Health Psychology

A Social Rank Explanation of How Money Influences Health

Michael Daly, Christopher Boyce, and Alex Wood

Online First Publication, August 18, 2014. http://dx.doi.org/10.1037/hea0000098

Health Psychology

0278-6133/14/$12.00 http://dx.doi.org/10.1037/hea0000098

A Social Rank Explanation of How Money Influences Health

Michael Daly
University of Stirling

Christopher Boyce and Alex Wood
University of Stirling and University of Manchester

Objective: Financial resources are a potent determinant of health, yet it remains unclear why this is the case. We aimed to identify whether the frequently observed association between absolute levels of monetary resources and health may occur because money acts an indirect proxy for a person's social rank. ***Method:*** To address this question we examined over 230,000 observations on 40,400 adults drawn from two representative national panel studies; the British Household Panel Survey and the English Longitudinal Study of Ageing. We identified each person's absolute income/wealth and their objective ranked position of income/wealth within a social reference-group. Absolute and rank income/wealth variables were then used to predict a series of self-reported and objectively recorded health outcomes in cross-sectional and longitudinal analyses. ***Results:*** As anticipated, those with higher levels of absolute income/wealth were found to have better health than others, after adjustment for age, gender, education, marital status, and labor force status. When evaluated simultaneously the ranked position of income/wealth but not absolute income/wealth predicted all health outcomes examined including: objective measures of allostatic load and obesity, the presence of long-standing illness, and ratings of health, physical functioning, role limitations, and pain. The health benefits of high rank were consistent in cross-sectional and longitudinal analyses and did not depend on the reference-group used to rank participants. ***Conclusions:*** This is the first study to demonstrate that social position rather than material conditions may explain the impact of money on human health.

Keywords: social status, social rank, relative income, health inequalities, allostatic load

Supplemental materials: http://dx.doi.org/10.1037/hea0000098.supp

Human health is socially stratified yet it is unclear what dimensions of socioeconomic status (SES) lead to adverse health outcomes (Antonovsky, 1967). Epidemiological studies including the Whitehall studies of British civil servants have provided evidence that each step down the social hierarchy is associated with a graded increase in risk of physiological dysregulation, disease morbidity, and mortality (Marmot, Bosma, Hemingway, Brunner, & Tansfeld, 1997; Marmot et al., 1991). However, traditional accounts of the health impact of ordered differences in SES (e.g., by occupational prestige or income) have not clearly disentangled the contribution of social position from access to material resources (Kawachi, Adler, & Dow, 2010; Marmot & Wilkinson, 2001). In this study, we directly tested competing *rank-income/wealth* and *absolute-income/wealth* hypotheses. In line with a rapidly growing research literature we predicted that money would affect health by acting as a proxy for a person's social rank.

Observational and experimental studies of dominance hierarchies among nonhuman animals in captivity and in the wild have shown that subordinate animals experience higher levels of stress than other animals (Sapolsky, 2005; Shively, Laber-Laird, & Anton, 1997). This is because the social environment of low-ranking animals is characterized by a lack of control and predictability and subordinate animals tend to display hypervigilance to threat (Shively, 1998). From an evolutionary perspective, such vigilance can be considered an adaptive response enabling a low-ranking animal to escape attack and respond quickly when threatened (Gilbert, 2006). However, the ongoing stress of social subordination can mobilize the sympathetic nervous system and evoke prolonged endocrine responses (Archie, Altmann, & Alberts, 2012; Tung et al., 2012). In this way, what is initially an adaptive fight or flight response may lead to chronic stress-activation and adverse health consequences (Slavich & Irwin, 2014). Such deleterious health effects of low rank cannot be attributed to health selection or to poor nutrition; they occur when rank is experimentally manipulated and when food is readily available to all animals (Sapolsky, 2005; Shively et al., 1997).

Quasi-experimental, and experimental evidence from human studies also supports the idea that variability in the SES-health relationship may be attributable to differences in social rank. For

Michael Daly, Behavioural Science Centre, Stirling Management School, University of Stirling; Christopher Boyce and Alex Wood, Behavioural Science Centre, Stirling Management School, University of Stirling, and School of Psychological Sciences, University of Manchester.

This research was supported by a European Commission co-funded Government of Ireland CARA Postdoctoral Mobility Fellowship and funding from the United Kingdom Economic and Social Research Council (Grant numbers RES-062-23-2462 and ES/K00588X/1). The data from all studies were accessed through the United Kingdom Data Archive and can be downloaded from http://data-archive.ac.uk/. The British Household Panel Survey (BHPS) is archived as SN 3909 and the English Longitudinal Study of Ageing (ELSA) as SN 5050. The authors have no conflicts of interest to declare.

Correspondence concerning this article should be addressed to Michael Daly, Behavioural Science Centre, Stirling Management School, University of Stirling, FK9 4LA, United Kingdom. E-mail: michael.daly@stir.ac.uk

instance, Nobel Prize winners live longer than year of birth and country-matched nominees, a finding that could potentially be attributed to the associated increase in social rank (Rablen & Oswald, 2008). Although Nobel winners represent an atypical group evidence from representative samples suggests that where people believe they are positioned in society, as indexed by measures of subjective social status, appears to be predictive of health outcomes, even when the influence of objective measures of SES is adjusted for (Demakakos, Nazroo, Breeze, & Marmot, 2008; Singh-Manoux, Marmot, & Adler, 2005). Finally, experimentally induced subordinate status has also been associated with negative emotional reactions and blood pressure reactivity in response to stress (Mendelson, Thurston, & Kubzansky, 2008).

