	0.115	-0.145 (0.093)	-0.099	0.121
	No source	**-0.210 (0.093)**	**-0.142**	**0.024**	**-0.195 (0.093)**	**-0.132**	**0.036**	**-0.214 (0.095)**	**-0.144**	**0.024**
Children	Low	-0.019 (0.116)	-0.015	0.864	0.006 (0.116)	0.004	0.959	0.033 (0.119)	0.025	0.778
(ref: high)	Medium	-0.027 (0.119)	-0.017	0.820	-0.007 (0.120)	-0.004	0.954	0.011 (0.120)	0.007	0.926
	No source	0.035 (0.123)	0.018	0.778	0.058 (0.123)	0.031	0.636	0.113 (0.125)	0.059	0.367
Other Family	Low	-0.060 (0.077)	-0.045	0.439	-0.041 (0.078)	-0.031	0.598	-0.045 (0.078)	-0.033	0.562
(ref: high)	Medium	-0.001 (0.081)	-0.001	0.986	0.011 (0.081)	0.007	0.889	0.003 (0.082)	0.003	0.962
	No source	0.055 (0.125)	0.015	0.662	0.058 (0.124)	0.015	0.638	0.044 (0.124)	0.011	0.723
Friends	Low	-0.000 (0.063)	-0.000	1.000	0.024 (0.064)	0.017	0.713	0.020 (0.065)	0.014	0.757
(ref high)	Medium	0.048 (0.069)	0.032	0.485	0.066 (0.069)	0.044	0.339	0.052 (0.069)	0.035	0.450
	No source	0.099 (0.152)	0.019	0.518	0.096 (0.152)	0.018	0.531	0.078 (0.153)	0.014	0.610
Social support - cumulative exposure										
Low positive										
Overall	Low Pos.	**0.033 (0.014)**	**0.063**	**0.018**	**0.030 (0.014)**	**0.056**	**0.035**			
scores	High Neg.	0.025 (0.016)	0.042	0.115	0.022 (0.016)	0.036	0.180			
	Pos.+Neg.	**0.026 (0.009)**	**0.070**	**0.008**	**0.023 (0.009)**	**0.062**	**0.021**			
Partner	2	0.167 (0.215)	0.020	0.436	0.069 (0.216)	0.008	0.749	0.067 (0.218)	0.008	0.756
(ref: 0)	1	-0.158 (0.110)	-0.038	0.151	-0.200 (0.111)	-0.048	0.072	-0.219 (0.111)	-0.053	0.051
	No source	-0.054 (0.040)	-0.037	0.178	**-0.085 (0.042)**	**-0.057**	**0.047**	**-0.108 (0.044)**	**-0.073**	**0.014**
Children	2	**0.242 (0.117)**	**0.055**	**0.039**	0.224 (0.117)	0.051	0.056	**0.244 (0.119)**	**0.055**	**0.040**
(ref: 0)	1	0.008 (0.072)	0.003	0.903	0.001 (0.073)	0.001	0.978	0.008 (0.074)	0.003	0.908
	No source	0.063 (0.051)	0.033	0.213	0.063 (0.051)	0.033	0.219	0.098 (0.053)	0.051	0.065
Other Family	2	0.051 (0.052)	0.027	0.322	0.039 (0.052)	0.020	0.450	0.046 (0.054)	0.024	0.394
(ref: 0)	1	0.075 (0.043)	0.047	0.085	0.066 (0.043)	0.041	0.125	0.077 (0.043)	0.048	0.078
	No source	0.121 (0.101)	0.032	0.231	0.105 (0.101)	0.028	0.298	0.095 (0.101)	0.025	0.344
Friends	2	-0.020 (0.091)	-0.006	0.826	-0.020 (0.090)	-0.006	0.822	-0.051 (0.092)	-0.015	0.576
(ref: 0)	1	-0.020 (0.091)	-0.031	0.252	-0.065 (0.053)	-0.032	0.219	-0.080 (0.054)	-0.040	0.141
