Working Paper Series

Melancholy and weight change: Panel evidence from a pre-industrial economy in the Bolivian Amazon

Ricardo Godoy, Elizabeth Goodman, Victoria Reyes-García, Tomás Huanca, William R. Leonard, Thomas McDade, Susan Tanner, Vincent Vadez

Tsimane' Amazonian Panel Study Working Paper # 13, Nov-2005

Melancholy and weight change:

Panel evidence from a pre-industrial economy in the Bolivian Amazon

Ricardo Godoy [a,*], Elizabeth Goodman [a], Victoria Reyes-García [a], Tomás Huanca [a], William R. Leonard [b], Thomas McDade [b], Susan Tanner [c], Vincent Vadez [a]

[a] Heller School for Social Policy and Management, Brandeis University, Waltham, MA 02454-9110, USA

[b] Department of Anthropology, Northwestern University, Evanston, Illinois 60208, USA

[c] Department of Anthropology, University of Michigan, Ann Arbor, MI 48109-1092, USA

Corresponding author:
* Corresponding author. Te.: +1-781-736-2784; fax: +1-781-736-2774
E-mail address: rgodoy@brandeis.edu (R. Godoy).

Acknowledgements

Grants from the programs of Biological and Cultural Anthropology of the National Science Foundation (0134225, 0200767, and 0322380) funded the research. Thanks go to Lilian Apaza, Esther Conde, Johnny Dávila, Homero Rivas, Yerko Lobo, Lourdes Parada, Bernabé Nate, Paulino Pache, Evaristo Tayo, Santiago Cari, José Cari, Manuel Roca, Daniel Pache, Javier Pache, and Vicente Cuata for help collecting the information and for logistical support.

Abstract

In recent years researchers have presented evidence linking depression with weight change in industrial nations, but little is known about mood and weight change in pre-industrial societies. We contribute to the literature by estimating the effect of melancholy at baseline on body-mass index (BMI; kg/mt^2) a year later and identifying the paths by which melancholy affects BMI in a foraging-farming society of Amazonian Amerindians in Bolivia (Tsimane'). We use panel data collected every three months (or quarters). Participants were interviewed a total of five times and included all people 16+ years of age in 13 villages (329 women, 350 men). We measured melancholy, or the absence of smiles or laughter during interviews lasting 45-80 minutes. The first quarter was used to pilot test methods and excluded from the regression analysis. We regress BMI at follow up (5^{th} quarter) against melancholy at baseline (2^{nd} quarter) controlling for many covariates. Melancholy at baseline correlated with 2.07% lower BMI; the 2.07% annual rate produces a significant effect on BMI when compounded over several years. The effect of melancholy on BMI weakened after controlling for fixed attributes of participants (e.g., genetic predisposition toward melancholy and weight gain/loss) and households (e.g., history of melancholy in the household). Unlike industrial nations, among Tsimane' melancholy did not lower earnings. As is true in industrial nations, among Tsimane' melancholy correlated with lower labor supply and productivity and less accumulation of human capital.

Key words: Depression; melancholy; Tsimane'; Bolivia; BMI; Nutritional status

Introduction

In recent years researchers have presented evidence linking depression with weight change in industrial nations. For instance, Onyike et al. used cross-sectional information from the USA and found that depression during the previous month correlates with higher current weight {Onyike, 2003 6289 /id}. Longitudinal studies in the USA show that childhood depression leads to adult obesity {Pine, 2001 6372 /id}{Richardson, 2003 6374 /id}. Using a nationally representative sample of 9374 adolescents in USA schools (grades 7-12), Goodman and Whitaker find a strong link between depression at baseline and weight gain a year later {Goodman, 2002 6159 /id}. They review evidence from the biological and medical sciences to suggest that chronic stress, neurobiological mechanisms, and alterations in the hypothalamic-pituitary-adrenal axis might explain the causal link from depression to weight gain. In industrial nations, depression triggers biological processes that induce people with access to food to change their habits of eating and physical activity and experience weight change.

But other studies suggest that depression can contribute to weight loss and might have a negligible effect on weight change. For example, Shioiri et al. studied 106 depressed inpatients in Japan at admission and discharge and found that depressed patients, particularly women, had lower weights {Shioiri, 1993 6375 /id}. Rosmond et al. draw on cross-sectional information from Swedish men and female immigrants in Sweden and found that mild forms of depression, such as melancholy, correlated with fat distribution, but not with body-mass index (BMI; kilograms/meters^2) {Rosmond, 2000 6231 /id}{Rosmond, 1996 6230 /id}. Berlin et al. studied 1694 participants in France

with depressive illness and found no correlation between BMI and melancholy {Berlin, 2003 6233 /id}. Carter et al. studied 89 patients with major depression and found no correlation between the direction of weight change and the severity of depression or melancholy {Carter, 1994 6232 /id}.

Most of the studies just reviewed draw on cross-sectional information, focus on the more severe forms of depression or clinical populations, and took place in industrial nations. Here we complement studies of depression and weight change in industrial nations by presenting longitudinal data on the link between melancholy and weight change from adults of a hunting, gathering, and farming society of Amerindians in the Bolivian Amazon (Tsimane'). The information consists of repeated measures collected from the same participants every three months (or quarters) during 15 consecutive months.