Existing evidence provides strong support for the idea that money affects health because it is a marker for where a person is ranked within a relevant socially constructed comparison group. However, this position contrasts sharply with "materialist" interpretations of how income and wealth are considered to influence health. Such accounts have emphasized how income and pricing constraints limit the health-enhancing goods and services people can access. This *absolute-income/wealth hypothesis* suggests that money is concavely related to health, so that wealthy people can essentially "purchase" better health up to a point where the returns to investment in health diminish (Kawachi et al., 2010). A third account proposes that the difference between a person's income and the income of those in a reference group can have health effects. Specifically, the *relative-income/wealth hypothesis* suggests that earning or owning less than one's peers can generate feelings of stress and anxiety that can influence health. At present, little consistent support exists for this idea with some studies reporting that the average income of relevant others negatively affects health (Gravelle & Sutton, 2009) and others reporting null or positive effects (Lorgelly & Lindley, 2008; Miller & Paxson, 2006; Wagstaff & van Doorslaer, 2000). In the present study we propose that a rank-based account will be more consistent than a relative/income wealth account. Specifically, we suggest that low ranked individuals will consistently show worse health than others across a range of reported and objective health indicators. Existing research has empirically disentangled rank and absolute income explanations to suggest rank judgments accurately reflect how people compare their incomes to others (Brown, Gardner, Oswald, & Qian, 2008). Furthermore, prior research has shown that a social rank model, rather than an absolute income account, explains how income affects emotional well-being and the tendency to experience distress and psychosomatic symptoms (e.g., irritability, dizziness) (Boyce, Brown, & Moore, 2010; Elgar et al., 2013; Wood, Boyce, Moore, & Brown, 2012). Although this work has directly tested competing rank and absolute income explanations, it remains possible that rank differences affected how people interpreted or reported their well-being and psychosomatic symptoms rather than directly affecting these characteristics.

In the current study we use a similar methodology to the above studies to empirically disentangle the potential health effects of objectively assessed income/wealth rank from effects that can be attributed to a person's absolute- or relative-income/wealth. Our study is novel in that we examine how rank relates to both self-reported and objectively recorded health indicators. If those who are identified as low rank based on an examination of objective characteristics like income and region also show higher levels of objective health-risk (e.g., obesity, allostatic load) then this association cannot be attributed to a potential effect of rank on the interpretation of health or use of response scales.

We examine over 230,000 observations on 40,400 adults drawn from two representative panel studies of British adults; the British Household Panel Survey (BHPS) and the English Longitudinal Study of Ageing (ELSA). We made three specific predictions about how money should relate to health. First, based on the existing literature we anticipated a positive relationship between how much participants own or earn and their health. Second, having a higher rank of income or wealth than others was anticipated to be positively linked to healthy functioning in baseline and longitudinal analyses. Third, associations between absolute income/wealth and health should be diminished substantially when "rank" effects are controlled for, suggesting that money may appear to influence health because it acts as a marker of social rank.

Method

Participants

This study draws from two large scale United Kingdom based panel studies. The first is the BHPS, a nationally representative longitudinal sample of approximately 10,000 individuals (British Household Panel Survey, 2010; Contoyannis, Jones, & Rice, 2004). The second is ELSA, an ongoing prospective cohort study of a nationally representative sample (initial sample of 12,099) of community-dwelling English adults aged 50 years and over.

BHPS sample. The BHPS survey investigates social and economic change and their effects in the United Kingdom. Data from the study has been used extensively by social science researchers and is described in detail elsewhere (British Household Panel Survey, 2010). The BHPS is a nationally representative longitudinal sample of approximately 5,500 households and 10,000 individuals surveyed each year from 1991 to 2007. Households were initially selected using a two-stage clustered probability design that was coupled with a systematic sampling procedure. Participants were reinterviewed annually until they died or decided to leave the survey. For a given wave of the survey the proportion of the sample reinterviewed the following year was ~90% and attrition has been shown to have little effect on the estimation of regression coefficients in the BHPS (Contoyannis, Jones, & Rice, 2004). Data on health status from Waves 1–17 of the BHPS were included in the current analyses. Those included in the cross-sectional analyses were aged 45.19 ($SD = 18.64$) on average, 54.4% were female, and 11.6% held a university degree.

ELSA sample. ELSA is an ongoing prospective cohort study of a nationally representative sample of community-dwelling English adults aged 50 years and over. The ELSA study aims to provide data to enhance understanding of the determinants of SES, health, and well-being of older English adults. The initial sample consisted of 12,099 individuals recruited from three waves of the Health Survey for England (HSE): 1998, 1999, and 2001. Initial participants were recruited if they were born before March 1, 1952 and were then interviewed as part of the first wave in 2002/2003. Approximately 78% of the initial sample were retained in Wave 2 in 2004/2005 (9,432) and 79% of this sample elected to attend a clinical assessment (7,666) as part of Wave 2. Attrition at the time of the Wave 2 interviews was particularly high among older individuals, males, and the less well educated. In the current study, Wave 2 was used as the baseline sample and Wave 4 (2008/2009) was used as the follow-up sample. As in Wave 2, those participating in Wave 4 completed questions detailing their health and underwent a clinical assessment, thus allowing longitudinal analyses to be completed across all health variables of interest. Those included in the baseline cross-sectional analyses were aged 65.99 ($SD = 10.74$) on average and 56% were female.

Measures

Absolute income/wealth. Detailed information about sources of household income was provided as part of the BHPS survey each year. The total gross annual household income variable was equivalized based on the size of the household to provide an indication of each household member's spending power. The equivalized income variable was then log-transformed to reduce skew. The income variable considers all key sources of payments received including those from paid regular work (e.g., employment, self-employment) occasional earnings, social security/benefit income, other social assistance income, and occupational pension income. The income levels derived have been shown to be comparable to those from the Family Expenditure Survey (Jarvis & Jenkins, 1995).

Measures of income or occupational status are potentially inappropriate measures of SES in older samples where many participants are retired. Total benefit unit nonpension wealth was, therefore, used to index the SES of those in the ELSA sample. This measure gauges a comprehensive set of wealth sources including current and savings account balances, shares, national savings, and premium bonds, and the value of primary and secondary housing. Private debt (e.g., credit card debt, outstanding loans), including housing debt were factored into the wealth calculation. This variable was then log-transformed to reduce skew.