	No source	0.078 (0.142)	0.014	0.581	0.054 (0.142)	0.010	0.704	0.056 (0.143)	0.010	0.697
High Negative										
Partner	2	0.327 (0.179)	0.048	0.068	0.298 (0.180)	0.044	0.097	0.307 (0.183)	0.045	0.094
(ref: 0)	1	0.004 (0.072)	0.001	0.955	-0.030 (0.072)	-0.011	0.675	-0.033 (0.074)	-0.012	0.651
	No source	-0.056 (0.040)	-0.038	0.164	**-0.087 (0.043)**	**-0.058**	**0.045**	**-0.108 (0.045)**	**-0.072**	**0.017**
Children	2	0.020 (0.289)	0.002	0.943	0.012 (0.289)	0.001	0.966	-0.103 (0.296)	-0.009	0.727
(ref: 0)	1	-0.019 (0.082)	-0.006	0.813	-0.032 (0.083)	-0.010	0.699	-0.041 (0.085)	-0.013	0.630
	No source	0.055 (0.051)	0.028	0.281	0.054 (0.051)	0.028	0.290	0.091 (0.053)	0.048	0.085
Other Family	2	0.114 (0.141)	0.021	0.419	0.114 (0.142)	0.021	0.419	0.115 (0.146)	0.022	0.431
(ref: 0)	1	0.064 (0.073)	0.023	0.383	0.044 (0.073)	0.016	0.542	0.058 (0.074)	0.021	0.428
	No source	0.101(0.101)	0.027	0.311	0.087 (0.100)	0.023	0.381	0.082 (0.100)	0.022	0.412
Friends	2	0.054 (0.179)	0.008	0.762	0.030 (0.179)	0.004	0.866	0.046 (0.182)	0.007	0.798
(ref: 0)	1	-0.046 (0.062)	-0.019	0.457	-0.067 (0.062)	-0.028	0.283	-0.066 (0.062)	-0.028	0.291
	No source	0.082 (0.142)	0.015	0.561	0.056 (0.142)	0.010	0.692	0.031 (0.142)	0.005	0.827

Notes. Source: ELSA, waves 4 and 6; B = regression coefficients; SE = standard errors; β = standardised regression coefficients; bold values are statistically significant at p ≤ 0.05.

Appendix E.2. Associations between hair cortisone and positive and negative experiences of social support in complete-case analyses (N = 1,524).

Outcome: *Cortisone (log)*		**Model 1**			**Model 2**			**Model 3**		
		B(SE)	β	p-value	B(SE)	β	p-value	B(SE)	β	p-value
Social Support – cross-sectional										
Positive										
Overall scores	Low Pos.	0.040 (0.039)	0.026	0.126	0.024 (0.026)	0.023	0.351			
	High Neg.	-0.006 (0.036)	-0.004	0.852	-0.029 (0.035)	-0.020	0.406			
	Pos.+Neg.	0.021 (0.020)	0.026	0.295	0.004 (0.019)	0.006	0.808			
Partner	High	0.023 (0.136)	0.014	0.862	0.088 (0.133)	0.055	0.509	0.109 (0.135)	0.069	0.417
(ref: low)	Medium	-0.030 (0.151)	-0.010	0.840	0.024 (0.146)	0.008	0.867	0.025 (0.147)	0.009	0.863
	No source	0.115 (0.139)	0.066	0.408	0.163 (0.137)	0.093	0.232	0.175 (0.138)	0.100	0.207
Children	High	-0.166 (0.088)	-0.106	0.058	-0.140 (0.085)	-0.089	0.102	-0.145 (0.088)	-0.093	0.099