We contribute to studies of melancholy and weight change in two ways. First, we estimate the link between melancholy (a mild form of depression) at baseline and weight change at follow up to assess whether the link from melancholy to weight change found in industrial nations also holds in a small-scale, pre-industrial economy. In a small-scale, pre-industrial economy, melancholy probably trigger the same biological mechanisms found in industrial nations discussed by Goodman and Whitaker{Goodman, 2002 6159 /id}, but the shortage of food and the energy requirements necessary to carry out fixed daily subsistence activities likely prevents melancholic people from changing their habits of eating or physical activity, thus weakening the relation between melancholy and weight change. Second, we draw on research findings and insights from industrial nations to explore whether melancholy works through the same socioeconomic paths found in

industrial nations: labor supply, labor productivity, human capital, and earnings.

Sample and methods of collecting information

The information presented here comes from a longitudinal study in progress that started in 1999 on the effects of market exposure on the well-being of Tsimane', a highly autarkic society in the early stages of continuous contact with the market economy. A foraging and farming society of native Amazonians in Bolivia, the Tsimane' number 8000 people and live in ~100 villages. The information presented comes from five consecutive quarterly surveys done among the same participants between August 2002 and November 2003. Participants included 319 women and 336 men over the age of 16 from 267 households in 13 villages along the Maniqui River, department of Beni. In each village, we surveyed all people over 16 years of age. The sample represents ~20% of the total Tsimane' population. Since most Tsimane' live in their villages and do not move out permanently outside of the Tsimane' territory, self-selection should not bias results. We selected villages at different distances from the market town of San Borja (population ~19,000) to capture cross-sectional variance in market participation. We dropped the first quarter of observations from the analysis because we used the first quarter to test methods of data collection; we use a total of four consecutive quarterly observations for each participant. We call the second quarter (August 16-November 15, 2002) baseline and the fifth or last quarter (May 16-August 15, 2003) follow up.

We collected information each quarter using different methods applied during different times of the quarter. During the first quarter we collected information on health history and school grades completed, and gave participants math and writing tests to

assess their academic skills. Interviewers judged the participant's proficiency speaking Spanish. Each quarter we asked participants about their monetary income, wealth, social capital (e.g., frequency of gifts given to people outside their household), self-perceived emotions (e.g., happiness, anger), and self-perceived health. During the interviews we collected information on the number of people living in the household and noted whether participants smiled and laughed, a point to which we return when we discuss how we measured melancholy. Interviews lasted 45-80 minutes/adult and took place in the participant's house. During 1-2 days/quarter we took anthropometric measures from all villagers.

Last, we did scans or spot observations to assess activity level and labor productivity. To do scans, researchers visited each household in the village once a week on a day chosen at random. Visits took place at different times of the day (7-10am, 10am-1pm, 1-4pm, or 4-7pm), which we also selected at random. After arriving at the household, interviewers recorded the number of adults present in the house and the activity of each participant at the moment they first saw the participant. Interviewers asked each participant about their activities during the previous 24 hours, and about the type and amount of plants, game, fish, and crops brought to the household during the past 24 hours. If an adult was absent during the scan, interviewers asked another adult or child to provide the information. We recorded whether the information came from the adult we intended to interview or from proxy respondents. We did not record information on laughter or smiles during scans. We scanned participants an average of six times each quarter (std dev=3.59) and spent about five minutes with each adult doing scans during a week.

Four female and four male researchers collected information. Seven of the eight surveyors lived permanently in the villages during the duration of the study, and four had lived longer in the villages as part of the longitudinal study. Three of the surveyors spoke the Tsimane' language moderately well, but all used translators.

Econometric model and variables

For the empirical analysis and to facilitate comparison with industrial nations, we build on the work of Goodman and Whitaker {Goodman, 2002 6159 /id} in the USA and estimate the parameters for the following linear approximation of BMI:

$$[1]\quad \ln \mathrm{BMI}_{ihvq=5} = \alpha + \beta D_{ihvq=2} + \delta W_{ihvq=2} + \eta H_{ihv=2} + \theta \mathrm{BMI}_{q=2} + \zeta C_{ihvq=2} + \varepsilon_{ihvq}$$

ln BMI represents the logarithm of body-mass index (BMI) for person i of household h and village v during follow up. Among explanatory variables, D stands for melancholy, W stands for personal wealth, H stands for self-perceived poor health, and C stands for control variables (e.g., household size, participant's sex and age). Among explanatory variables, we also include BMI at baseline. We measure all explanatory variables at baseline to reduce biases from possible reverse causality.

Dependent variable

We followed the protocol of Lohman et al. and measured participants in light

clothing without shoes or hats {Lohman, 1988 5226 /id}. We recorded physical stature (standing height) to the nearest millimeter using a portable stadiometer or a plastic tape measure and body weight to the nearest 0.20 kg using a standing scale.

