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ROBUSTNESS IN HEALTH RESEARCH: DO DIFFERENCES IN HEALTH MEASURES, TECHNIQUES, AND TIME FRAME MATTER?

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Abstract

Survey-based health research is in a boom phase following an increased amount of health spending in OECD countries and the interest in ageing. A general characteristic of survey-based health research is its diversity. Different studies are based on different health questions in different datasets; they use different statistical techniques; they differ in whether they approach health from an ordinal or cardinal perspective; and they differ in whether they measure short-term or long-term effects. The question in this paper is simple: do these differences matter for the findings? We investigate the effects of life-style choices (drinking, smoking, exercise) and income on six measures of health in the US Health and Retirement Study (HRS) between 1992 and 2002: (1) self-assessed general health status, (2) problems with undertaking daily tasks and chores, (3) mental health indicators, (4) BMI, (5) the presence of serious long-term health conditions, and (6) mortality. We compare ordinal models with cardinal models; we compare models with fixed effects to models without fixed-effects; and we compare short-term effects to long-term effects. We find considerable variation in the impact of different determinants on our chosen health outcome measures; we find that it matters whether ordinality or cardinality is assumed; we find substantial differences between estimates that account for fixed effects versus those that do not; and we find that short-run and long-run effects differ greatly. All this implies that health is an even more complicated notion than hitherto thought, defying generalizations from one measure to the others or one methodology to another.

Keywords: Morbidity, Mortality, Lifestyle, Alcohol, Smoking, Exercise, Income

JEL Classifications: Z1, C23, C25, I31

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Introduction

An emerging economic literature uses survey data to examine the relationship between health outcomes (including death) and socioeconomic factors such as income, policy interventions, and lifestyle choices[1]. Importantly, there is little consensus among these studies over the direction and magnitude of these relationships, and over what are the short-term and long-term determinants of health. One reason for these differences is that these studies differ in terms of the set of health measures they examine, the statistical techniques they employ and whether they measure short-run or long-run effects.

This paper asks the 'robustness of findings' question: by how much do the estimates of specific control variables that are commonly used in the literature vary depending on the particular health measure used as the dependent variable, the type of statistical technique employed and the time span of the analysis? This question goes to the heart of the issue of whether the findings in one study, based on particular health questions and particular techniques, carry over to more general settings. To answer this question, we use the US Health and Retirement Survey (HRS) panel data. We focus on a set of explanatory variables that are of general interest to policy makers and health researchers. This includes income and three important lifestyle choices (smoking, drinking, and exercise). We investigate the effects of these explanatory variables on 6 different measures of health (stated health; mental health; difficulties performing several chores; Body Mass Index (BMI); doctor-assessed serious illnesses; and mortality). We use both cross-sectional and longitudinal statistical techniques, and we compare both short-term and long-term effects.

We will look at the following 4 robustness questions:

1. Does our set of control variables imply similar effects – in terms of the direction and significance – on all the six health outcome measures?

2. Does it matter whether one treats health as ordinal (which is when we can only say one health state is higher than another) or cardinal (which is when we can say one state is a specific amount better than another health state)?

3. Is it important to control for fixed traits of the respondent?

[1] Recent contributions looking at the relation between health and a variety of lifestyles and financial measures include Adams et al. (2003); Attanasio and Hoynes (2000); Benzeval et al. (2000); Benzeval and Judge (2002); Burstrom and Fredlund (2001); Case et al. (2004); Gerdtham and Johannesson (2004); Meer et al. (2003); Ruhm, (2000); Jones et al. (2004). A general introduction to this vast field, which now includes hundreds of studies, is in Jones (ed, 2007).

4. Do short-run effects differ from long-run effects?

We tackle each question in a separate section, where we firstly review the literature pertaining to that question and then present the results for our chosen set of control variables (income and the three lifestyle variables) on the six health outcomes in the HRS. In examining each of these questions, we start from what seems to be the dominant position in the literature and then introduce deviations from that dominant position. This requires us to first use *cross-sectional* techniques for the pooled total sample (no fixed effects) whilst interpreting health outcomes as ordinal variables and the coefficients as aggregate effects (without untangling short-run and long-run effects).[2] In later sections we then introduce cardinal models, consider fixed effects, and make a distinction between short-run and long-run effects. We may mention here that we do not wish to make any causal claims about the relationships found in this paper, i.e. we do not wish to claim that the results of this or that methodology represent 'the truth' whilst the rest is 'wrong'. We are merely interested in robustness.