Rank income/wealth. Following a methodology developed elsewhere (Boyce et al., 2010), three income/wealth rank variables were created for each individual to represent the rank of their income/wealth within three different comparison groups, as more direct proxies for their social rank. In the BHPS the initial analysis ranked each participant's income within the region in which they lived. The 19 geographical regions of the United Kingdom specified in the BHPS (e.g., inner London, outer London, rest of the South East) were included as comparison groups. Subsequent analyses in the BHPS tested the role of income rank using education and gender groups. In the final analyses participants were ranked within comparison groups based on 5 year age bands. Each individual i's relative income rank R_i within a comparison reference group of size n was given by:

$$R_i = \frac{i - 1}{n - 1}$$

This ratio produces an income rank variable that is normalized between 0 and 1, where i – 1 represents the number of people in the individual's reference group who have incomes lower than individual i. The ELSA wealth rank variables were produced using the same methodology applied in the BHPS and outlined above. Because of the absence of regional information comparison groups were based on education and gender groups in the primary analyses and these estimates were then contrasted with those derived from analyses that ranked participants within comparison groups based on age. For some of the reference groups (e.g., educational qualifications) there was a small portion of missing data (not exceeding 4% of observations). To retain individuals who were missing the variable used to construct reference groups in the sample we inputted each participant's sample-wide (as opposed to reference group specific) income/wealth rank for the year in question.

Self-reported health outcomes. Self-rated health was assessed each year in the BHPS using the question "Compared to people of your own age, would you say that your health over the past 12 months has on the whole been excellent, good, fair, poor or very poor?" Self-rated health was treated as a continuous variable with those in "excellent" health given a score of 1 and those in "very poor" health given a score of 5.

In the BHPS the SF-36 (Brazier et al., 1992) was completed by participants in Waves 9 (1999) and 14 (2004) of the BHPS. The SF-36 gauges eight key domains of health-related functioning, four of which have been proposed to index health status: general health, physical function, role limitations because of physical problems, and pain (Ware, Kosinski, & Keller, 1994). We utilize these four domains in the current analyses. The scales showed a high degree of internal consistency reliability with Cronbach's α levels for each scale exceeding 0.80 (i.e., general health, $\alpha = .85$; physical function, $\alpha = .94$; role limitations, $\alpha = .93$; pain, $\alpha = .87$). Scores for each scale were coded and rescaled to form an index ranging from 0 = *worst possible health* to 100 = *best possible health*.

In ELSA self-rated health was gauged using the question: "In general, would you say your health is." Participants indicated how they perceived their health using a continuous scale with five points indicating progressively worse health (1 = *excellent*, 2 = *very good*, 3 = *good*, 4 = *fair*, and 5 = *poor*). Long-standing illness was assessed in ELSA using an item which inquired as to whether participants ". . . have any long-standing illness, disability or infirmity?" A further clarification was also provided: "By long-standing I mean anything that has troubled over a period of time, or that is likely to affect over a period of time." Binary yes/no responses were recorded for this item.

Where at least one long-standing illness was reported to be present, participants were asked "(Does this/Do these) illness(es) or disability(ies) limit activities in any way?" This item was coded using a yes/no binary response category indicating the presence or absence or role limitations. Finally, two questions were asked to identify if participants suffer from pain and to gauge the intensity of any pain present. First, participants were asked "Are you often troubled with pain." If they gave a positive response then they were asked "How bad is the pain most of the time? Is it . . ." and they rated the intensity of the pain experienced as either "mild," "moderate," or "severe." A composite variable was formed using these two items ranging from 0 = *not often troubled with pain*, to 3 = *often troubled with severe pain*.

Allostatic load. The calculation of allostatic load utilized in the current study followed guidelines outlined specifically for the biomarkers included in the ELSA data (Read & Grundy, 2012). C-reactive protein and fibrinogen were used to assess immune functioning. Systolic and diastolic blood pressure provided an index of cardiovascular functioning. Respiratory functioning was gauged using a measure of peak expiratory flow. Body fat was measured using the waist-to-hip ratio. Finally, metabolic functioning was assessed with three measures: the ratio of total blood cholesterol to high-density lipoprotein cholesterol, triglyceride levels, and glycated hemoglobin levels. Those in the upper quartile for all individual metrics except diastolic blood pressure and peak expiratory flow were deemed to be a high-risk group. Those with diastolic blood pressure and peak flow levels in the bottom quartile were likewise considered to be at high risk. Allostatic load indices were calculated by summing the number of times each individual scored in the high-risk group across the nine measures included. The formation of quartile indices and their subsequent summation was performed separately for men and women. Following this, allostatic load scores were merged into a single index with scores ranging from 0 = *does not fall in any high risk quartile*, to 9 = *falls in all high risk quartiles examined*.

All blood samples were analyzed in accordance with the technical specifications and quality control guidelines outlined in the Health Survey of England technical report (Graig, Deverill, & Pickering, 2006). Systolic and diastolic blood pressure was recorded using the Omron HEM-907 blood pressure monitor and the average levels from three seated readings were used in the current analyses. Peak expiratory flow rate was gauged using a spirometer. Three measures were taken and the quickest rate of exhalation (liters per minute) was utilized in the analyses. Three measures of the participant's waist and hip were taken and the average was levels were used to produce the waist-hip ration included in the current analyses.

Obesity. Anthropometric data were collected by nurses as part of the clinical assessments in Waves 2 and 4 of ELSA. This included a measure of standing height that was assessed with a portable stadiometer. Participants were requested to stand in the middle of the base plate and to look straight ahead to produce an accurate and consistent reading of height. Next, participants were weighed using the Tanita THD-305 portable electronic scales. Each participant's body mass index (BMI) was calculated and those with a BMI of 30 kg/m^2 or above were categorized as obese.

Covariates. To control for relative income/wealth effects, the average income/wealth of an individual's reference group was included as an additional covariate in all analyses. The demographic controls included in all analyses were: age, gender, education, marital status, disability status, and labor force status. In addition, in the BHPS for each observation dummy variables were included that identified the individual's region of residence and the survey wave from which the data were drawn. Some of the covariates had missing values and, therefore, to avoid excluding relevant participants, we included dummy variables to indicate that the covariate had a missing value. Further, if the variable in question were a continuous variable we recoded the missing value with the sample-wide mean in the respective sample. This practice ensured that the inputted values did not influence subsequent results. The portion of data missing for any given covariate did not exceed 4%. We also ran all analyses without implementing these techniques for dealing with missing data and the results were unchanged.