Explanatory variable: Melancholy

During the interview when we asked participants about their socioeconomic status, health, and other topics, researchers noted whether participants laughed, smiled, or did neither. We define melancholy as a binary dummy variable that took the value of one if the participant neither laughed nor smiled during the baseline interview, and zero otherwise. The absence of smiles or laughter is a reasonable proxy for melancholy because across cultures, people associate smiles with a spontaneous feeling of enjoyment {O'Quin, 1981 6123 /id} or happiness {Fridlund, 1994 6127 /id}{Fernandez-Carrocera, 2003 5767 /id}{Ekman, 2002 6111 /id}{Ekman, 1993 6112 /id}{Godoy, 2005 6178 /id}.

To assess whether the absence of smiles and laughter is a reasonable proxy for melancholy, we ran a probit regression with melancholy as a dependent dummy variable and self-reported sadness, sex, age, and schooling as explanatory variables. We estimated the probability of melancholy when explanatory variables increased by one unit above their mean value. We found that people who said they were never sad were 2.63% more likely to smile or laugh during the interview ($p<0.088$).

Though reasonable as a proxy for melancholy, the absence of smiles and laughter poses problems of measurement and interpretation. First, interviewers might have influenced a participant's display of emotions. Participants may have been more likely to

display melancholy with some surveyors because they may have felt more comfortable with surveyors of one sex, or because some surveyors laughed or smiled more, inducing participants to reciprocate with a smile or a laugh. Since interviewers had to include their unique identification number in the survey, we can control for interviewer bias by adding a dummy variable for each interviewer. As we shall see, we do not find evidence of interviewer bias.

Second, the displays of melancholy we measured cover melancholy toward interviewers with their translators, not melancholy toward other villagers in ordinary interactions. Perhaps expressions of melancholy toward other villagers in daily interactions correlate weakly with expressions of melancholy toward a team of an interviewer with a translator during a formal interview. We did not have interviewers act as observers of participants when participants interacted with other people besides the interviewer and the translator in ordinary settings. We hypothesize that the expressions of melancholy we measured approximate what a participant most likely would have expressed in ordinary settings because interviewers lived permanently in the village and interacted frequently with participants (and were therefore not perceived as strangers) and because another Tsimane' (the translator) was present in the interview.

Last, the absence of smiles or laughter likely reflects anhedonia, but we cannot tell whether our measure of melancholia is a state or trait marker. In industrial nations researchers have developed sophisticated instruments to measure depression {Korner, Nielsen, et al. 1990 5553 /id}{American Psychiatric Association 1994 5554 /id}{Radloff 1977 6234 /id}, but to our knowledge the instruments have yet to be validated in very different cultural and economic settings, such as the one where we worked.

We had no instrumental variable to control for the endogeneity of melancholy {Marcotte, 2003 6168 /id}. Standard instruments for melancholy in industrial nations include family history of mental illness. Ettner and her colleagues found that using instrumental variables to estimate lost earnings from mental illness produced larger estimates than estimates from ordinary-least squares {Ettner, 1997 6169 /id}. If the same applies to pre-industrial nations and to other outcomes besides earnings (e.g., weight change), then one could interpret our estimates as a lower bound of the true magnitude.

Control variables

Control variables included household size and the participant's age, sex, wealth, schooling, self-perceived poor health, and body-mass index, all measured at baseline. The age variable contained measurement errors; 27.43% of participants said they did not know their exact age, but the share could be higher because few people had birth certificates. We estimated household size by counting the number of people living in the household during each quarter. We equate personal wealth with the financial value of 18 physical assets owned by the participant. Assets included traditional (e.g., bows, arrow) and commercial (e.g., metal fishhooks) goods. Schooling refers to the maximum school grade attained by the participant. We asked participants to report the three main ailments they had experienced during the two weeks before the day of the interview. For each illness, we asked them to report the total number of days they had felt ill. Table 1 contains definition and summary statistics of the variables used in the regression analysis.

-INSERT TABLE 1 ABOUT HERE-

Melancholy among Tsimane'

In recent articles and dissertations {Byron, 2003 5964 /id} {Huanca 2000 4365 /id} {Reyes-Garcia, Byron, et al. 2003 5691 /id} {Vadez, Reyes-Garcia, et al. 2004 5604 /id} {Godoy, Byron, et al. 2005 6209 /id} we provide historical and ethnographic information on the Tsimane', including discussions of their nutritional status {Godoy, Gurven, et al. 2004 5617 /id} {Godoy, Reyes-Garcia, et al. 2005 6097 /id} {Foster, Byron, et al. 2003 5532 /id}, so here we limit ourselves to a description of melancholy to set the stage for the econometric results.

The Tsimane' word for melancholy, *yoqui*, includes all forms of sadness and depression. During open-ended ethnographic interviews, Tsimane' said they felt sad when they returned home from a hunting or a fishing expedition without a catch, when someone in their family died or got sick, when they lost valuable physical assets, or when someone in their household left for a long time. Other causes of sadness included bad dreams, witchcraft, and encounters with wild animals in the forest that presage misfortune. We found three recent cases of suicide, all by men using shotguns. Survivors said that love affairs by the men with other women had sparked marital disputes, which caused wives to beat their husbands in public or refuse to be gracious hosts. Continuous marital disputes drove the men to commit suicide.