The advantage of using a single data source extends beyond merely being able to study different health measures of the same individuals living at the same time in the same country. Importantly, using a single data set also means that one can use the same control variables for each individual health outcome. This in turn implies that we can eliminate that source of difference between estimates, a characteristic that sets this study apart from a literature survey which, by design, is hampered by the presence of different controls in the different published studies.

The papers closest to the present study are Jones and Schurer (2007) and Ferrer et al. (2004). Jones and Schurer (2007) compare the results of many different models of health satisfaction. They focus in particular on the importance of fixed effects for the results, applying the methodology introduced in Ferrer et al. (2004). Ferrer et al. (2004) go through a similar robustness exercise as this paper, but they focus on life satisfaction. The current paper expands on these two papers by looking at multiple, different, measures of health, by making the distinction between short-run and long-run effects, and by focussing on the predicted strength of lifestyle choices.

Our paper also relates to the medical and psychometric literature surrounding measurement, validity, and reliability (for a comprehensive treatment of these, see Trochim, 1996). Whilst the terminology of this paper centres around the word 'robustness' in the economic sense of the word, i.e. whether one gets the same research findings under different circumstances, it can also

be interpreted as an exercise in 'validity': asking whether different health measures correlate with behavioural choices in the same way is a form of 'convergent validity' (do different constructs measure the same thing); to ask if different patient- or doctor-generated health measures relate to behavioural choices in the same way as death does is a form of 'criterion related validity' (does one set of constructs measure the same things as a reliable other construct, i.e. death); asking whether different health measures pick up some 'known' health effect (such as the negative effect of smoking) is a form of 'content validity' (does a construct measure what we know it should measure). Where this paper differs from that literature is that it mainly asks whether these validity characteristics hold across different methodological choices.

The rest of the paper is organized as follows. Section 1 describes the data used and provides some descriptive statistics regarding the main variables of the interest. Section 1 also takes the opportunity of looking at the issue of construct reliability, including the internal consistency of the composite health measures we use. In sections 2-5, we investigate the 4 dimensions of robustness. Section 6 draws conclusions.

1. Data and Definitions

1.1. Data

The data used in this paper are drawn from the first six waves of the Health and Retirement Study (HRS). The HRS is a nationally representative biannual panel for the US, which surveys approximately 7,600 households with a primary respondent between the ages of 51 and 61 during the first year of the study. The first wave of the panel was conducted in 1992, so the primary respondents represent cohorts born between 1931 and 1941 and our sample covers the period 1992-2002. If an age-eligible primary respondent had a spouse or partner co-residing then the spouse or partner was also given the same individual level interview separately, regardless of his or her age. In collecting household level information, only one respondent is interviewed, generally the financially responsible member of the household. In addition to a large number of usual demographic characteristics such as race, education and marital status, the survey collects detailed information on the nature of retirement decisions, expectations, housing, income and wealth holdings, work history, family composition, and the availability of insurance and pensions. Of particular interest for the present analysis is that the HRS provides detailed information on each respondent's health and cognitive status.

[2] By using the term "*cross-sectional*", we mean "*the pooled total sample*" of the longitudinal data at hand, which ignores the panel aspect of the data and pools all observations into a single cross-sectional sample.

The HRS distinguishes death as a separate source of non-response. Our pooled sample has 58,422 year-person observations and an overall number of 1,248 deaths. The frequency of deaths in Wave 2 through Wave 6 is, respectively, 216, 233, 239, 270, and 290.

1.2. Defining Health Status

We use five alternative but clearly related measures of health status or morbidity, and supplement these by also capturing mortality directly.

