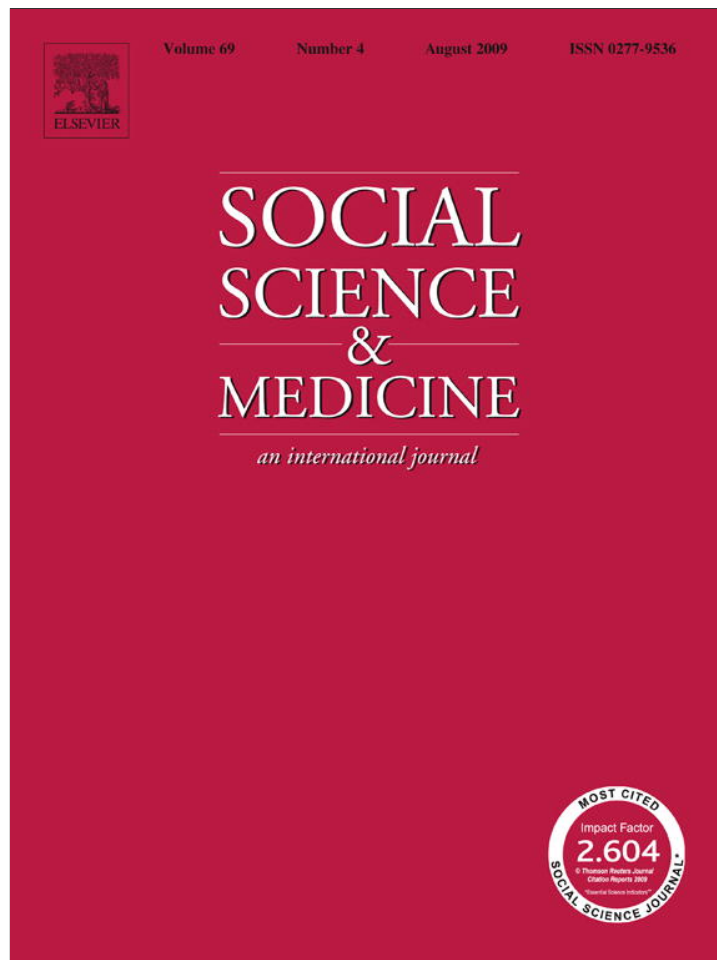


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Inequality in social rank and adult nutritional status: Evidence from a small-scale society in the Bolivian Amazon[☆]

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ABSTRACT

Research on the social determinants of health has highlighted (a) the adverse effects of social inequality on individual health and (b) the association between individual social rank and health. In this paper, we contribute to the growing literature on the health consequences of social inequalities by assessing the association between village level inequality in social rank, a form of non-material inequality, and indicators of nutritional status. We use quantitative survey information from 289 men (18+ years of age) from a society of forager-farmers in the Bolivian Amazon (Tsimane'). We construct village level measures of non-material inequality by using individual measures of men's positions in the village hierarchy according to prestige (or freely conferred deference) and dominance (or social rank obtained through power). We find that village inequality in dominance, but not village inequality in prestige, is associated with short-term indices of individual nutritional status. Doubling the coefficient of variation of dominance in a village would be associated to a 6.7% lower BMI, a 7.9% smaller mid-arm circumference, and a 27.1% smaller sum of four skin folds of men in the village. We also find that once we decouple individual social rank based on dominance from individual social rank based on prestige, only prestige-based social rank is associated with nutritional status. Potential explanations for our findings relate to the differential forms of resource access derived from the two forms of social hierarchies and to the social and psychological benefits associated with prestige versus the social costs and psychological stress generated by dominance.

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Introduction

Using data from industrial nations, researchers have recently provided quantitative evidence of the effects of two social processes on individual health. First, a growing body of research has documented the adverse effects of income inequality on individual health (Kawachi, 2002; Wilkinson, 1996; Wilkinson, 2000), suggesting that the concentration of income might affect health through the breakdown of social cohesion (Kawachi, 2002) and the creation of psychological stress (Wilkinson, 1997). Non-material social inequalities, such as discrimination based on race or gender,

might also affect individual health (Krieger, 1993) (but see also Lynch (2004) for reactions to this work). Second, researchers have also found an association between social rank, or position in dominance hierarchies, and individual health: each step down the socioeconomic ladder is associated with increased morbidity and mortality (Adler, Boyce, Chesney, Folkman, & Syme, 1993; Marmot, 2004; Marmot, Ryff, Bumpass, Shipley, & Marks, 1997).