We asked participants what had made them sad during the current week. Over the five quarters, 41% of the responses indicated that nothing had made them sad during the current week; we found no statistically significant different in responses between women and men ($chi2=1.33$, $p<0.249$). In Table 2 we present the most common causes of

sadness for the 59% of responses who reported feeling sad, and who mentioned at least one cause for their sadness. Note that the unit of observation in Table 2 is the response during each of the five quarters, not the person; since we interviewed people a maximum of five times, one person could be represented up to five times in Table 2 if the person reported having been melancholic during each of the five quarters. For instance, a person could have said that illness had made her/him said on another quarter, and loss of animals during another quarter. This explains why the sample size of Table 2 differs from the sample size of participants.

INSERT TABLE 2 ABOUT HERE

The results of Table 2 suggest that the most important self-perceived causes of melancholy had to do with own illness or with the illness of someone else in the household, with insufficient food, and with gossip. Women and men gave similar answers. Slightly over a fifth of the women (22.5%) and 18.3% of the men said that insufficient food had made them melancholic ($chi2=3.12$, $p<0.007$), and 16.3% of the women and 12.8% of the men said that gossip had made them melancholic ($chi2=2.85$, $p<0.09$). About a quarter of the women (23.7%) and 21.8% of the men said that their own illness had made them melancholic, and 21.1% of the women and 18.1% of the men said that the illness of others in their household had made them melancholic.

Minor causes of melancholy included the loss of domesticated animals (women=6.3%, men=5.0%), insufficient money (women=3.9%, men=6.3%), anger at kin outside of the household (women=3.6%, men=5.3%), and upsetting dreams (women=4.1%, men=3.3%). Despite their low annual personal level of income (US$332) {Godoy, Overman, et al. 2002 5251 /id}, Tsimane' did not mention low monetary income

or the shortage of physical assets as a leading cause of melancholy. Instead, major causes of melancholy had to do with fundamentals, such as illness and inadequate food, and with gossip. In small-scale, collectivistic pre-industrial societies without formal institutions to impose law and order, the threat of gossip induces compliance with the norms of the group {Haviland 1977 6165 /id}{Lutz & White 1986 6138 /id}.

The share of people displaying melancholy (defined as the absence of laughter and smiles) increased as the study unfolded from 8.40% of the sample at baseline (Table 1), to 11.46% during the third and fourth quarters (n=995), to 15.48% during the fifth quarter (n=478). Over the four quarters, 11.29% of the sample displayed melancholy (227 out of 2011).

Results

Table 3 contains the parameter estimate for the melancholy variable of expression [1]. Row 1 contains the results of the core regression and rows 2-13 contain the results of sensitivity analyses.

INSERT TABLE 3 ABOUT HERE

The result of the core regression suggests that melancholy at baseline correlates with 2.07% lower BMI at follow up ($t=3.11$, $p<0.009$). People who did not smile or laugh at baseline had, at follow up, a BMI that was 2.07% lower than the BMI of those who either smiled or laughed. A negative 2.07% annual growth rate in BMI can have a significant long-term effect on BMI. To explore the topic we ran a simulation in which we start with the BMI of a melancholic women and men at baseline. Melancholic women

and men at baseline had BMI of 21.73 (women) and 22.87 (men); people who were not melancholic had BMI of 23.24 (women) and 23.26 (men) at baseline. Assuming a constant annual growth rate in BMI of -2.07%, a melancholic women and men after a decade would have experienced an 18.92% decline in BMI relative to their baseline BMI; the BMI of a melancholic women and men after a decade would reach 17.62 (women) and 18.54 (men). The results suggest that what might at first sight appear as a miniscule effect of melancholy on BMI would, over time, compound into a significant nutritional impact.

Since previous research in the USA suggests that the effect of depression may vary by sex and by income, we tested for heterogeneity {Marcotte & Wilcox-Gok 2003 6168 /id}{Marcotte & Wilcox-Gok 2001 6167 /id}. We added an interaction term for sex*melancholy at baseline, and found that the coefficient of the interaction term was small (-0.004) and statistically insignificant ($t=0.26$, $p<0.796$). The interaction term for baseline melancholy*baseline BMI was negative (-0.006) and marginally statistically significant ($t=1.95$, $p<0.07$), suggesting some heterogeneity by baseline BMI. Since we found weak evidence of heterogeneity, we present results for the pooled sample only.

In row 2 we add a variable for social isolation – the number of visits received by the participant during the month before the interview. We do so because the literature in social epidemiology from industrial nations suggests that weak social capital contributes to depression {Kawachi & Kennedy 2002 5652 /id}, so failure to control for social isolation could produce a bias from omitted variable. The coefficient for the melancholy variable does not change after we add the variable for social isolation. In regressions not shown we also added variables for (a) physical distance between the house of the

participant and the closest neighbor or (b) the walking time from the participant's house to the school (typically at the center of the village). We found that in both cases the coefficient of the melancholy variable remained largely unchanged.