As our first measure, survey respondents are asked to rate their current health status on the familiar 1-5 scale, where 1 = Excellent Health (16.7% of all pooled observations), 2 = Very Good Health (29.8%), 3 = Good Health (29.5%), 4 = Fair Health (16.2%) and 5 = Poor Health (7.7%). Our second measure is a composite index relating to the level of difficulty the respondent has in performing a number of normal day-to-day activities or tasks. Specifically, we count the number of affirmative answers to the following 11 questions regarding difficulty in performing tasks:

Whether the respondent has some difficulty with: Dressing (5.1%); Bathing (3.6%); Eating (1.4%); Getting in or out of bed (4.7%); Walking several blocks (19.2%); Sitting for two hours (18.6%); Getting up from a chair (30.0%); Climbing several flights of stairs (33.4%); Lifting 10lbs (17.6%); Extending arms (12.1%); Pushing or pulling large objects (18.8%).

Note that we make no attempt here to place differential weights on these tasks. Similarly, our overall mental health variable aggregates answers to the following questions, where coding is 0 for No and 1 for Yes, and the responses to the happiness and enjoyment items are counted as positive and the rest as negative:

Whether the respondent: Felt Depressed (13.5%); Everything was an effort (20.1%); Sleep was restless (26.4%); Was happy (86.1%); Felt Lonely (12.2%); Felt Sad (15.0%); Could not get going (17.3%); Enjoyed life (91.5%).

Our fourth health measure uses information on doctor-diagnosed health problems. In the HRS each individual is asked in each wave whether or not a doctor has ever told him or her that he or she had the following serious illnesses:

High blood pressure (41.1%); Diabetes (13.0%); Cancer (7.9%); Lung disease (7.8%); Heart problems (15.7%); Stroke (4.3%); Psychiatric problems (11.7%); Arthritis (46.8%).

Again, the coding takes a value of 0 for No and 1 for Yes, and our composite measure is the sum. Finally, Body Mass Index (BMI) is the respondent's self-reported weight (in kilograms) divided by his or her square of height (in meters). Since the vast majority of the sample has a BMI of over 20, we examine BMI as a linear variable: the issue that having a very low BMI is deemed unhealthy does not arise sufficiently often in the data to warrant investigation. Average BMI in the HRS is approximately 27, substantially above what is regarded as a normal BMI measure by the US Department of Health and Human Services.[3]

1.3. Defining Lifestyle Choice Variables

The HRS collects information on a number of individual health related lifestyle variables, of which we focus on three. These are smoking, alcohol consumption and regular exercise.

Our smoking variable is simply a binary indicator for whether or not the respondent currently smokes. In the pooled panel, approximately 22% of the sample falls into the current smoker category. When we look at the data wave by wave, it is notable that the smoking rate is relatively high in the first wave and there is a monotonically decreasing time trend in smoking prevalence over the sample period covered.

The questions relating to alcohol consumption asked in the HRS changed slightly between waves 1-2 and waves 3-6. To derive a consistent measure of drinking across all waves we create a drinking intensity variable which indicates the number of alcoholic drinks per week that the respondent consumes. In the pooled data, approximately 53 % of the individuals consume alcohol and the average number of standard drinks per week, conditional on drinking is 6.92.

Our regular exercise variable is also a binary indicator and shows whether the respondent participates in vigorous physical activity or exercise at least 3 times a week. However, the change in wording of the exercise questions between waves 1-2 and the rest of the data is slightly more problematic than for drinking. More explicitly, beginning from wave 3, the HRS asked each individual a single exercise question which is:

> *On average over the last 12 months have you participated in vigorous physical activity or exercise three times a week or more? By vigorous physical activity, we mean things like sports, heavy housework, or a job that involves physical labor.*

Our dummy variable for waves 3 through 6 is set to 1 if the respondent answered yes to this question, and 0 otherwise. For waves 1 and 2, we use answers to the following questions:

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[3] A BMI between 18.5 and 24.9 is considered normal, with 25-29.9 classified as overweight and 30+ classified as

Wave 1

Question 1: How often do you participate in vigorous physical exercise or sports -- such as aerobics, running, swimming, or bicycling? (Would you say 3 or more times a week, 1 or 2 times a week, 1 to 3 times a month, less than once a month, or never?)

Question 2: How often do you do heavy housework like scrubbing floors or washing windows?

Wave 2

How often do you participate in vigorous physical activity or sports - -such as heavy housework, aerobics, running, swimming, or bicycling?