(ref: low)	Medium	-0.160 (0.095)	-0.082	0.092	-0.137 (0.092)	-0.070	0.137	-0.141 (0.093)	-0.072	0.129
	No source	-0.111 (0.099)	-0.049	0.263	-0.098 (0.096)	-0.044	0.307	-0.130 (0.099)	-0.058	0.191
Other Family	High	0.043 (0.051)	0.023	0.400	0.024 (0.049)	0.013	0.619	0.023 (0.052)	0.013	0.652
(ref: low)	Medium	-0.009 (0.044)	-0.005	0.833	0.000 (0.043)	0.000	0.999	0.002 (0.044)	0.001	0.964
	No source	-0.177 (0.115)	-0.040	0.125	-0.166 (0.112)	-0.037	0.138	-0.161 (0.112)	-0.036	0.150
Friends	High	0.048 (0.071)	0.018	0.498	0.019 (0.069)	0.007	0.781	0.005 (0.072)	0.001	0.943
(ref: low)	Medium	-0.021(0.042)	-0.013	0.607	-0.026 (0.040)	-0.016	0.519	-0.024 (0.042)	-0.015	0.567
	No source	0.102 (0.161)	0.016	0.525	0.036 (0.156)	0.005	0.815	0.042 (0.157)	0.006	0.785
Negative										
Partner	Low	-0.064 (0.100)	-0.042	0.526	-0.034 (0.099)	-0.022	0.731	-0.004 (0.101)	-0.003	0.961
(ref: high)	Medium	0.053 (0.103)	0.030	0.609	0.057 (0.101)	0.033	0.572	0.073 (0.102)	0.042	0.475
	No source	0.078 (0.104)	0.045	0.451	0.085 (0.101)	0.048	0.403	0.108 (0.103)	0.062	0.296
Children	Low	-0.162 (0.130)	-0.103	0.213	-0.151 (0.127)	-0.096	0.234	-0.147 (0.130)	-0.094	0.256
(ref: high)	Medium	-0.075 (0.134)	-0.040	0.576	-0.083 (0.130)	-0.045	0.524	-0.086 (0.132)	-0.046	0.511
	No source	-0.092 (0.138)	-0.041	0.505	-0.097 (0.134)	-0.043	0.467	-0.119 (0.137)	-0.053	0.385
Other Family	Low	-0.013 (0.087)	-0.008	0.880	0.033 (0.085)	0.021	0.692	0.039 (0.086)	0.024	0.650
(ref: high)	Medium	0.058 (0.092)	0.034	0.525	0.079 (0.089)	0.046	0.372	0.087 (0.089)	0.051	0.329
	No source	-0.179 (0.140)	-0.040	0.201	-0.129 (0.136)	-0.029	0.343	-0.105 (0.136)	-0.024	0.437
Friends	Low	-0.009 (0.071)	-0.006	0.890	0.025 (0.070)	0.015	0.719	0.060 (0.071)	0.037	0.400
(ref high)	Medium	-0.015 (0.078)	-0.008	0.847	-0.004 (0.075)	-0.002	0.951	-0.004 (0.076)	-0.002	0.954
	No source	0.094 (0.172)	0.015	0.583	0.058 (0.167)	0.009	0.728	0.080 (0.168)	0.012	0.632
Social support - cumulative exposure										
Low positive										
Overall scores	Low Pos.	0.019 (0.015)	0.031	0.226	0.008 (0.015)	0.013	0.600			
	High Neg.	-0.002 (0.018)	-0.003	0.906	-0.015 (0.018)	-0.021	0.401			
	Pos.+Neg.	0.008 (0.011)	0.020	0.433	-0.001 (0.010)	-0.003	0.892			
Partner	2	-0.024 (0.242)	-0.002	0.920	-0.123 (0.237)	-0.013	0.602	-0.153 (0.240)	-0.016	0.522
(ref: 0)	1	-0.076 (0.124)	-0.015	0.539	-0.114 (0.125)	-0.023	0.345	-0.131 (0.122)	-0.027	0.285