The scarce research on the effects of income inequality and social rank on individual health in small-scale societies supports the second, but not the first of the findings from industrial nations. In our prior research among the Tsimane', a native Amazonian population of forager-farmers, we found that income inequality within the village is not associated with individual measures of nutritional status (Godoy, Byron et al., 2005), such as indicators of caloric and nutrient reserves. But we found supporting evidence for the social gradient in health among the same indigenous population. Using a measure of social rank that captures the locally

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perceived position of an individual in the village hierarchy and controlling for personal income and other correlates, we found a positive association between individual social rank and measures of nutritional status. A higher ranking in the hierarchy was associated with a greater BMI, larger mid-arm circumference, and a greater sum of the four skin fold measurements (Reyes-García, McDade et al., 2008). Our second finding echoes those of previous descriptive research on small-scale societies: high social status typically leads to higher total fertility and survivorship due to preferential access to resources during times of need (Boone, 1998; Patton, 2005; Sugiyama & Chacon, 2000; Wiessner, 2002).

In this paper, we contribute to the growing literature on the social processes that may affect individual health by addressing both findings. Specifically, we ask: does village level inequality in social rank, a form of non-material inequality, have adverse effects on nutritional status in small-scale societies? Researchers have argued that socio-economic status is a good proxy for social rank among humans (Sapolsky, 2004). Here we suggest that inequality in socioeconomic status measured through income inequality does not adequately capture social hierarchies in small-scale societies. Research shows that social hierarchies are common to all human societies, though not necessarily based on income (Boehm, 1999a; Sahlins, 1958; Wiessner, 1996). For example, researchers have found that social rank in forager societies is linked to physical dominance (Chagnon, 1988; Patton, 2000), hunting ability (Gurven & von Rueden, 2006; Kaplan & Hill, 1985), generosity (Patton, 2005; Stearman, 1989), ability to relate with outsiders (Reyes-García, Molina et al., 2008), or a combination of those traits (von Rueden, Gurven, & Kaplan, 2008). Thus, differentiating between income inequality and other forms of non-material inequality, such as inequality in social rank, might shed light on the effects of social inequality on individual health.

In this article, we estimate the association between village inequality in social rank and individual anthropometric indices of short-run nutritional status among Tsimane' male adults. We follow Henrich and Gil-White (2001) and differentiate between social rank obtained through power (hereafter dominance) and social rank obtained through freely conferred deference (hereafter prestige). For the empirical analysis we use cross-sectional data from the Tsimane', a foraging-farming society in the Bolivian Amazon. Based on research that highlights the adverse effects of inequality on health, we expect to find a negative association between village inequality in social rank, especially when measured through dominance, and individual anthropometric indices of short-run nutritional status.

Methods

Data for this article come from a study (2002-present) of the Tsimane'. The Institutional Review Board for research with human subjects of Northwestern University and Brandeis University and the Great Tsimane' Council approved the study. Before enrolment in the study, we obtained assent from participants. These data were collected by experienced interviewers and translators who had been a part of the panel study from its beginning. Previous publications provide ethnographic information about the Tsimane' (Daillant, 2003; Huanca, 2008). In several articles, we have also described in detail methods used to collect data on anthropometric measures (Godoy, Byron et al., 2005), income (Godoy et al., 2006), and social rank (Reyes-García, McDade et al., 2008; Reyes-García, Molina et al., 2008). Here we provide a brief description of those methods.

The people

The Tsimane' are one of the largest native Amazonian groups in Bolivia, with about 8000 people in approximately 100 villages settled

along river banks and logging roads (Censo Indígena, 2001). For their subsistence, Tsimane' rely on slash-and-burn farming supplemented by hunting, gathering, and wage labor in logging camps, cattle ranches, and in the homesteads of highland colonist farmers.

In previous research, we have found that individual-level variables, such as schooling (Brabec, Godoy, Reyes-García, & Leonard 2007; Reyes-García, Vadez et al., 2008), wealth (Godoy, Reyes-García et al., 2005), and social rank (Reyes-García, McDade et al., 2008) are associated in a positive and statistically significant way with adult nutritional status. We have also found that village level variables, such as income inequality and social capital, are not associated with individual nutritional status when considered alone (Godoy, Byron et al., 2005; Godoy, Reyes-García et al., 2005), although social capital and income inequality complement each other in their association with BMI: the rich who refrain from sharing their wealth have lower BMI than the rich who display generosity (Brabec et al., 2007).