For wave 1, the derivation of our exercise dummy combines the two questions. The physical exercise indicator is set to 1 if either response is three times or more a week. For wave 2, the derivation is based on the number of times and frequencies to arrive at a yes or no conclusion. The dummy variable is set to 1 if the person responds in terms of amount of exercise per day, or if the respondent answers 3+ times a week, 12+ times a month, or 156+ times a year. Given our definition, we observe that in 37 % of all person-year cases respondents exercise regularly at least three times or more per week.

Table A.1 in the appendix gives the means and standard deviations of all the variables used in the ensuing analyses. The socio-economic variables include the main ones used in panel analyses. The average age in the pooled data is 59, with more females (57%) than males (43%), a representative number of Hispanics (8%) and Blacks (15%), and with an average education level of 12 years.

1.4. Internal Consistency and Validity

In the appendix we also provide two correlation matrices that inform us about the internal consistency of our composite health measures. Table A.2 details the correlation amongst the difficulties with 11 normal daily activities that make up the variable 'difficulties with tasks'. As one can see, the correlation between each pair of self-reported task-related difficulties is positive and the vast majority of the coefficients ranges from 0.2 to 0.5, which provides some justification for adding them linearly together into a composite index.

Table A.3 details the 8 items that make up the 'mental health' scale. Again, the relations are as one would require: the 'negative' items all correlate positively with each other whilst

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obese.

correlating negatively with the 'positive' items of happiness and enjoying life. The internal correlations are of the same order of magnitude, giving some support for adding the negative items and subtracting the positive ones into a composite index.

Wallace and Herzog (1995) specifically examine the original reasons to include and keep the current set of health measures in the HRS data. On the basis of the correlation matrix between the various components of the health measures, they report 'a high rate of convergent, discriminant and construct validity'. For instance, each severe disease included into the HRS was found to plausibly correlate with physical self-reported health measures including 'Mobility difficulty', 'Large muscle difficulty', 'ADL difficulty' and 'poor vision'. These authors stress that the whole point of including so many different health measures into the HRS was in order to cover all aspects of health in one dataset.

From this study we take it as given that the health measures we use successfully capture important components of health and proceed to see whether they yield the same answers under different research methodologies.

2. Do the control variables have similar effects on each health measure?

A key issue in the health economics literature is whether different health measures tell the same story. For example, if self-stated health and mortality are affected by the same lifestyle variables to the same degree, then one can use results on either one of them to draw inferences about the other. If, on the other hand, different health measures give rise to very different stories, then one has to be far more careful in drawing general inferences about 'health' from looking at any single or even at a group of health variables. Knowing something about one health measure then says little about other health variables, meaning that the relevance of any finding on any single variable becomes far more limited. [4]

Since most empirical researchers have no influence on the construction of datasets, the health measures that they use are often not the ones that they might have chosen in an ideal world. Typically, cross-section and panel datasets will have only a few health questions, and these questions will differ from survey to survey. Cross-sectional surveys for instance invariably have no information on individuals who die in the survey year and hence inferences on mortality from cross-sectional data can only be made if there are health measures that are not just predictive of mortality but that are affected in roughly the same way as death by every health-related choice.

[4] Studies using the HRS have treated this issue in different ways. Adams et al. (2003) consider each dimension of health independently while they recognize that all indicators might be interrelated. Hurd and Kapteyn (2003) consider self-reported health status and Smith (2003) studies serious health conditions. Adda et al. (2003) and Michaud and Soest (2004) build a health index combining an array of indicators into one dimension.

Panel surveys differ in their coverage of health issues and differ in the wording of their health questions. For example, the US PSID panel dataset and the German Socio Economic Panel (GSOEP) have self-stated health every year but not doctor-assessed health or any of the other measures we include in this paper. The European Community Household Panel (ECHP) includes measures of mental health and self-reported physical limitations, but does not yet appear to have good mortality data. The British Household Panel Survey (BHPS) includes both self-assessed health, a measure of mental health, a list of physical disabilities, and a general health question based on 12 items ranging from sleep deprivation to being stressed (the GHQ12). The BHPS, however, lacks doctor-assessed health. The HRS doesn't have the GHQ12 but has the other variables. Moreover, the questions posed differ between these panels in terms of their wording and their scope. The self-assessed health variable in the BHPS, for instance, asks people to rate themselves relative to others of the same age whereas the self-assessed health variable in the ECHP is not age-related. The ECPH asks for physical limitations in a slightly different way to the HRS (the HRS asks whether people have difficulties doing certain tasks; the ECPH asks how well people can do things). Finally, wordings change over time within the same survey, such as in the BHPS where self-assessed health in the 9th wave was not related to 'health in the last 12 months' whereas self-assessed health in all other waves was related to health in the previous year. It is of practical importance to know whether all these differences matter.