	No source	**0.095 (0.045)**	**0.054**	**0.036**	0.079 (0.047)	0.045	0.090	0.076 (0.049)	0.043	0.119
Children	2	0.185 (0.132)	0.036	0.161	0.150 (0.128)	0.029	0.244	0.138 (0.131)	0.026	0.290
(ref: 0)	1	0.083 (0.081)	0.026	0.310	0.040 (0.080)	0.012	0.613	0.040 (0.081)	0.012	0.619
	No source	0.054 (0.057)	0.024	0.341	0.039 (0.056)	0.017	0.483	0.011 (0.058)	0.005	0.846
Other Family	2	0.079 (0.058)	0.035	0.177	0.054 (0.057)	0.024	0.338	0.056 (0.059)	0.025	0.341
(ref: 0)	1	0.018 (0.048)	0.010	0.701	-0.004 (0.047)	-0.002	0.920	-0.001 (0.048)	-0.001	0.980
	No source	-0.169 (0.114)	-0.038	0.137	-0.165 (0.110)	0.037	0.134	-0.165 (0.110)	-0.037	0.136
Friends	2	0.054 (0.102)	0.013	0.594	0.017 (0.099)	0.004	0.860	-0.003 (0.101)	-0.000	0.975
(ref: 0)	1	-0.009 (0.060)	-0.004	0.877	-0.025 (0.058)	-0.010	0.668	-0.033 (0.059)	-0.014	0.571
	No source	0.108 (0.160)	0.017	0.498	0.043 (0.155)	0.006	0.780	0.060 (0.158)	0.009	0.703
High Negative										
Partner	2	0.230 (0.202)	0.029	0.254	0.129 (0.197)	0.016	0.512	0.106 (0.200)	0.013	0.594
(ref: 0)	1	-0.020 (0.081)	-0.006	0.797	-0.044 (0.079)	-0.014	0.579	-0.043 (0.081)	-0.013	0.595
	No source	**0.089 (0.046)**	**0.051**	**0.051**	0.072 (0.047)	0.041	0.129	0.066 (0.049)	0.037	0.183
Children	2	0.298 (0.325)	0.023	0.360	0.232 (0.317)	0.018	0.463	0.308 (0.325)	0.024	0.342
(ref: 0)	1	0.060 (0.093)	0.016	0.520	0.023 (0.091)	0.006	0.799	0.038 (0.093)	0.010	0.679
	No source	0.048 (0.057)	0.021	0.402	0.034 (0.056)	0.015	0.541	0.018 (0.058)	0.008	0.757
Other Family	2	-0.212 (0.159)	-0.034	0.183	-0.282 (0.155)	-0.045	0.069	**-0.308 (0.160)**	**-0.049**	**0.054**
(ref: 0)	1	0.096 (0.082)	0.029	0.243	0.086 (0.080)	0.026	0.283	-0.167 (0.110)	-0.037	0.129
	No source	-0.181 (0.113)	-0.041	0.108	-0.170 (0.109)	-0.038	0.119	0.090 (0.081)	0.027	0.268
Friends	2	0.126 (0.202)	0.015	0.532	0.027 (0.196)	0.003	0.890	0.018 (0.199)	0.002	0.925
(ref: 0)	1	-0.041 (0.070)	-0.015	0.552	-0.062 (0.068)	-0.022	0.364	-0.067 (0.068)	-0.024	0.325
	No source	0.103 (0.160)	0.016	0.519	0.039 (0.155)	0.006	0.802	0.027 (0.156)	0.004	0.862

Notes. Source: ELSA, waves 4 and 6; B = regression coefficients; SE = standard errors; β = standardised regression coefficients; bold values are statistically significant at p ≤ 0.05.

Appendix E.3. Associations between R_{hcc} and positive and negative experiences of social support in complete-case analyses (N = 1,524).