Sample

We collected data through a survey that took place from June through September 2005 among nearly all the households ($n = 252$) in 13 Tsimane' villages straddling the Maniqui river. Villages were at different distances from San Borja, the closest market town (population about 19,000). We asked every person over 16 years of age, or younger if s/he headed a household, ($n = 611$) to name all the important people in the village and state why they were important. We selected 16 years of age as the base because this is the age at which Tsimane' establish their own households and are considered adults. Participants include 304 women and 307 men. We found that participants were more likely to name men as important people than women. Eighty-six men, or 28% of the male sample, were nominated at least once, whereas only six women, or 2% of the female sample, received at least one nomination. We also found that men on average received more nominations than women; the average man received 2.7 nominations ($SD = 7.80$), and an average woman received 0.04 nominations ($SD = 0.34$). Because women received so few nominations, we limit the analysis to men. The total sample with complete information for multivariate analysis includes 302 adult men.

Dependent variable: anthropometric indices of short-run nutritional status

To enhance comparability with previous work and strengthen robustness in results, we use three anthropometric indices of short-run nutritional status as outcome: (a) body-mass index ($BMI: kg/m^2$), (b) mid-arm circumference (cm), and (c) the sum of four skin folds biceps, triceps, sub-scapular, and supra-iliac (mm). The three indices reflect different dimensions of short-run nutritional status (Gibson, 1990). BMI is a measure of body composition and the most widely used measure of nutritional status among adults (National Institutes of Health, 1998; Shetty & James, 1994). Mid-arm circumference provides an index of both protein and energy status (Frisancho, 1990). The skin fold measures are sensitive to short-term change in subcutaneous fat stores and are thus good measures of energy reserves (Frisancho, 1990).

To collect the information on short-run nutritional status we trained surveyors to measure physical stature, weight, mid-arm circumference, and skin fold thickness following the protocol of Lohman, Roche, and Martorell (1988). We measured subjects in light clothing without shoes or hats. We measured body weight to the nearest 0.20 kg using a Tanita Digital standing scale. We recorded stature (standing height) to the nearest millimetre using a portable stadiometer or a plastic tape measure. BMI was

calculated as weight in kg/height in m². Mid-arm circumference was measured to the nearest millimetre using plastic tape measures. Skin fold thickness was measured to the nearest 0.5-mm using Lange callipers.

Explanatory variables: Village level inequality in social rank

To measure village inequality in social rank, we first constructed individual measures of social rank by calculating the number of nominations received by each man on the lists of important people in the village (Costenbader & Valente, 2003; Valente, 1995). We coded responses to the open-ended question about the informants' reason for the nomination into three categories: (1) nominations given because of the person's role as past or present village authority (e.g., village representative, school teacher, religious leader), (2) nominations given because of personal attributes of the nominee (e.g., elder, knowledgeable, good character), and (3) nominations given because of other reasons (e.g., family member). The first two types of nominations act as proxies for two different types of social rank: nominations given because of the person's role as village authority might refer to a man's social rank obtained through power (dominance), whereas nominations given because of personal attributes might refer to a man's social rank obtained through freely conferred deference (prestige) (Henrich & Gil-White, 2001). Most nominations (72%) related to the person's dominance, and only 12.5% of the nominations related to the person's prestige. We used the number of nominations received by an individual to construct three individual-level variables. Social rank captures the total number of nominations received by a person; dominance captures nominations received because of the man's role as village authority, and prestige captures nominations received because of the man's personal attributes.

Based on individual measures of social rank, we then constructed a set of variables that act as proxies for village inequality in social rank. We calculated the village coefficient of variation (CV), or the ratio of the standard deviation to the mean multiplied by 100, of the

variables social rank, dominance, and prestige. The CV is a unitless measure useful to compare the dispersion between variables with markedly different means. For example, as we will see later, we found that the standard deviation of the variable dominance was 7.08, whereas the standard deviation of prestige was only 0.32 (Table 1). However, those numbers should be interpreted in relation to the mean, which was also higher for dominance (avg = 2.27) than for prestige (avg = 0.32). The CV allows one to compare the dispersion in variables taking into account differences in their mean. A higher CV indicates more dispersion, which in our case should be read as fewer individuals concentrating more nominations.

Control variables

Control variables in our regression analysis include covariates of nutritional status, such as age, schooling, daily income, self-perceived health, individual social rank, and household size. We also include village level variables that might affect both inequality in social rank and adult nutritional status, such as village-to-town distance. We provide the definition and summary statistics of the control variables in Table 1.