Statistical Analyses

Because of the hierarchical nature of the data in the BHPS with years (Level 1) nested within persons (Level 2) we used multilevel random coefficient modeling to test the study hypotheses in this sample (Luke, 2004). The multilevel analyses utilized 218,589 observations on 31,644 individuals for the cross-sectional analyses examining self-rated health and 181,830 observations on 25,505 participants for the longitudinal analyses. The follow-up rate for the longitudinal self-rated health analysis in BHPS was 81%. The analyses testing the link between income and the SF-36 subscales (i.e., general health perceptions, limitations because of physical health, pain, physical functioning, which were measured in only two waves of the BHPS) contained 20,112 to 20,301 participants in the cross-sectional sample and 9,693 to 9,762 participants in the longitudinal analyses. Differences in samples sizes between subscales for both the cross-sectional and longitudinal analyses reflected unanswered questions for that measure. For all longitudinal analyses, the health metric in question at a given time-point (t) was regressed on the health measure at t-1, as well as t-1 income and covariates. The follow-up rate for the longitudinal analyses of the SF-36 was 65% on average across the subscales. The sample size was reduced because of participant drop-out in BHPS over the period between 1999 when the SF-36 was first administered and follow-up in 2004.

In ELSA multivariate logistic and linear regression analyses were first used to test if absolute wealth was related to the health factors examined (i.e., self-rated health, presence of a long-standing illness, role limitations because of illness, pain levels, allostatic load levels, and obesity). For the cross-sectional analyses the sample size utilized from the initial clinical assessment wave of ELSA (2004/2005) ranged from 3,487 (i.e., allostatic load analysis) to 8,756 (long-standing illness). A substantial portion of the 2004/2005 ELSA sample who completed the main interview did not elect to take part in the clinical assessment (21%) or provide blood samples (a further 5% of the main sample) and only participants with complete biological data were included in the allostatic load analyses explaining most of the difference in sample size across analyses. The longitudinal analyses (sample size ranging from 2,185 to 6,244) regressed each health measure at a given time-point (t) on the same health measure at t-1, along with t-1 wealth and covariates. The follow-up rates for the self-report outcomes in ELSA ranged from 70% to 71% and were slightly lower for allostatic load (63%) and obesity (66%).

Next, the rank wealth variable was entered into the cross-sectional and longitudinal models. To ensure robustness, in the BHPS and ELSA we tested each relationship using rank variables constructed based on how much participants earn or own relative to those of the same gender and level of education (e.g., among high school educated males or college educated females), and others of the same age (using 5 year age-blocks). In addition, BHPS data allowed participant's to be ranked within a comparison group of people from the same geographical area. We considered counterfactual health outcomes that are unlikely to be affected by social rank[1] but were unable to identify a suitable variable for this test.

Results

Each participant was assigned a rank that gauged how many people in the individual's comparison group he or she earns or owns more than, relative to the size of the comparison group

[1] We aimed to identify commonly experienced (to ensure sufficient power for a comparison) health outcomes that have not previously shown a strong social gradient and may not be expected to be affected by rank. This search was unsuccessful with all potential outcomes examined either demonstrating an existing social gradient or being too rare to produce a meaningful counterfactual test of the rank hypothesis. For instance, breast cancer is a condition with a shallower social gradient than many health conditions and the incidence of which may not be substantially affected by the stress of low rank. In ELSA ~0.5% of the sample have been previously diagnosed with the condition. Our analyses revealed no association between social rank and breast cancer in the data. However, based on this analysis we cannot decipher whether this null result is because of the small sample of individuals with this condition or to a lack of an effect of rank.

(ranging from 0 = *lowest rank* to 1 = *highest rank*) (Boyce et al., 2010; Wood et al., 2012). To ensure the robustness of the results we tested each relationship using at least two types of reference groups which represent the kinds of groups to which participants may compare themselves to (Singer, 1981). Rank income and wealth variables were used to predict a comprehensive set of health metrics in cross-sectional and longitudinal analyses using linear regression and multilevel modeling techniques. The characteristics of the samples and key variables utilized are detailed in Table 1.

Absolute and relative income/wealth and health. Data from participants from ELSA was used to estimate the cumulative physiological effects of net benefit unit wealth (logarithmically transformed). Multisystemic physiological dysregulation was gauged using a measure of allostatic load calculated from biological data collected as part of physical examinations and laboratory tests conducted during ELSA. Cross-sectional analyses showed that absolute wealth levels were inversely related to our allostatic load measure composed of biological markers of cardiovascular (diastolic/systolic blood pressure), metabolic (lipid profile, waist-hip ratio, glycosylated hemoglobin), respiratory (peak expiratory flow), and inflammatory (C-reactive protein, fibrinogen) functioning, as shown in Table 2. Absolute wealth also predicted low levels of objectively assessed obesity (BMI $\geq$30 kg/m^2) in cross-sectional analysis.

In both cross-sectional and longitudinal analyses of the ELSA data absolute wealth levels predicted several self-reported health measures including fewer chronic illnesses or health-related limitations in physical and normal role activities, low levels of pain, and favorable health perceptions, as shown in Table 2. Similarly, among participants drawn from the BHPS we identified a strong inverse link between absolute levels of equivalized household income (logarithmically transformed) and self-reported health-related limitations, bodily pain, and a positive link with general health perceptions (Ware & Sherbourne, 1992) in both cross-sectional and longitudinal analyses. In line with prior research we found no consistent evidence that health is influenced by the degree to which a person's income or wealth differs from the mean of their reference group (Subramanian & Kawachi, 2006). Furthermore, entering the mean reference income/wealth level into the analyses did little to attenuate the association between absolute income/wealth and health. Nevertheless, to account for possible influences of relative income/wealth effects we included the average income/wealth of an individual's reference group income/wealth in all regression models.