In row 3 we add a variable for the self-perceived sadness of the participant at baseline. Again, the coefficient of the melancholy variable hardly changes. The dummy variable for self-perceived sadness at baseline (not shown) also correlated negatively with BMI at follow up, but the coefficient (-0.001) was much smaller than the coefficient for absence of smiles or laughter (-2.08), and was also statistically insignificant ($t=0.35$, $p<0.75$), lending support to our use of an objective measure of melancholy rather than to a self-perceived measure. In row 4 we add a variable for physical activity at baseline. The variable captures the share of time researchers found participants idle during scans or spot observations. The coefficient of the melancholy variable increases from –2.07% to –2.55% ($t=2.36$, $p<0.036$), but remains negative, suggesting a negative indirect effect from the omission of the variable for physical activity.

In row 5 we control for the role of smoking and drinking commercial alcohol since they correlate with weight gain and depression in industrial nations {Goodman & Whitaker 2002 6159 /id}. The new regression produces a parameter estimate for the melancholy variable similar to the one in the core regression. In row 6 we add a full set of dummy variables for interviewers to control for possible interviewer bias. Controlling for interviewer at baseline does not change much the coefficient of the melancholy variable.

In rows 7a-7b we add a measure of income inequality in the village since income inequality might affect health {Wilkinson 1996 5189 /id}{Kawachi & Kennedy 2002

5652 /id}. As a proxy for income we use separately both physical stature and BMI; we use the two because physical stature proxies for long-run nutritional status (or permanent income) and BMI proxies for short-run nutritional status (or temporary income). Introducing the coefficient of variation (standard deviation/mean) of physical stature of adults in the village into the core regression reduces the coefficient for the melancholy variable from –2.07% to –1.70% ($t=1.86$, $p<0.088$). Introducing the village coefficient of variation of BMI lowers the parameter estimate of melancholy to –1.4% and makes the coefficient statistically insignificant at the 90% confidence level or higher ($t=1.54$, $p<0.14$).

In row 8 we add at the same time all the variables discussed in this section (except for the coefficient of variation of BMI) and find that the coefficient of the melancholy variable increases from –2.07% to –2.44% and remains statistically significant ($t=2.36$, $p<0.036$).

In row 9 we exclude pregnant women since pregnancy and lactation affect BMI and might affect mood. The coefficient of the melancholy variable falls to –1.77% but remains statistically significant ($t=2.38$, $p<0.035$). Clustering by households rather than by villages (row 11) and controlling for village fixed effects (row 12) by adding dummy variables for villages also does not affect results. Melancholy at baseline continues to correlate with –1.65% ($t=1.74$, $p<0.10$) (row 12) and with –2.07% ($t=1.82$, $p<0.07$) lower BMI at follow up (row 11).

Since melancholy might reflect the role of household variables, such as history of depression in the household and genetic clustering within a household {Marcotte & Wilcox-Gok 2001 6167 /id} {Marcotte & Wilcox-Gok 2003 6168 /id}, in row 10 we run a

model with fixed effects for households. Once we control for the fixed effects of households, melancholy at baseline correlates with only -0.17% lower BMI at follow up, and the result becomes statistically insignificant ($t=0.13$, $p<0.89$). Further, since genetics might influence both the propensity to feel melancholic and BMI, we use a fixed-effect model for the person (rather than the household) with contemporaneous measures of BMI, melancholy, and the other variables that change over time. Those results (not shown) suggest that melancholy correlates with –0.04% ($t=0.12$, $p<0.90$) lower BMI. In sum, the results of the regressions that control for the role of fixed attributes of households or participants suggest that some of the effects of melancholy described earlier pick up the role of fixed or unmeasured attributes of households (e.g., role models, family history of melancholy) or the person (e.g., genetics) that correlate with both the melancholy and BMI.

Besides the results of the sensitivity analyses shown in Table 3, we did two other analyses (not shown). First, we estimated whether baseline BMI affected melancholy at follow up, rather than baseline melancholy affecting subsequent BMI. We used a probit regression with melancholy at follow up against all the explanatory variables of the core model (except for melancholy) at baseline. We found that baseline BMI did not correlate strongly with subsequent melancholy. A one-point increase in BMI over the sample mean BMI of 23.17 at baseline correlated with a 0.52% lower probability of being melancholic at follow up ($z=1.47$, $p<0.14$).

Second, we assessed whether melancholy at baseline affected other anthropometric indicators of short-run nutritional status besides BMI. To explore the topic, we re-estimated the core regression using the age and sex-standardized z score of

mid-arm muscle area at follow up as a dependent variable. The z score of mid-arm muscle area provides an index of lean body (muscle) development and protein reserves and is standardized relative to the age and sex norms of Frisancho (1990). With acute nutritional stress or protein deprivation, muscle wasting and low indices of arm muscularity will occur. We re-estimated expression [1] using age and sex-standardized indices of mid-arm muscle area at follow up, and all the baseline control variables of expression [1] with one exception. We took out baseline BMI and replaced it with the baseline measure of age and sex-standardized z score of mid-arm muscle area. The result of the ordinary-least squares regression confirms the results discussed so far. Melancholy at baseline correlated with a decrease of 0.17 ($t=2.52$, $p<0.022$) standard deviations in the age and sex-standardized z score of mid-arm muscle area at follow up.