Estimation strategy

For the empirical analysis, we assess the association between (a) three individual indicators of nutritional status (BMI, mid-arm circumference, and sum of four skin folds) and (b) village inequality in social rank, while controlling for individual and village variables that have been shown to be associated with nutritional status. To ease the reading of the coefficients, we transformed the explanatory and outcome variables to logarithms. When outcome and explanatory variables are in logarithms, coefficients can be read as elasticities (%Δ outcome/1% Δ explanatory). For the estimation, we used ordinary-least square regressions with robust standard errors and clustering by village.

Table 1
Definition and summary statistics of variables used in regressions, men over 18 years of age ($n = 302$).

Variable	Definition	N	Mean	SD
I. Outcome variables (in regressions entered in natural logarithm)				
BMI	Body-mass index (kg/m ²)	302	23.45	2.28
Mid-arm circumference	Mid-arm circumference of subject (cm)	302	27.14	2.23
Sum of four skin folds	Sum of biceps, triceps, sub-scapular, supra-iliac skin fold thickness (mm)	302	36.12	12.73
II. Explanatory variable (in regressions entered in natural logarithm)				
CV-social rank	Village coefficient of variation of individual total nominations as important person	13	259	79
CV-dominance	Village coefficient of variation of individual nominations because of the person's role as village authority.	13	266	80
CV-prestige	Village coefficient of variation of individual nominations because of the person's attributes.	13	200	170
III. Control variables				
Individual level				
Age	Age of participant (years)	302	36.93	17.72
Schooling	Maximum school grade achieved by participant	302	2.75	2.88
Daily income	Average personal monetary income from (1) value of a basket of foods consumed during a day and (2) monetary income from sale, barter, and wage labor; in <i>bolivianos</i> (Bs) (1US \$ = 7.98 Bs)	302	31.31	23.40
Social rank	Total number of nominations received by the person as "important person in the village"	302	2.59	7.64
Dominance	Total number of nominations received by the person because his role as village authority.	302	2.27	7.08
Prestige	Total number of nominations received by the person because of his personal attributes.	302	0.32	1.08
Days in bed	Number of days spent in bed due to illness during the fourteen days before the day of the interview.	302	1.23	2.24
Household level				
Household size	Number of people in the household	228	6.39	2.87
Village level				
Mean status	Average number of nominations in a village	13	2.56	0.93
Mean dominance	Average number of nominations because a person's role as village authority	13	2.23	0.78
Mean prestige	Average number of nominations because of personal attributes	13	0.32	0.44
Walk access	Number of hours walking in the dry season from village to the town of San Borja or to the closest road	13	2.58	2.74

Caveats

Our estimations have at least two caveats. First, we might have systematic measurement error in our explanatory variable. Research suggests that there is bias in the recall of people in social positions higher than the informant: informants more often name people in higher social positions than themselves (Festinger, Schachter, & Back, 1950; Warner, 1963). Unfortunately, we do not have information that would enable us to detect systematic measurement bias in our variables. Second, our estimations might be biased by the role of omitted variables. We try to overcome this problem by including additional variables in our robustness tests, but we cannot rule out the possibility that there are other omitted variables not considered.

Results

Social inequality

Our data show evidence of social inequality among the Tsimane' villages in our sample. Nominations were concentrated in just over a quarter of the sample: 71.5% (or 216) of the men in our sample were not nominated as important people in the village, 74.8% (or 226) were not nominated because of their role as village authority, and 87.7% (or 265) were not nominated because of personal attributes. The average CV for social rank is 259 (SD = 79, min = 120, max = 409), suggesting considerable variation around mean measures of village inequality in social rank. We find higher variation in the CV of dominance than in the CV of prestige. The average CV for prestige is 199 (SD = 169, min = 0, max = 500), whereas the average CV for dominance is 266 (SD = 80, min = 113, max = 411), suggesting that Tsimane' society contains important social inequalities related to dominance, whereas prestige is more evenly spread.

Nutritional status

Tsimane' adult men fall in the normal range of body-mass index. The average participant had a BMI of 23.45 (SD = 2.26) (Table 1). Of the adult men, 79% fell in the normal or healthy range of BMI (18.5–24.9) (Shetty & James, 1994). Among those who received at least one nomination, 68% fell in the healthy or normal range and 30.2% fell in the overweight range (25–30). Among those who did not receive a nomination, 84.2% fell in the healthy range and only 14% fell in the overweight range. In sum, Tsimane' men who were nominated generally fell in the upper end of the BMI distribution, with more overweight men among those with higher social rank.