Rank Income/Wealth and Health

To test our second and third predictions, we regressed each health variable on the person's rank within the comparison group, their absolute income/wealth, and the mean income/wealth of those in the relevant comparison group. The cross-sectional analyses of BHPS and ELSA data revealed that lower ranked individuals had poor health at baseline regardless of their absolute- or relative-income/wealth, as summarized for education and gender comparison groups in Table 3 and all comparison groups in SI Appendix Tables S1 through S10. In the cross-sectional analyses of the ELSA data low rank was a strong predictor of allostatic load and obesity at baseline, over and above absolute or relative wealth. In ELSA low-ranked participants also reported a high incidence of chronic illness, as well as enduring functional limitations and feelings of body pain, and poor general health at baseline. Similarly, in the BHPS low-ranked individuals felt their health was poor, and indicated that they suffered bodily pain and limitations to their physical functioning and normal role activities. Our cross-sectional analyses also revealed strong support for our third prediction. When the health outcomes were regressed on absolute and rank income/wealth variables, only the effect of a person's rank within their reference group remained as a statistically significant predictor, as shown in Table 3.

By adjusting for the initial levels of each health variable at baseline, our longitudinal analyses demonstrated that the ranked position of a person's income or wealth was closely linked to subsequent changes in health. Over the 4 year period examined in the ELSA study low ranked individuals went on to develop more chronic illnesses, increased allostatic load and obesity, raised feeling of pain, and worsening perceptions of health and functional limitations. Similarly, low ranked participants in the BHPS showed a decline in physical functioning and an increase in pain and role limitations resulting from poor health. The longitudinal analyses verified that the change in health over time linked to absolute levels of income/wealth (detailed in Table

Table 1
Summary of Characteristics of the BHPS and ELSA Samples Utilized for Cross-Sectional Analyses

	BHPS sample				ELSA sample		
	N/Obs.	M/%	*SD*		*N*	M/%	*SD*
Age	31,644/218,584	45.19	18.64	Age	8,762	65.99	10.74
Female (%)	31,644/218,589	53.76		Female (%)	8,762	56.04	
Education[a]	31,644/211,346	1.14	1.01	Education[b]	8,762	4.61	2.25
Self-rated health[c]	31,644/218,589	2.21	0.97	Self-rated health[d]	8,638	2.78	1.11
General health[e]	20,112/29,692	69.41	22.34	Long-standing illness (%)	8,756	55.56	
Limitations because of physical health[e]	20,169/29,811	82.81	34.16	Long-standing illness is limiting (%)	4,864	61.37	
Pain[e]	20,180/29,843	79.85	26.25	Pain[f]	8,754	0.69	1.00
Physical functioning[e]	20,301/30,009	85.65	24.41	Allostatic load[g]	3,487	2.00	1.54
				Obesity[h] (%)	6,762	28.18	

[a] BHPS: ranging from 0 = *no qualifications*, to 3 = *degree level qualifications or above*. [b] ELSA: ranging from 0 = *no qualification*, to 7 = *degree level qualification or above*. [c] BHPS: from 1 = *excellent health*, to 5 = *very poor health*. [d] ELSA: from 1 = *excellent health*, to 5 = *poor health*. [e] Assessed using the SF-36 (23). [f] ELSA: ranging from 0 = *not often troubled with pain*, to 3 = *often troubled with severe pain*. [g] 0 = *does not fall in any biomarker high risk quartile*, to 9 = *falls in all high risk quartiles examined*. [h] BMI of 30 kg/m^2 or above.

Table 2

Summary of Cross-Sectional and Longitudinal Regressions Demonstrating the Relationship Between Absolute Income (BHPS) and Wealth Levels (ELSA) and Health Measures

	Cross-sectional analyses			Longitudinal analyses		
	N/Obs.	b	*SE*	*N*/Obs.	b	*SE*
BHPS outcome variables						
Self-rated health[a]	31,644/218,589	−0.05**	0.00	25,505/181,830	−0.04**	0.00
General health[b]	20,112/29,692	2.15**	0.18	9,707	0.95**	0.27
Physical functioning[b]	20,301/30,009	1.21**	0.15	9,762	0.69**	0.24
Limitations because of physical health[b]	20,169/29,811	1.86**	0.29	9,677	2.26**	0.48
Pain[b]	20,180/29,843	1.74**	0.22	9,693	1.55**	0.35
ELSA outcome variables						
Self-rated health[a]	8,638	−0.19**	0.02	6,036	−0.08**	0.02
Long-standing illness[a]	8,756	−0.22**	0.03	6,244	−0.16**	0.05
Long-standing illness is limiting[a]	4,864	−0.24**	0.05	3,383	−0.18**	0.06
Pain[a]	8,753	−0.13**	0.01	6,240	−0.04*	0.02
Allostatic load[a]	3,487	−0.32**	0.04	2,185	−0.08	0.04
Obesity[a]	6,762	−0.26**	0.04	4,463	−0.02	0.08

Note. All regressions included demographic controls: age, gender, education, marital status, disability status, and labor force status, and average income/wealth of an individual's reference group. BHPS regressions contain additional dummy variables identifying both region and wave.
[a] High scores on this variable indicate worse health. [b] High scores on this variable indicate better health.
* $p < .05$. ** $p < .01$.

2), was removed in all cases when the person's relative rank was considered (shown in Table 4). We found little evidence that the choice of reference group (e.g., gender and education, age, and geographic region) affected the link between low rank and unfavorable health outcomes, as can be seen in SI Appendix Tables S1 through S22.

Discussion

In line with our predictions our findings point primarily to psychosocial rather than material explanations of why financial resources influence health. We suggested that low-rank exposes subordinate individuals to excessive demands originating in the social environment. To test this idea we transformed absolute income and wealth data to identify where each person ranks within a social reference group. We found that low ranked individuals appeared to experience a pronounced cumulative physiological "cost" of their rank that we observed as allostatic load or elevated levels of physiological activity across multiple regulatory systems (e.g., cardiovascular, metabolic, respiratory, and inflammatory). Crucially, the effect of a person's rank within their reference group dominated all analyses, eliminating the established link between absolute income/wealth and health.