We now do a brief survey on what the literature says about the effect of our 4 main control variables on different health measures.

Income

Attempts to understand different causal pathways through which socio-economic status and health affect each other have been numerous (see, for example, Smith, 1999 and Adler et al., 1994 for reviews). The effect of wealth, or more generally socio-economic status, on health have also been studied extensively in recent years (Adams et al., 2003; Adda et al., 2003; Hurd and Kapteyn, 2003; Meer et al., 2003; Michaud and Soest, 2004; Smith, 2003).

A typical finding of this group of studies is that higher income improves functional health, a number of chronic conditions, and self-rated health (see Robert and House, 1996, for instance). In their review of the recent literature, Frijters et al. (2005) report that there is a strong positive cross-sectional relationship between income and self-reported health. They confirm this finding using the GSOEP data. Frijters et al. (2007) find that higher incomes increase life expectancy, a result that concurs with many other studies. There has, however, been no positive relationship found for some health measures, like the GHQ12 (see for instance Clark and Oswald, 1994).

In summary, the literature leads us to expect income to improve most indicators of health.

Smoking

The consensus in the literature is that cigarette smoking is the leading cause of lung cancer deaths, of chronic bronchitis and a significant cause of heart disease and stroke (U.S. Department of Health and Human Services, 1989). Ezzati and Lopez (2003) estimate that there were up to 5 million premature smoking-related deaths in 2000 in the world. Yet, whilst the impact of smoking on life expectancy and various particular diseases has been extensively studied, much less is known about its effect on survey-based health measures. Smoking is known to reduce BMI by reducing appetite. Arday et al. (1995) find that smoking leads to respiratory tract symptoms and reduces self-rated physical health in a cross-section of adolescents. Johnson and Richter (2002) also find that smoking reduces self-perceived health in cross-sectional data. Whether smoking positively affects mental health is an open question. For a more detailed review on smoking and health, see Sloan et al. (2003 and 2004).

Given the consensus that smoking is bad for health, we expect to find smoking to worsen all health outcomes.

Drinking

There is much less consensus on the effects of drinking on health, relative to smoking. Di Castelnuovo et al. (2006) perform a meta-analysis of prospective studies on alcohol dosing and mortality and they find that low levels of alcohol intake (1-2 drinks per day for women and 2-4 drinks per day for men) are inversely associated with mortality. Moderate drinking (2 drinks per day for men and 1 drink for women) was associated with lower mortality rates compared to non-drinkers in the US (Liao et al., 2000) and the Netherlands (San Jose et al., 2000). Particular health benefits from drinking are reported for coronary disease and especially for type 2 diabetes (Caruso et al., 2000). Yet, Knupfer (1987) does not report any health benefits from drinking; drinking very infrequently has similar effects as drinking moderately, implying that the estimated benefits from drinking in other studies may be due to reverse causality (people drink if they are healthy). Indeed, Sturm (2002), using data from the US Health Care for Communities survey, finds significant negative influences from average drinking on physical health scales and on a number of chronic health conditions.

Hence for drinking there is strong reason to suspect that effects will differ in both sign and magnitude with respect to its influence on different health measures.

Exercise

Whilst exercise has long been thought to be good in terms of combating obesity and improving stamina, surprisingly little is known in terms of its effect on survey-based responses. Quittan et al. (1999)'s study is an exception. It looks at the impact of a three-month exercise program on the perception of quality of life in patients with chronic conditions and finds only weak correlations between parameters of physical performance and quality of life domains. Since they evaluate an actual intervention rather than non-experimental data, their findings strongly suggest that the relation between exercise and health, especially in the short-run, is more complicated than previously thought. What we also know from other studies is that exercise is strongly correlated with socio-economic status, making it hard empirically to say something about causality. Cutler and Glaeser (2005), for instance, find that the wealthier on average engage more in exercise and are less likely to be obese.