We examined the association among the three indicators of nutritional status and found a positive and statistically significant correlation ($r = 0.74$, $p < 0.0001$ for BMI and mid-arm circumference; $r = 0.70$, $p < 0.0001$ for BMI and sum of four skin fold). Given the BMI values and the correlations found, we assume that higher levels of BMI, mid-arm circumference, and sum of four skin fold indicate better short-run nutritional status.

Regression results

Table 2 contains the regression results. Four findings merit discussion. First, the CV of social rank in a village showed a statistically significant and negative association with the three individual anthropometric indices of short-run nutritional status (Table 2, columns [1], [3], and [5]). The higher the CV of social rank in a village, the lower the BMI, mid-arm circumference, and sum of skin folds of men in the village. Doubling the CV of social rank in

a village, i.e., doubling the dispersion in nominations based on social rank, would be associated to a 6% lower BMI, a 7% smaller mid-arm circumference, and a 28% lower sum of four skin folds of men in the village. For the three regressions, the association was significant at the 95% confidence interval.

Second, when using the two variables that decouple dominance and prestige as explanatory variables, we find that only the CV of dominance is associated in a significant way with the outcomes (Table 2, columns [2], [4], [6]). As in estimations using the CV of social rank, the associations between the CV of dominance and indicators of nutritional status are negative and significant at the 95% confidence level. The coefficients of the regressions with BMI and mid-arm circumference are higher when using the CV of dominance as the explanatory variable than when using the CV of social rank, whereas the coefficient of the regressions with the sum of four skin folds is higher when using the CV of social rank as the explanatory variable than when using the decoupled measures. For example, we found that doubling the CV of dominance in a village would be associated to a 6.7% lower BMI (versus 6.3% for the regression with the CV of social rank); a 7.9% smaller mid-arm circumference (versus 7.1%), and a lower 27.1% sum of four skin folds of men in the village (versus 28%). The CV of prestige is not associated in a statistically significant way with any of the three indicators of nutritional status analyzed.

Third, results from our estimations suggest that once we control for the CV of social rank, individual social rank is not associated with BMI or the sum of four skin fold (columns [1], [5]), although it is associated with mid-arm circumference (column [3]). When including the CV of dominance and the CV of prestige as separate measures (columns [2], [4], [6]), we find that individual prestige is associated in a positive and statistically significant way with two of the three indices of nutritional status, whereas individual dominance is not.

Finally, in a test of joint significance to assess whether individual or village level variables, as a group, were associated with anthropometric indices of short-run nutritional status, we found that although most individual-level variables used in the analysis (age, schooling, daily income, social rank, and days in bed) did not show a strong and consistent association with anthropometric indices of short-run nutritional status, they had a jointly significant association with BMI and mid-arm circumference. Village level variables (walk access and mean social rank) were jointly significant for mid-arm circumference and the sum of four skin folds.

Robustness

We did further tests to ensure robustness in our results (Table 3). Regressions in Table 3 resemble regressions in Table 2 columns [2], [4], [6], except for the changes reported in the column named "Changes". Since results in Table 2 suggest that inequality in dominance matters more than inequality in prestige in explaining indices of short-run nutritional status, in Table 3 we only report the coefficient for the variable that measures inequality in village level dominance.

We start our robustness test by using a different measure of inequality, the Gini coefficient (Table 3, line [2]). From the different measures of dispersion, we use the Gini coefficient because it is a standard measure of dispersion that has been used in previous research on the effects of inequalities on health in small-scale societies (Godoy, Byron et al., 2005). The Gini coefficient ranges from 0 to 1, with lower numbers indicating a more even spread of the variable. As with the CV, we computed the village Gini coefficient of social rank, dominance, and prestige.

In subsequent tests, we added variables that research suggests (a) affect nutritional status but that were not included in our core

Table 2
Regression results of indicators of nutritional status against inequality in social rank for Tsimane' men in 2005 (≥ 16 years) ($n = 302$); see notes.