In sum, the results of the analysis suggest that melancholy at baseline correlates with lower measures of short-run nutritional status at follow up. Participants who neither smiled nor laughed during the interview at baseline had 2.07% lower BMI and 0.17 lower standard deviations in age and sex-standardized z score of mid-arm muscle area at follow up than participants who displayed mirth. The results also suggest that conventional estimates of the effect of melancholy on weight change are likely biased because they pick up the role of fixed, unmeasured attributes of the household and participant. Once we control for unmeasured, unobserved fixed heterogeneity of participants and households, the effect of melancholy at baseline on BMI at follow up weakens considerably.

Extensions

In this section we extend the analysis to decide whether melancholy correlates with other outcomes found in industrial nations. The evidence from industrial nations suggests that depression affects labor supply, labor productivity, investments in social and human capital, and earnings. Kessler et al. find that depression in the United States erodes labor productivity by increasing absenteeism and impairment in the workplace {Kessler, Barber, et al. 1999 6164 /id}. Depression correlates with lower school attainment {Kessler, Foster, et al. 1995 6161 /id} and with more social isolation {Wilkinson 1997 5219 /id}{Macinko & Starfield 2001 5639 /id}{Kawachi & Kennedy 2002 5652 /id}{Marmot & Wilkinson 2001 6260 /id}{Matt 2002 6263 /id}. By reducing labor supply and labor productivity, and by reducing investments in social and human capital, depression lowers earnings. Marcotte and Wilcox-Gok recently reviewed the literature on the impact of mental illness on individual earnings in industrial nations, and found that depressed participants earned less than participants who were not depressed. Estimates ranged from a low of 3-10% less income for anxiety disorders and for anti-social behaviors, to 20-35% less income for schizophrenia and for other forms of severe mental illness {Marcotte & Wilcox-Gok 2001 6167 /id}.

In Table 4 we show the results of regressions with measures of labor supply, labor productivity, and investments in social capital as dependent variables at follow up; as explanatory variables we include measures of melancholy and body-mass index and various controls, all at baseline.

INSERT TABLE 4 ABOUT HERE

Columns 3-4 suggest that melancholy at baseline correlates with reduced labor

supply at follow up. Melancholic people at baseline were, at follow up, 23.62% more likely to be idle during scans ($t=1.98$, $p<0.048$) (column 4) and they were also likely to spend an additional 2.64 days in bed from self-perceived illness during the 14 days before the day of the interview ($t=2.57$, $p<0.011$) (column 3). Furthermore, melancholic people were less productive farmers. Melancholic people did not differ from others in the amount of wildlife, firewood, or plantains they brought to their households (regression results not shown), but they differed in the amount of farm crops they brought to the household. In column [5] we show the results of regressions with the amount of kilograms of farm crops brought from the field at the end of the day (dependent variable) against melancholy at baseline (explanatory variable). Melancholic people brought, on average, 25.21 fewer kilograms of crops ($t=1.80$, $p<0.073$) than people who were not melancholic.

The results shown in columns 1-2 of Table 4 suggest that melancholy at baseline correlated with less social capital and with a greater debt burden at follow up. During the week before the day of the interview, melancholic people engaged in one less episode of communal labor or helping behavior toward other villagers ($t=1.79$, $p<0.07$; mean=0.31, std dev 0.57). By investing less than others in social capital, melancholic people may have had a thinner safety net for use when misfortunes struck. Unfortunately, we do not have information on the frequency and size of misfortunes and on the methods of coping with misfortunes to test the hypothesis.

Perhaps because they invest less in social capital, melancholic people had to borrow more money from outside traders to cope with misfortunes. In column 2 we see that melancholy at baseline correlated with an increase of 114 bolivianos in total debt at

follow up ($t=1.85$, $p<0.065$) (1 US dollar = 7.45 bolivianos). We tested whether causality could have run from a greater debt burden at baseline to melancholy at follow up because perhaps debt to creditors caused melancholy. To test the idea we ran a probit regression with melancholy at follow up against debt burden at baseline, with all the explanatory variables of the core regression, and found no statistically significant result ($z=0.91$, $p<0.361$). We tentatively conclude that causality probably runs from melancholy to debt burden, but we lack the information to establish the direction of causality with certainty.

In Table 5 we show partial correlation coefficients between melancholy and modern and traditional human capital. Modern forms of human capital include maximum school attainment and objective measures of skills in math, writing, and speaking Spanish. Traditional forms of human capital include knowledge and uses of local plants. We used three different surveys to estimate various dimensions of traditional plant knowledge and used each survey during a different quarter. Partial correlation coefficients suggest that melancholy correlated with lower measures of modern and traditional human capital, but results were statistically significant at the 90% confidence level or higher only for scores in the math test, and for two of the three measures of traditional plant knowledge.

INSERT TABLE 5 ABOUT HERE

Last, we assessed the effect of melancholy on earnings. We equate earnings with money earned from wage labor and sales measured for the two weeks before the day of the interview. The measure is problematic because of the undeveloped market for labor and goods in a highly autarkic economy, and because of self-selection into the modern economy. For example, 48.43% of the sample reported zero earnings. This said, we used

earnings as a dependent variable in a standard earnings function with contemporaneous melancholy, schooling, age, sex, z score of height for age, and distance from village to town as explanatory variables. We used an ordinary-least squares regression with clustering by participant and we also used a random-effect regression. In neither case were results statistically significant. Melancholy correlated with 17.49% ($t=1.29$, $p<0.19$) lower earnings in the ordinary-least squares regression and with 13.00% ($z=1.08$,$p<0.27$) lower earnings in the random-effect regression.