Our findings suggest that for subordinate individuals, the stress of low rank may progressively impair the capacity of multiple physiological systems to dynamically adjust to environmental

Table 3

Summary of Cross-Sectional Regressions Simultaneously Examining the Association Between Health Measures and Both Absolute Income/Wealth and Ranked Position of Income/Wealth

	Absolute income/wealth			Rank income/wealth[a]		
	N/Obs.	b	*SE*	*N*/Obs.	b	*SE*
BHPS outcome variables						
Self-rated health[b]	31,644/218,589	0.00	0.01	31,644/218,589	−0.15**	0.01
General health[c]	20,112/29,692	−0.32	0.34	20,112/29,692	6.69**	0.80
Physical functioning[c]	20,301/30,009	−0.50	0.30	20,301/30,009	4.58**	0.71
Limitations because of physical health[c]	20,169/29,811	−1.13	0.58	20,169/29,811	7.85**	1.34
Pain[c]	20,180/29,843	−0.87*	0.44	20,180/29,843	6.93**	1.01
ELSA outcome variables						
Self-rated health[b]	8,638	−0.02	0.02	8,638	−0.55**	0.06
Long-standing illness[b]	8,756	0.05	0.05	8,756	−0.86**	0.14
Long-standing illness is limiting[b]	4,864	−0.07	0.07	4,864	−0.54**	0.19
Pain[b]	8,754	−0.03	0.02	8,754	−0.34**	0.06
Allostatic load[b]	3,487	−0.09	0.07	3,487	−0.66**	0.15
Obesity[b]	6,762	−0.00	0.06	6,762	−0.86**	0.17

Note. All regressions included demographic controls: age, gender, education, marital status, disability status, and labor force status, and average income/wealth of an individual's reference group. BHPS regressions contain additional dummy variables identifying both region and wave.
[a] Income/wealth levels are ranked by education and gender groups. Additional analyses using age (BHPS, ELSA) and geographic area (BHPS) reference groups are detailed in Tables S1–S22. [b] High scores on this variable indicate worse health. [c] High scores on this variable indicate better health.
* $p < .05$. ** $p < .01$.

Table 4
Summary of Longitudinal Regressions Simultaneously Predicting Health Measures From Absolute Income/Wealth and Ranked Position of Income/Wealth

	Absolute income/wealth			Rank income/wealth[a]		
	N/Obs.	b	*SE*	*N*/Obs.	b	*SE*
BHPS outcome variables						
Self-rated health[b]	25,505/181,830	−0.00	0.01	25,505/181,830	−0.11**	0.02
General health[c]	9,707	0.11	0.55	9,707	2.33	1.32
Physical functioning[c]	9,762	−0.23	0.49	9,762	2.52*	1.16
Limitations because of physical health[c]	9,677	−0.11	0.98	9,677	6.48**	2.33
Pain[c]	9,693	−0.30	0.70	9,693	5.07**	1.67
ELSA outcome variables						
Self-rated health[b]	6,036	−0.02	0.06	6,036	−0.20**	0.06
Long-standing illness[b]	6,244	−0.00	0.07	6,244	−0.45*	0.18
Long-standing illness is limiting[b]	3,383	0.02	0.09	3,383	−0.68**	0.24
Pain[b]	6,240	0.02	0.03	6,240	−0.18**	0.07
Allostatic load[b]	2,185	0.13	0.07	2,185	−0.59**	0.16
Obesity[b]	4,463	0.25	0.13	4,463	−0.84**	0.31

Note. All regressions included demographic controls: age, gender, education, marital status, disability status, and labor force status, and average income/wealth of an individual's reference group. BHPS regressions contain additional dummy variables identifying both region and wave.
[a] Income/wealth levels are ranked by education and gender groups. Additional analyses using age (BHPS, ELSA) and geographic area (BHPS) reference groups are detailed in Tables S1–S22. [b] High scores on this variable indicate worse health. [c] High scores on this variable indicate better health.
* $p < .05$. ** $p < .01$.

pressures resulting in a failure to maintain healthy functioning (Seeman, Epel, Gruenewald, Karlamangla, & McEwen, 2010). In support of this notion we observed the emergence of chronic illness, bodily pain, functional limitations, perceptions of poor general health and a high risk of obesity among those of a low relative rank. When examined simultaneously the ranked position of an individual's income or wealth within a comparison group consistently predicted both the initial existence of health problems and the emergence of a host of health problems over time, whereas absolute income or wealth had no effect.

These results provide important insight into the long-debated question as to how money induces health effects. Our findings suggest that the biological effects of social subordination may explain how differences in income and wealth lead to graded patterns of disease and mortality. From a social rank perspective the well-established diminishing health benefits of money with increasing income could be attributed to the positively skewed shape of income distribution in industrial nations (Kunst et al., 2005). This means that more money is needed to improve one's rank at high levels of income, potentially leading to the curvilinear relationship between absolute income and health (Kunst et al., 2005; Wood et al., 2012). Our results also point to potential explanations for within and between country comparisons of the health effects of money that have been long-observed in medicine and epidemiology.

For instance, within advanced nations absolute income and health are typically found to be closely related at the individual level. However, at the between country-level, average national income and health are often weakly related (Wilkinson, 1992). From a social rank perspective, earnings and wealth act as a proxy for the rank a person holds in society and the number of high and low ranked people within a given society is fixed. Therefore, if the average income differs between two countries this alone is unlikely to affect a person's social rank and this may explain why few health effects are observed. However, it is possible that income or wealth may be a more salient marker of social rank in certain societies. For instance, in unequal societies, income and signals of income could be more readily apparent and better markers of social rank than in more equal societies. It follows that a person's income/wealth rank may cause greater stress at each level of the social hierarchy in an unequal society. This may explain why the citizens of less equal countries have worse health than those from more equitable nations, even after adjusting for how much people earn on average in each country (Wilkinson & Pickett, 2006).