Explanatory variables:	Outcome variable. Natural logarithm of					
	BMI		Mid-arm circumference		Sum four skin fold	
	[1]	[2]	[3]	[4]	[5]	[6]
CV – social rank, log	–0.063** (0.024)	^	–0.071*** (0.019)	^	–0.280*** (0.074)	^
CV – dominance, log	^	–0.067** (0.023)	^	–0.079*** (0.015)	^	–0.271*** (0.082)
CV – prestige, log	^	0.001 (0.003)	^	0.0003 (0.001)	^	–0.003 (0.009)
Controls						
Individual-level variables						
Social rank	0.001 (0.0005)	^	0.001*** (0.0006)	^	0.002 (0.002)	^
Dominance	^	–0.0001 (0.0004)	^	0.0009 (0.0006)	^	0.001 (0.002)
Prestige	^	0.015*** (0.004)	^	0.012*** (0.003)	^	0.021 (0.020)
Age	0.0007** (0.0002)	0.0007** (0.0002)	–0.00002 (0.0002)	–0.00009 (0.0002)	0.0009 (0.001)	0.0008 (0.001)
Schooling	0.006* (0.003)	0.006* (0.003)	0.003 (0.001)	0.003 (0.002)	0.009 (0.006)	0.009 (0.006)
Daily income	0.0003* (0.0001)	0.0003* (0.0002)	0.0003* (0.0001)	0.0003* (0.0001)	0.0005 (0.0008)	0.0005 (0.0008)
Days in bed	0.001 (0.002)	0.001 (0.002)	0.0009 (0.002)	0.0005 (0.001)	–0.003 (0.008)	–0.004 (0.008)
Household level variables						
Household size	0.001 (0.002)	0.001 (0.002)	0.003* (0.001)	0.002 (0.001)	0.015** (0.006)	0.014** (0.006)
Village level variables						
Walk access	0.003 (0.002)	0.002 (0.002)	0.002 (0.001)	0.002 (0.001)	0.032*** (0.007)	0.031*** (0.007)
Mean social rank	–0.009 (0.010)	^	–0.009 (0.005)	^	–0.019 (0.022)	^
Mean dominance	^	–0.010 (0.010)	^	–0.004 (0.008)	^	–0.009 (0.027)
Mean prestige	^	–0.024* (0.014)	^	–0.026** (0.009)	^	–0.016 (0.056)
Constant	3.44*** (0.158)	3.46*** (0.157)	3.66*** (0.111)	3.71*** (0.106)	4.86*** (0.420)	4.82*** (0.463)
Joint test						
Individual level	3.95**	8.74***	3.24***	8.96***	1.09	1.03
Village level	2.34	2.39*	4.99***	6.07***	8.05***	4.96***
R ²	0.09	0.11	0.10	0.12	0.09	0.10

Notes: ordinary-least squares (OLS) regressions with robust standard errors and clustering by village when the Breusch-Pagan test for heteroskedasticity Prob > chi2 lower than 0.10. For definition of variables see Table 1. *, ** and *** significant at the 10%, 5%, and 1% level.

model (lines [3]–[6]) or (b) mediate the association between income inequality and nutritional status (lines [7] and [8]). In line [3], we added household wealth and the CV of income. In previous research on the area, we found that wealth is associated with the nutritional status of the Tsimane' (Godoy, Reyes-García et al., 2005),

so by including wealth in the model, we rule out the possibility that our measures of social rank affect nutritional status through their potential association with wealth. Similarly, we include the CV of income to separate the effects of material and non-material forms of inequality.

Table 3
Robustness analysis. Explanatory variable reported: logarithm of CV-dominance.

Changes	Outcome variable. Natural logarithm of:		
	BMI	Mid-arm circumference	Sum four skin fold
	[1]	[2]	[3]
[1] Core model	–0.067*** (0.023)	–0.079*** (0.015)	–0.271** (0.082)
[2] Using Gini coefficient of dominance	–0.098 (0.074)	–0.161*** (0.054)	–0.670** (0.249)
[3] Added household wealth and the village CV-income	–0.062** (0.027)	–0.075*** (0.015)	–0.277** (0.098)
[4] Added mother's stature ($n = 142$)	–0.130** (0.055)	–0.137*** (0.040)	–0.438** (0.166)
[5] Added number of traditional healers and caregivers in village	–0.076*** (0.119)	–0.079*** (0.028)	–0.167 (0.105)
[6] Added village size	–0.090*** (0.018)	–0.094*** (0.024)	–0.292*** (0.092)
[7] Added own social capital, residency duration, and village CV-social capital	–0.063* (0.030)	–0.081*** (0.023)	–0.293*** (0.087)
[8] Added individual emotions (anger, fear)	–0.067*** (0.021)	–0.079*** (0.015)	–0.272*** (0.082)

In line [4], we added mother's stature to control for hereditary components that might affect the nutritional status of a person through genetic make up (Henneberg & van den Berg, 1990).