Discussion and conclusion

The analysis of the relation between BMI and melancholy in a small-scale, pre-industrial society confirms some results from industrial nations, fails to confirm others, and points to three areas deserving further research to advance the cross-cultural understanding of various forms of depression and weight change.

Differences

In contrast to what we find in industrial nations, in the small-scale, pre-industrial economy of the Tsimane' melancholy at baseline did not correlate with weight gain at follow up. Recall from Table 1 that insufficient food ranked among the top causes of self-perceived melancholy. Although the same biological mechanisms likely operate among people in industrial and in pre-industrial economies, the trammels of resource scarcity, particularly food, in a pre-industrial economy weakens the link between

depression and weight change found in industrial nations. Furthermore, the strength of the link between melancholy and weight weakens after we control for unobserved, unmeasured fixed attributes of households and participants. The attributes would include variables such as family history of melancholy and genetic predisposition toward melancholy and weight gain (or loss).

In industrial nations depression produces large costs owing to its prevalence, persistence, early onset, and lack of effective treatment {Wang, Simons, et al. 2003 6155 /id}{Greenberg, Kessler, et al. 1996 6157 /id}{Greenberg, Kessler, et al. 2003 6163 /id}. We found no significant direct effects of melancholy on earnings, but the finding masks the difficulties of measuring income with accuracy in a pre-industrial, highly autarkic economy.

Similarities

As is true in industrial nations, in the pre-industrial economy of the Tsimane' melancholy correlated with lower labor supply, lower levels of some types of labor productivity, and lower accumulation of some forms of human capital. Furthermore, the prevalence rate among the Tsimane' for what we have called melancholy – absence of laugher and smiles during an interview lasting 45-80 minutes – resembles the prevalence rate for depression in the USA. During 1990-2000, 7.8-10.1% of adults in the USA had some form of depression {Greenberg, Kessler, et al. 2003 6163 /id}. We found roughly similar figures. At baseline and over the four quarters, 8.04% (baseline) and 11.29% (four quarters) of participants were melancholic.

Limitations and next steps

The study has at least three limitations. First, future studies would profit from adapting and validating more sophisticated measure of melancholy from industrial nations. The step would enhance comparison of results across cultures. Recall we did not use the methods because they have yet to be validated in very different socioeconomic settings such as the Tsimane' Second, owing to the difficulties of measuring earnings in a highly autarkic setting, future studies would do well to measure income (or consumption) with more accuracy. Last, to obtain reliable estimates of the effects of depression of various intensities on weight change one will need to identify instrumental variables for depression, or present a convincing strategy to identify causality. Since we did not have instrumental variables for melancholy, our estimates could contain endogeneity biases of an unknown magnitude and direction. We saw that controlling for fixed attributes of households and participants reduced the effect of melancholy on BMI. More so than the measure of depression, causal identification will likely remain the main stumbling block in the quantitative, cross-cultural understanding of how various intensities of depression affect weight change.

Table 1

Definition and summary statistic of variables at baseline (2nd quarter) used in regression analysis for Tsimane' Amerindians over 16 years of age

Name	***Definition***	***N***	***Mean***	***Std Dev***
Dependent variable:				
BMI	Body-mass index (kilograms/ meters^2) in 5th quarter; in regression entered in logarithms	369	23.541	2.66
Explanatory variables at baseline (2nd quarter) for core model:				
Melancholy	1=subject did not smile or laughed; 0 otherwise	357	.084	.277
BMI	Body-mass index; kilograms/meters^2	369	23.147	2.55
Male	Sex of subject; 1=male; 0=female (%)	369	.457	.498
Age	Age of subject in years	369	35.501	14.729
Health	Self-reported person-days ill during the last 14 days from three principal ailments	362	5.522	7.454
Wealth	Value in bolivianos of 18 modern & traditional physical assets (1 US $=7.45 bolivianos)	362	1127	1236
Schooling	Maximum schooling achieved by subject	369	1.742	2.161
Household Size	Household size measured by number of people living in household	369	6.696	2.746
Covariates at baseline (2nd quarter) for sensitivity analyses:				
Isolation	Number of visits received last month; 0=nobody, 1=some, 2=many	360	0.666	0.620
Sadness	Last week how often did you feel sad? 1=never, 2=sometimes, 3=many times	360	1.930	0.694
Alcohol	Number of times subject drank commercial alcohol during the week before the interview	359	0.224	0.521
Cigarettes	Number of cigarettes smoked by subject during the week before the interview	360	0.852	3.304
Idle	Share of time subjects seen idle in scans or spot observations	265	0.222	0.387
Inequality height	Coefficient of variation (std dev/mean) of stature in village during 2nd quarter	13	0.251	0.128
Inequality BMI	Coefficient of variation (std dev/mean) of BMI in village during 2nd quarter	13	0.105	0.16
Outcome variables at follow up (5th quarter) for Table 4:				
Help	Number of times subject helped other Tsimane' outside household last week	459	0.239	0.471
Credit	Total credit in bolivianos owed by the subject	459	49.459	187.02
Bed	Total number of days bed ridden from illness in last two weeks	419	0.767	1.671
Idle	See above	387	0.187	0.291
Crops	Kilograms of crops brought into the household	388	4.231	11.872