Outcome: R_{hcc} *(log)*		Model 1			Model 2			Model 3		
		B(SE)	β	*p*-value	B(SE)	β	*p*-value	B(SE)	β	*p*-value
Social Support – cross-sectional										
Positive										
Overall scores	Low Pos.	0.101 (0.053)	0.050	0.057	**0.105 (0.053)**	**0.052**	**0.049**			
	High Neg.	**0.147 (0.072)**	**0.054**	**0.040**	**0.151 (0.072)**	**0.055**	**0.036**			
	Pos.+Neg.	**0.103 (0.040)**	**0.068**	**0.010**	**0.107 (0.040)**	**0.070**	**0.008**			
Partner	High	0.190 (0.272)	0.062	0.486	0.277 (0.274)	0.090	0.311	0.228 (0.276)	0.074	0.409
(ref: low)	Medium	0.331 (0.301)	0.060	0.062	0.380 (0.301)	0.069	0.206	0.355 (0.302)	0.065	0.240
	No source	-0.015 (0.279)	-0.004	0.272	0.016 (0.281)	0.004	0.953	-0.058 (0.284)	-0.017	0.836
Children	High	-0.088 (0.176)	-0.029	0.614	-0.082 (0.176)	-0.027	0.642	-0.104 (0.181)	-0.034	0.565
(ref: low)	Medium	-0.163 (0.190)	-0.043	0.392	-0.178 (0.190)	-0.047	0.938	-0.185 (0.190)	-0.049	0.332
	No source	-0.014 (0.199)	-0.003	0.941	-0.001 (0.198)	-0.000	0.993	0.075 (0.204)	0.017	0.711
Other Family	High	-0.004 (0.102)	-0.001	0.964	-0.006 (0.102)	-0.001	0.951	0.022 (0.107)	0.006	0.835
(ref: low)	Medium	-0.068 (0.089)	-0.022	0.441	-0.081 (0.089)	-0.026	0.362	-0.075 (0.092)	-0.024	0.413
	No source	0.382 (0.231)	0.045	0.098	0.335 (0.230)	0.039	0.146	0.317 (0.230)	0.037	0.168
Friends	High	-0.171 (0.143)	-0.032	0.232	0.019 (0.069)	0.007	0.781	-0.129 (0.149)	-0.024	0.386
(ref: low)	Medium	0.071 (0.084)	0.023	0.394	-0.026 (0.040)	-0.016	0.519	0.069 (0.086)	0.022	0.420
	No source	0.099 (0.008)	0.321	0.758	0.036 (0.156)	0.005	0.815	0.102 (0.322)	0.008	0.750
Negative										
Partner	Low	-0.307 (0.201)	-0.105	0.127	-0.236 (0.203)	-0.080	0.244	-0.261 (0.207)	-0.089	0.207
(ref: high)	Medium	**-0.475 (0.207)**	**-0.142**	**0.022**	-0.395 (0.208)	-0.119	0.058	-0.408 (0.210)	-0.122	0.207
	No source	**-0.564 (0.208)**	**-0.167**	**0.006**	**-0.537 (0.208)**	**-0.159**	**0.010**	**-0.605 (0.213)**	**-0.179**	**0.004**
Children	Low	0.117 (0.261)	0.038	0.652	0.165 (0.261)	0.054	0.527	0.226 (0.266)	0.074	0.395
(ref: high)	Medium	0.012 (0.269)	0.003	0.963	0.067 (0.269)	0.018	0.802	0.112 (0.270)	0.031	0.677
	No source	0.172 (0.277)	0.039	0.534	0.231 (0.277)	0.053	0.403	0.381 (0.282)	0.088	0.176
Other Family	Low	-0.125 (0.175)	-0.041	0.474	-0.128 (0.175)	-0.042	0.463	-0.144 (0.177)	-0.047	0.414
(ref: high)	Medium	-0.060 (0.184)	-0.018	0.744	-0.051 (0.184)	-0.015	0.778	-0.077 (0.184)	-0.023	0.675
	No source	0.304 (0.280)	0.035	0.279	0.262 (0.279)	0.030	0.348	0.206 (0.279)	0.024	0.460
Friends	Low	0.010 (0.143)	0.003	0.943	0.029 (0.143)	0.009	0.839	-0.013(0.146)	-0.004	0.925
(ref high)	Medium	0.128 (0.155)	0.037	0.410	0.159 (0.155)	0.046	0.306	0.127 (0.156)	0.037	0.416
	No source	0.133 (0.344)	0.011	0.699	0.162 (0.344)	0.013	0.636	0.099 (0.344)	0.008	0.772
Social support - cumulative exposure										
Low positive										