The present study informs each of these potential applications by clearly demonstrating that a person's relative rank of monetary or propriety resources robustly predicts health and changes in health. Our study was strengthened by our examination of a broad set of health outcomes and potential reference groups across two longitudinal national data sets. However, several limitations remain. We relied on a nonrandomized cohort study design making it difficult to infer causality. For instance, the cross-sectional associations observed between income/wealth rank and health could be partially attributable to reverse causality. It is possible that health "shocks" could adversely affect income or wealth through reduced earnings and medical expenses diminishing ones income/wealth rank within a relevant comparison group (Smith, 1999).

We account for direction of causality, at least in part, by demonstrating that income/wealth rank predicts changes in health over time. However, the rank—health association could be a result of other underlying factors that simultaneously improve a person's social rank and health. For example, intelligence and desirable personality traits such as self-control and emotional stability have been shown to enhance both social status and health (Deary, Batty, Pattie, & Gale, 2008; Deary et al., 2005; Moffitt et al., 2011). In addition, the present study is limited in that we did not assess verified diagnoses of specific health conditions or mortality. We examined how rank affected a range of health outcomes including obesity and allostatic load that were objectively assessed. However, these variables could be viewed as intermediate indicators that are predictive of poor health but are a step removed from direct measures of disease. Future work should test whether low rank contributes to specific illnesses or leads to an elevated risk of mortality in humans.

Our measure of social rank was objective in that it gauged the precise rank of each person's income or wealth within defined groups such as age-bands, education levels, and geographic regions. This approach has some benefits over assessing subjective perceptions of social rank. It avoids problems associated with self-report such as common-method variance which could lead to spurious relationships with self-reported health outcome measures (Wood et al., 2012). However, directly assessing perceptions of social rank within the reference categories examined would have provided a possible subjective verification of the results of the study. Future research should systematically identify how objective rank and perceptions of rank are interrelated and contribute to health in a full panel design.

The present work has outlined the relevance of hierarchical rank to health. It has shown that the role of social rank extends beyond that of relative-income/wealth. Furthermore, the impact of rank does not seem to be contingent on the reference group examined or the sample utilized. Crucially, hierarchical rank dominates and overrides the frequently observed effect of absolute-income/wealth on health. This is the first study to use a powerful empirical test to distinguish the material and psychosocial health effects of financial resources. By empirically disentangling the contribution of these two competing explanations this research uncovers strong support for a social rank model of how money influences health.

References

Antonovsky, A. (1967). Social class, life expectancy and overall mortality. *Milbank Memorial Fund Quarterly, 45,* 31–73. doi:10.2307/3348839

Archie, E. A., Altmann, J., & Alberts, S. C. (2012). Social status predicts wound healing in wild baboons. *Proceedings of the National Academy of Sciences of the United States, 109,* 9017–9022. doi:10.1073/pnas.1206391109

Boyce, C. J., Brown, G. D. A., & Moore, S. (2010). Money and happiness: Rank of income, not income, affects life satisfaction. *Psychological Sciences, 21,* 471–475. doi:10.1177/0956797610362671

Brazier, J. E., Harper, R., Jones, N. M., O'Cathain, A., Thomas, K. J., & Westlake, L. (1992). Validating the SF-36 health survey questionnaire: New outcome measure for primary care. *British Medical Journal, 305,* 160–164. doi:10.1136/bmj.305.6846.160

British Household Panel Survey. (2010). *British Household Panel Survey user manual volume A: Introduction, technical report and appendices*. Colchester, University of Essex, United Kingdom.

Brown, G. D. A., Gardner, J., Oswald, A. J., & Qian, J. (2008). Does wage rank affect employees' well-being? *Industrial Relations, 47,* 355–389. doi:10.1111/j.1468-232X.2008.00525.x

Contoyannis, P., Jones, A. M., & Rice, N. (2004). The dynamics of health in the British household panel survey. *Journal of Applied Econometrics, 19,* 473–503. doi:10.1002/jae.755

Deary, I. J., Batty, D., Pattie, A., & Gale, C. (2008). More intelligent, more dependable children live longer: A 55-year longitudinal study of a representative sample of the Scottish Nation. *Psychological Science, 19,* 874–880. doi:10.1111/j.1467-9280.2008.02171.x

Deary, I. J., Taylor, M. D., Hart, C. L., Wilson, V., Davey Smith, G., Blane, D., & Starr, J. M. (2005). Intergenerational social mobility and mid-life status attainment: Influences of childhood intelligence, childhood social factors, and education. *Intelligence, 33,* 455–472. doi:10.1016/j.intell.2005.06.003

Demakakos, P., Nazroo, J., Breeze, E., & Marmot, M. (2008). Socioeconomic status and health: The role of subjective social status. *Social Science & Medicine, 67,* 330–340. doi:10.1016/j.socscimed.2008.03.038

Elgar, F. J., De Clercq, B., Schnohr, C. W., Bird, P., Pickett, K. E., . . . Currie, C. (2013). Absolute and relative family affluence and psychosomatic symptoms in adolescents. *Social Science & Medicine, 91,* 25–31. doi:10.1016/j.socscimed.2013.04.030

Gilbert, P. (2006). Evolution and depression: Issues and implications. *Psychological Medicine, 36,* 287–297. doi:10.1017/S0033291705006112

Graig, R., Deverill, C., & Pickering, K. (2006). Quality control of blood, saliva and urine analytes. In K. Spronston & J. Mindell (Eds.), *Health survey for England 2004, methodology and documentation, vol. 2* (pp. 34–41). London: The Information Centre.

Gravelle, H., & Sutton, M. (2009). Income, relative income, and self-reported health in Britain 1970–2000. *Health Economics, 18,* 125–145. doi:10.1002/hec.1354

Jarvis, S. S., & Jenkins, S. P. (1995). *Do the poor stay poor? New evidence about income dynamics from the British Household Panel Survey*. Occasional Paper No. 95–2, ESRC Research Centre on Micro-Social Change, University of Essex, Colchester.