In lines [5] and [6], we added village level variables that might affect village social hierarchies and individual health and nutritional status, such as the number of traditional healers and caregivers in a village and the village's population (using the total number of households in the village as a proxy). For example, in villages with more traditional healers, we might find both greater numbers of nominations of prestigious individuals and better indicators of health.

To control for variables that might mediate the association between village inequality in dominance and individual nutritional status, in line [7] we included proxies for individual and village social capital. Social capital protects the nutritional status of adults in industrial and small-scale societies from the harmful effects of income inequality (Godoy, Reyes-García et al., 2005; Kawachi, Kennedy, Lochner, & Prothrow-Stith, 1997), so it might also protect from non-material forms of inequality. As proxies for individual social capital, we included the total monetary value of gifts received by a subject in the seven days prior to the interview, as well as the number of years the individual had continuously lived in the village. As a proxy for village social capital, we included the CV of the monetary value of gifts received by a subject.

Negative feelings have been singled out as one of the main mechanisms through which income inequality affects health (Godoy et al., 2006b; Wilkinson, 1997), so in line [8] we added two variables that act as proxies for negative emotions. Our proxies for negative emotions include the number of times a person reportedly felt angry and fearful in the seven days prior to the interview.

Two findings stand out from our robustness tests. First, the main results hold up virtually unchanged after (i) using the Gini coefficient as measure of inequality, (ii) controlling for additional correlates of nutritional status (lines [3]–[6]), and (iii) controlling for variables that mediate the association between income inequality and nutritional status (lines [7] and [8]). We only find two exceptions. In line [2], when using the Gini coefficient of dominance as a measure of social inequality, the association with BMI is not statistically significant, although the association with mid-arm circumference and sum of skin folds remains significant. In line [5], when controlling for the number of traditional healers and caregivers in the village, the CV of dominance is not associated with the sum of skin folds, although it is associated with BMI and mid-arm circumference. Second, for the three outcome variables examined, the coefficients of the CV of dominance are higher in regressions controlling for mother's stature (line [4]).

Discussion and conclusions

We center the discussion on two related findings. First, we find that among Tsimane' adult men, degree of village inequality in power (i.e., CV of dominance), but not degree of village inequality in freely conferred deference (i.e., CV of prestige), is negatively associated with short-term indices of nutritional status. Second, once we differentiate between a person's dominance and prestige, only individual prestige has a positive association with own nutritional status.

Our first finding, that village inequality in dominance bears a negative association with individual indices of nutritional status, suggests that in small-scale societies forms of non-material inequality have adverse effects on individual health. Specifically, we find that our measure of dominance has a more dispersed distribution than our measure of prestige, and the increase in the dispersion of dominance nominations in a village (i.e., fewer individuals receiving more nominations) bears a negative association

with the nutritional status of adult men in the same village. This finding dovetails with previous research on the effects of social inequalities on health (Kawachi, 2002; Marmot, 2006; Sapolsky 2004), but moves one step further by highlighting the potential role of non-material forms of inequality in explaining the social gradient of health. It is possible that forms of non-material inequality are a better proxy for social heterogeneity in small-scale societies than income inequality, but even in industrial societies forms of non-material inequality might affect individual health. These findings illustrate the importance of considering multiple types of inequality when studying the association between social inequalities and health.

Our results also suggest that not all forms of non-material inequality are related to health. We find that village inequality in dominance, but not village inequality in prestige, bears a negative association with individual nutritional status. Although we do not have a clear explanation for this, our intuition is that those two types of social hierarchy rely on different forms of resource access that might help explain their different association with individual nutritional status. Prestigious individuals gain priority in access to resources because there is a group-wide perception that both the individuals and the group can benefit from showing deference to prestigious individuals (Henrich & Gil-White, 2001). Prestigious individuals can contribute to other individuals and the group either through resources (i.e., meat from good hunters) or knowledge (i.e., information on resource location). For example, in our previous research we found some evidence that prestige among the Tsimane' is associated with ethnomedical plant knowledge, an association that we speculate was stronger in the past (Reyes-García, Molina et al., 2008). Ethnographic work suggests that Tsimane' traditional healers were exempted from agricultural work (Huanca, 2008) and that even today people with ethnomedical knowledge enjoy many privileges (such as gifts or help). At the same time, healers provide important services to villagers who seek treatment for physical and spiritual ailments, and who also inquire about other matters, such as the location of medicinal plants in the forest. Thus, differences in prestige would imply transfers of resources from the non-prestigious to the prestigious individuals (through priority access to resources and privileges), but also transfers of material or non-material resources from the prestigious to the non-prestigious individuals (through sharing resources or information). Thus, large inequalities in prestige would increase the overall transfer of resources within a group. Furthermore, the bidirectional transfer of resources might stimulate social cohesion, with potential additional protective effects on health (Wilkinson, 1997).