Exercise appears to be another lifestyle where robustness may be an issue.

Results for the HRS

Using the pooled total sample, the first set of results pertain to *cross-sectional models* without any differentiation between short- and long-run effects. We estimate ordered probit models for self-reported health, mental health, difficulties with chores, and doctor-assessed serious illnesses. As explained in the data section, our self-reported health measure is scaled 1 to 5 and thus is an ordered ordinal variable by definition. In order to estimate ordered models for mental health, difficulties with chores, and doctor assessed serious illnesses, we rank respondents based on the sum of their responses, as described in the data section. For BMI, a cardinal variable by definition, we use a simple least-squared analysis; for death, a binary variable, we use probit analysis. Table 1 below reports the coefficients on the 4 chosen control variables in each regression of the 6 health outcomes of interest, and their statistical significance. Results for the full set of covariates and their specifications are provided in the appendix at the end of the paper (see Table A.4).

Because this study is mainly concerned with *robustness* in terms of the *direction* of the relationship between independent variables and the dependent health measures, we simply report the coefficient estimates on our four key variables from the six regressions in this table and those following. Each of these significant coefficients implies a different marginal effect on the corresponding dependent variable. However, as the measurement scales across health measures

are very different, one needs to keep in mind that the implied marginal effects will not be readily comparable in terms of magnitudes.

Table 1: The Relationships between Income, Lifestyle Variables and Health Outcomes in the HRS Data 1992-2002 with Cross-Sectional, Aggregate Models

	Stated Health (+)	Difficulties with Tasks (-)	Mental Health (+)	BMI (-)	Serious Illnesses (-)	Death (-)
Log income at t	0.1161**	-0.0698**	0.0855**	0.0073	-0.0451**	-0.0164**
	(0.0034)	*(0.0034)*	*(0.0033)*	*(0.0076)*	*(0.0032)*	*(0.0082)*
No. of drinks at t	0.0081**	-0.0104**	0.0023**	-0.0026	-0.0087**	-0.0008
	(0.0008)	*(0.0008)*	*(0.0008)*	*(0.0023)*	*(0.0007)*	*(0.0022)*
Regular exercise at t	0.4326**	-0.4400**	0.1922**	-0.1336**	-0.2349**	-0.3228**
	(0.0093)	*(0.0099)*	*(0.0099)*	*(0.0204)*	*(0.0093)*	*(0.0307)*
Smoking at t	-0.1827**	0.1028**	-0.1658**	-0.7984**	-0.0277**	0.2734**
	(0.0109)	*(0.0113)*	*(0.0114)*	*(0.0416)*	*(0.0110)*	*(0.0288)*

** indicates significant at 95%. Standard errors are reported in parentheses. The (+) or (-) sign of the particular variables refers to the variables presumed relation with 'health'.

The main point to note in Table 1 is that the same explanatory variable differs in terms of the direction of influence on different health outcomes. This is particularly true for smoking and drinking. For smoking we find, on the one hand, that it seriously reduces stated health (-0.18), increases difficulties with tasks (+0.1), reduces mental health (-0.17) and makes death more likely (+0.27). On the other hand, smoking reduces BMI (which has been known for a long time) but also reduces the number of serious illnesses as measured by a doctor (by -0.03). For drinking we find, on the one hand, no significant effect on BMI or the probability of dying, while on the other hand improved stated health, fewer difficulties with tasks, improved mental health, and a reduced number of serious illnesses.

For income and exercise the results are more robust across health measures. For income we find a fairly robust improvement in all health indicators, i.e. better stated health (by +0.116), fewer difficulties with tasks (by -0.07), better mental health (+0.09), no significant effect on BMI, fewer illnesses (-0.05) and a reduced probability of death (-0.06). Regular exercise unambiguously improves all health indicators.

These results show that with standard ordinal cross-sectional techniques, different health indicators give conflicting results. This finding is particularly relevant if we reflect that hitherto in this literature, the results for one health outcome have sometimes been taken to say something about 'health' as a whole. Arday et al. (1995), for instance, focus on respiratory tract symptoms

and self-rated physical health status, but in their conclusion simply talk about the "health" consequences of cigarette smoking. Ellen (2001) looks at birth weight, but in the conclusions talks about "infant health" disparities. Similar conflations of particular measures with 'health' were found in all the other studies we reviewed above on the importance of lifestyle choices for health. Table 1 shows that the underlying presumption, i.e. that one measure of health is representative of health as a whole, is not so innocuous.