Kawachi, I., Adler, N. E., & Dow, W. H. (2010). Money, schooling, and health: Mechanisms and causal evidence. *Annals of the New York Academy of Sciences, 1186,* 56–68. doi:10.1111/j.1749-6632.2009.05340.x

Kunst, A. E., Bos, V., Lahelma, E., Bartley, M., Lissau, I., Regidor, E., . . . Mackenbach, J. (2005). Trends in socioeconomic inequalities in self-assessed health in 10 European countries. *International Journal of Epidemiology, 34,* 295–305. doi:10.1093/ije/dyh342

Lorgelly, P. K., & Lindley, J. (2008). What is the relationship between income inequality and health? Evidence from the BHPS. *Health Economics, 17,* 249–265. doi:10.1002/hec.1254

Luke, D. A. (2004). *Multilevel modeling*. Thousand Oaks, CA: Sage.

Marmot, M. G., Bosma, H., Hemingway, H., Brunner, E., & Stansfeld, S. (1997). Contribution of job control and other risk factors to social variations in coronary heart disease incidence. *The Lancet, 350,* 235–239. doi:10.1016/S0140-6736(97)04244-X

Marmot, M. G., Smith, G. D., Stansfeld, S., Patel, C., North, F., Brunner, E., . . . Davey Smith, G. (1991). Health inequalities among British civil servants: The Whitehall II study. *The Lancet, 337,* 1387–1393. doi:10.1016/0140-6736(91)93068-K

Marmot, M., & Wilkinson, R. G. (2001). Psychosocial and material pathways in the relation between income and health: A response to Lynch et al. *British Medical Journal, 322,* 1233–1236. doi:10.1136/bmj.322.7296.1233

Mendelson, T., Thurston, R. C., & Kubzansky, L. D. (2008). Affective and cardiovascular effects of experimentally-induced social status. *Health Psychology, 27,* 482–489. doi:10.1037/0278-6133.27.4.482

Miller, D. L., & Paxson, C. (2006). Relative income, race, and mortality. *Journal of Health Economics, 25,* 979–1003. doi:10.1016/j.jhealeco.2006.02.003

Moffitt, T., Arseneault, L., Belsky, D., Dickson, N., Hancox, R., Harrington, H. L., . . . Caspi, A. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences of the United States, 107,* 2693–2698.

Rablen, M. D., & Oswald, A. J. (2008). Mortality and immortality: The Nobel Prize as an experiment into the effect of status upon longevity. *Journal of Health Economics, 27,* 1462–1471. doi:10.1016/j.jhealeco.2008.06.001

Read, S., & Grundy, E. (2012). *Introduction to biomarkers: Allostatic load measures in the English Longitudinal Study of Ageing (ELSA)*. Retrieved from http://eprints.ncrm.ac.uk/2310/

Sapolsky, R. M. (2005). The influence of social hierarchy on primate health. *Science, 308,* 648–652. doi:10.1126/science.1106477

Seeman, T., Epel, E., Gruenewald, T., Karlamangla, A., & McEwen, B. S. (2010). Socio-economic differentials in peripheral biology: Cumulative allostatic load. *Annals of the New York Academy of Sciences, 1186,* 223–239. doi:10.1111/j.1749-6632.2009.05341.x

Shively, C. A. (1998). Social subordination stress, behaviour, and central monoaminergic function in female cynomolgus monkeys. *Biological Psychiatry, 44,* 882–891. doi:10.1016/S0006-3223(97)00437-X

Shively, C. A., Laber-Laird, K., & Anton, R. F. (1997). Behavior and physiology of social stress and depression in female cynomolgus monkeys. *Biological Psychiatry, 41,* 871–882. doi:10.1016/S0006-3223(96)00185-0

Singer, E. (1981). Reference groups and social evaluation. In M. Rosenberg & R. H. Turner (Eds.), *Social psychology: Sociological perspectives* (pp. 66–93). New York, NY: Basic Books.

Singh-Manoux, A., Marmot, M. G., & Adler, N. E. (2005). Does subjective social status predict health and change in health status better than objective status? *Psychosomatic Medicine, 67,* 855–861. doi:10.1097/01.psy.0000188434.52941.a0

Slavich, G. M., & Irwin, M. R. (2014). From stress to inflammation and major depressive disorder: A social signal transduction theory of depression. *Psychological Bulletin,* doi:10.1037/a0035302

Smith, J. P. (1999). Healthy bodies and thick wallets: the dual relation between health and economic status. *Journal of Economic Perspectives, 13,* 145–1466.

Subramanian, S. V., & Kawachi, I. (2006). Being well and doing well: On the importance of income for health. *International Journal of Social Welfare, 15,* S13–S22. doi:10.1111/j.1468-2397.2006.00440.x

Tung, J., Barreiro, L. B., Johnson, Z. P., Hansen, K. D., Michopouloset, V., Toufexis, D., . . . Gilad, Y. (2012). Social environment is associated with gene regulatory variation in the rhesus macaque immune system. *Proceedings of the National Academy of Sciences of the United States, 109,* 6490–6495.

Wagstaff, A., & van Doorslaer, E. (2000). Income inequality and health: What does the literature tell us? *Annual Review of Public Health, 21,* 543–567. doi:10.1146/annurev.publhealth.21.1.543

Ware, J. E., Kosinski, M., & Keller, S. D. (1994). *SF36: Physical and Mental Summary Scales: A user's manual*. Boston, MA: The Health Institute, New England Medical Center.

Ware, J. E., & Sherbourne, C. D. (1992). The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Medical Care, 30,* 473–483. doi:10.1097/00005650-199206000-00002

Wilkinson, R. G. (1992). Income distribution and life expectancy. *British Medical Journal, 304,* 165–168. doi:10.1136/bmj.304.6820.165

Wilkinson, R. G., & Pickett, K. E. (2006). Income inequality and population health: A review and explanation of the evidence. *Social Science & Medicine, 62,* 1768–1784. doi:10.1016/j.socscimed.2005.08.036

Wood, A. M., Boyce, C. J., Moore, S. C., & Brown, G. D. A. (2012). An evolutionary based social rank explanation of why low income predicts mental distress: A 17 year cohort study of 30,000 people. *Journal of Affective Disorders, 136,* 882–888. doi:10.1016/j.jad.2011.09.014

Received December 9, 2013
Revision received March 14, 2014
Accepted March 18, 2014 ■