Contrary, powerful individuals gain priority access to resources because of their relative ability to inflict costs (as is also the case among non-human primates, Boesch, 2006; Cowlshaw & Dunbar, 1991; de Waal, 2000). Thus, differences in dominance would imply transfers of resources only in one direction, from the non-dominant to the dominant or powerful. Transfers of resources from the non-dominant to the dominant would be made only to avoid costs, but without other benefits for the non-dominant. With large dominance inequality, this unidirectional transfer of resources could deprive the non-dominant from needed resources that would concentrate among the dominant. Furthermore, as is the case for the increase in income inequality in industrial societies (Kawachi, 2002), in small-scale societies the rise of social hierarchies based in dominance could be associated with the decline of social capital, strengthening the negative association between inequality in dominance and health.

In the case of the Tsimane', priority access to resources by powerful individuals is likely to be associated with a well-known phenomenon in the development literature: elite capture

(Dasgupta & Beard, 2008; Platteau, 2004). The Tsimane' regularly receive material and non-material resources from governmental and non-governmental organizations working to improve the well-being of rural and indigenous people in the area. Examples of resources that Tsimane' have received over the last years include relief funds after floods, adult literacy courses, vaccination campaigns, the construction of individual (i.e., water pumps) or communal (i.e., schools) facilities, and the like. Typically, those resources are channelled through the village's formal representatives. Village representatives are the first to access those resources and, furthermore, they often have the ability to affect how the resources are to be distributed. Thus, village representatives have the ability to inflict costs, for example, by omitting the name of a particular family from a list of those who should benefit from any of those resources, or not sharing privileged information (such as the date when the nurses will be visiting the village for vaccinations) with them.

Though plausible, the previous explanation makes counter-intuitive our second finding. If inequality in dominance implies a unidirectional flow of resources from the non-dominant to the dominant, then one should expect a positive association between individual dominance and individual indices of nutritional status. Our data, however, suggest that while individual prestige bears a positive association with nutritional status, individual dominance does not. A potential explanation for that puzzle relates to the social and psychological benefits associated with prestige versus the social costs and psychological stress generated by dominance.

Prestige-based social rank relies on freely conferred deference, whereas dominance-based social rank relies on the potential ability of the dominant to inflict costs. Prestige-based social rank, therefore, might be more stable and less costly to maintain than dominance-based social rank. For example, social status based on dominance can generate resentment and envy that might lead subordinate groups to ridicule, form coalitions, and challenge power inequities (Boehm, 1999b; Emerson, 1962), eventually resulting in a loss of the dominant group's social status. As with other stressors, having to maintain a social rank based on dominance might force the biological system to persistent adjustative efforts that might wash out the benefits generated by the flow of resources that comes with dominance-based social rank.

The explanations to our two main findings are consistent with findings from research on social capital, defined as the resources embedded in social relations. Putnam (2000) distinguishes between bonding and bridging social capital. Bonding social capital comes from homogeneous and redundant social relations, whereas bridging social capital comes from heterogeneous social relations and structural holes. The empirical evidence on the positive effects of bonding ties in health and the association of bridging ties and stress is overwhelming. For example, Cohen, Gottlieb, and Underwood (2000) have shown that the size, composition, and structure of personal networks have a positive association with health for a variety of reasons (effective resource access, counselling about healthy conduct, stress-buffering effects). Research also suggests that the creation and maintenance of bridging capital is associated with higher level of stress because brokers have to face conflicting demands, behave in social worlds with different rules, and experience role conflict (Burt, 1992; Coleman, 1990; Cornwell, 2009). Thus, whereas social capital is strongly associated with social rank in general (Lin, 2001), bonding social capital might be more associated with prestige and bridging social capital might be more associated with dominance and stress.

We conclude by highlighting some directions for future research. Previous research on the effects of social inequalities on individual health has concentrated on industrial nations and has mainly focused on inequalities in socioeconomic status. Findings

from this study suggest that in less hierarchical societies, the effect of social inequalities on individual health does not come from inequalities on socioeconomic status, but from a non-material form of inequality – inequality in power. Future research on industrial nations should address whether, independent of the effect of income inequality on health, non-material forms of social inequality also have pernicious effects on individual health.

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