Table 2

Quarterly self-reported causes of melancholy during the current week among adult Tsimane', Bolivia (five quarters, 2002-2003)

Cause of sadness:	***Women (n=582)***		***Men (=599)***		***Pooled (n=1,181)***	
	%	***Std Dev***	***%***	***Std Dev***	***%***	***Std Dev***
Own illness	.237	.425	.218	.413	.227	.419
Insufficient food	.225	.417	.183*	.387	.204	.403
Other's illness	.211	.408	.181	.386	.196	.397
Gossip	.163	.369	.128*	.334	.145	.352
Animal loss	.063	.244	.050	.218	.056	.231
No money	.039	.194	.063*	.243	.051	.221
Anger at kin	.036	.186	.053	.225	.044	.207
Upsetting dreams	.041	.199	.033	.179	.037	.189

Notes: The unit of observation is the response of a person during a quarter. Answers are only for subjects reporting at least one cause for their sadness during the current week. Of 1,992 responses, 1,181 (59.29%) mentioned at least one cause of sadness during the current week. *, **, and *** statistically significant difference in chi2 test at the 10%, 5%, and 1% level.

Table 3

Relation between melancholy in 2nd quarter and BMI in 5th quarter among Tsimane' adults (16+), Bolivia, 2002-2003: Results of ordinary-least squares regressions (Dependent variable = logarithm of BMI in 5th quarter)

Models	***Coefficient & SE of melancholy***	***N and R^2***
1. Core: sex, age, days ill, wealth, schooling, household size, BMI, and melancholy - all at baseline	-.020 (.006)***	352 (0.79)
2. Core + isolation	-.020 (.006)***	352 (0.79)
3. Core + sadness	-.020 (.006)***	352 (0.79)
4. Core + idle	-.025 (.010)**	258 (0.82)
5. Core + alcohol and cigarette consumption	-.020 (.006)***	351 (0.79)
6. Core + interviewer effect	-.019 (.008)**	352 (0.80)
7. Core + inequality		
7a. Core + inequality of stature	-.017 (.009)*	344 (0.79)
7b. Core + inequality of BMI	-.014 (.009)	344 (0.79)
8. Core + controls [2] to [7a]	-.024 (.010)**	258 (0.84)
9. Core without pregnant women	-.017 (.007)**	324 (0.79)
10. Core + household fixed effects	-.001 (.013)	352 (0.92)
11. Core + clustering by households	-.020 (.011)*	352 (0.79)
12. Core + village fixed effects	-.016 (.009)*	352 (0.81)

Notes. BMI=body-mass index=kilograms/meters^2. Standard errors and R^2 are in parenthesis. *, **, and *** significant at 10%, 5%, and 1% level. Regressions include robust standard errors, clustering by village, and constant (not shown).

Table 4

Tobit regressions of socio-economic outcomes at follow up (5th quarter) against melancholy at baseline (2nd quarter)

Melancholy at baseline:	***Dependent variables (5th quarter):***				
	Help [1]	***Credit [2]***	***Bed [3]***	***Idle [4]***	***Crops [5]***
Coefficient	-.999*	114*	2.643**	.236**	-25.219*
SE	.558	61.81	1.027	.119	14.001
N	349	349	349	304	299
Pseudo R^2	0.083	0.026	0.044	0.065	0.054

Notes: *, **, and *** significant at the 90%, 95%, and 99% confidence level. Table 1 contains definition of dependent variables. Explanatory variables common to all regressions include: melancholy and BMI at baseline and sex, age, schooling, and household size during the 5th quarter. In addition, [1] includes days ill and monetary income earned 7-14 days before the interview and total wealth, [2] includes days ill 7-14 days before the interview and wealth, [3] includes wealth, [4] includes stature, and [5] includes days ill during the previous 14 days and wealth. All regressions include constant (not shown).

Table 5

Partial correlation coefficients between melancholy and human capital

Human capital	***Quarter***	***N***	***Correlation and (p value)***
MODERN:			
Schooling	2	536	-0.118 (0.093)
Math	2	536	-0.090 (0.421)
Writing	2	536	-.076 (0.701)
Speak Spanish	2	536	-0.110 (0.142)
TRADITIONAL:			
Objective botanical test	5	477	-0.156 (.003)
Uses of plants	4	523	-0.049 (0.834)
Recognize	3	466	-0.122 (0.047)

Notes: Math=0-4 score in test designed to assess skills adding, subtracting, multiplying, and dividing. Writing=ability to sign name (0=cannot, 1=with difficulty, 2=well). Speak Spanish = ability to speak Spanish (0=none, 1=some, 2 fluent). Schooling = maximum schooling attained. Objective botanical test = subjects asked to answer 10 questions about plants. Uses of plants = subjects asked whether they knew how to make artifacts from 18 plants. Recognize = subject asked whether they knew or could recognize 19 plants. Partial correlations include Šidák adjustments for multiple comparisons.

References