Overall scores	Low Pos.	0.056 (0.031)	0.047	0.073	0.059 (0.031)	0.050	0.060			
	High Neg.	0.062 (0.036)	0.044	0.091	0.066 (0.037)	0.048	0.072			
	Pos.+Neg.	**0.051 (0.022)**	**0.060**	**0.022**	**0.054 (0.022)**	**0.064**	**0.015**			
Partner	2	0.410 (0.484)	0.022	0.397	0.283 (0.486)	0.015	0.560	0.309 (0.490)	0.016	0.528
(ref: 0)	1	-0.290 (0.248)	-0.030	0.243	-0.346 (0.249)	-0.036	0.165	-0.374 (0.251)	-0.039	0.136
	No source	**-0.222 (0.090)**	**-0.066**	**0.014**	**-0.276 (0.096)**	**-0.082**	**0.004**	**-0.327 (0.100)**	**-0.097**	**0.001**
Children	2	0.370 (0.264)	0.037	0.162	0.366 (0.264)	0.036	0.166	0.424 (0.268)	0.042	0.114
(ref: 0)	1	-0.063 (0.163)	-0.010	0.698	-0.036 (0.165)	-0.005	0.825	-0.021 (0.167)	-0.003	0.899
	No source	0.090 (0.115)	0.021	0.430	0.105 (0.115)	0.024	0.363	0.214 (0.120)	0.049	0.074
Other Family	2	0.051 (0.118)	0.011	0.664	0.034 (0.117)	0.007	0.767	0.056 (0.122)	0.012	0.646
(ref: 0)	1	0.148 (0.100)	0.039	0.139	0.157 (0.097)	0.043	0.108	0.177 (0.101)	0.047	0.081
	No source	**0.447 (0.227)**	**0.052**	**0.049**	0.405 (0.227)	0.047	0.074	0.383 (0.227)	0.045	0.091
Friends	2	-0.097 (0.205)	-0.012	0.636	-0.059 (0.204)	-0.007	0.770	-0.106 (0.207)	-0.013	0.607
(ref: 0)	1	-0.115 (0.122)	-0.025	0.346	-0.105 (0.122)	-0.022	0.390	-0.135 (0.124)	-0.029	0.277
	No source	0.071 (0.320)	0.005	0.824	0.080 (0.320)	0.006	0.801	0.068 (0.323)	0.005	0.832
High Negative										
Partner	2	0.523 (0.404)	0.034	0.194	0.559 (0.404)	0.036	0.167	0.600 (0.411)	0.039	0.144
(ref: 0)	1	0.030 (0.162)	0.005	0.850	-0.025 (0.163)	-0.004	0.877	-0.033 (0.166)	-0.005	0.841
	No source	**-0.222 (0.092)**	**-0.065**	**0.015**	**-0.273 (0.097)**	**-0.080**	**0.005**	**-0.316 (0.102)**	**-0.093**	**0.001**
Children	2	-0.251 (0.650)	-0.010	0.700	-0.204 (0.651)	-0.008	0.753	-0.547 (0.666)	-0.022	0.411
(ref: 0)	1	-0.105 (0.186)	-0.015	0.571	-0.097 (0.187)	-0.013	0.603	-0.133 (0.191)	-0.019	0.486
	No source	0.077 (0.114)	0.018	0.499	0.089 (0.115)	0.020	0.436	0.193 (0.119)	0.044	0.107
Other Family	2	0.476 (0.319)	0.039	0.135	0.547 (0.319)	0.045	0.087	0.573 (0.327)	0.047	0.080
(ref: 0)	1	0.050 (0.165)	0.008	0.760	0.016 (0.165)	0.002	0.921	0.044 (0.166)	0.007	0.788
	No source	0.414 (0.226)	0.048	0.066	0.371 (0.225)	0.043	0.099	0.355 (0.225)	0.041	0.115
Friends	2	-0.001 (0.404)	-0.000	0.996	0.042 (0.404)	0.002	0.916	0.088 (0.409)	0.005	0.828
(ref: 0)	1	-0.065 (0.140)	-0.012	0.639	-0.093 (0.140)	-0.017	0.508	-0.085 (0.141)	-0.016	0.542
	No source	0.086 (0.319)	0.007	0.788	0.090 (0.320)	0.007	0.778	0.044 (0.320)	0.003	0.890

Notes. Source: ELSA, waves 4 and 6; B = regression coefficients; SE = standard errors; β = standardised regression coefficients; bold values are statistically significant at p ≤ 0.05.

Conflicts of interest

None of the authors have any conflicts of interest to declare related to the findings of this study.