3. Does it matter whether we treat health as ordinal or cardinal?

In the majority of the health economics literature, health variables are measured on an ordinal scale: 'good health' is seen as better than 'average health', but not by a known amount. In this section, we ask whether it actually makes a difference if we simply impose cardinality on the health outcomes. To this effect we cardinalise the 4 ordinal non-mortality health outcomes. This implies that for self-reported health, we take the lowest possible answer as a 1, and the highest as a 5. The difference between a 4 and a 5 is then taken to be the same as the difference between a 1 and a 2. For the number of difficulties with chores, this means we simply add them up and see them as equally important. In keeping with looking at cross-sectional relationships at this point, we do not yet add fixed effects or differentiate between short-run and long-run effects.

Is the issue of cardinal versus ordinal relevant though? Is there any reason ex-ante to suspect that cardinality would make a big difference? For happiness, we know from Ferrer et al. (2004) that it makes virtually no difference whether we take the different happiness answers as ordinal or as cardinal. For health measures, however, we are not aware of a systematic study of this issue, although existing empirical studies employ both ordinal and cardinal techniques without much analysis on whether it matters. Arday et al. (1995) for instance use only ordinal techniques to analyse stated health, whilst Sturm (2002) and Graham and Schmidt (1998) use cardinal techniques on various self-stated health outcomes. Johnson and Richter (2002) and Robert and House (1996) do both but do not analyse the differences in tradeoffs. Given that literature employs both techniques, we think it is interesting and relevant in our study to examine the generalisability of cardinal to ordinal and vice versa.

In the papers cited above, we observe a cardinalisation of health measures when health is the dependent variable and when the study is longitudinal rather than cross-sectional. It is easy to implement cross-sectional discrete choice models such as ordered probit or logit when the analysis is cross-sectional, but it is not very convenient to use ordinal models for studies which aim at complicated health issues in a multinomial longitudinal framework. Moreover, it may be

necessary for researchers to appeal to a cardinalisation of health measures in order to reduce the dimensionality of a complicated structural model that is otherwise too hard to solve. A good example is Deaton and Paxson (1998) who look at a cardinal measure of dispersion in health by assigning numerical values to self-reported health status (SRHS) ranging from 1 (excellent) to 5 (poor). While their aim was not to analyse directly the determinants of cardinal health, they nevertheless implicitly employ a cardinalisation of the underlying health construct by interpreting these numerical values in terms of distances. In their case a cardinalisation was virtually unavoidable since their aim was to investigate 'health inequality' which by its very nature needs some notion of distance between various outcomes.

As an aside, when health is used as an independent variable, one usually sees dummy indicators being used for health measures, i.e. an indicator variable for whether the health outcome is above some verbal label (such as 'good'). This is often portrayed as an ordinal approach to health measurement, but this is not quite accurate: when one replaces a continuous underlying ordinal variable by a single dummy indicating whether it is above some common threshold, one implicitly assumes that the 'distance' between actual levels of the ordinal variable is mainly captured by whether it is above the threshold or not. Reducing an ordinal variable to a dummy introduces measurement error that at the very least leads to a downward bias in the coefficient, and at worst makes the result difficult to interpret (i.e. if the ordinal variable is correlated with the other variables in the regression there is not even a guarantee than the estimated sign of the variable measured with error is correct). The 'purist solution' would be to take account of the measurement error in the estimation via a simultaneous equations system but this is usually quite difficult to implement, leading to the widespread practice of putting in dummy variables in place of the underlying continuous variable. All this illustrates that in practise, cardinal assumptions are rife in health research, making it important to ascertain whether it matters.

We report the coefficients of the 4 control variables for each of the 4 health measures that were cardinalised - self-reported health, mental health, difficulties with chores, and doctor assessed serious illnesses. Our methodology involves a simple least-squares specification for the cardinal variables. Table 2 provides results for our key independent variable and compares the coefficients of these cardinal analyses with those found in the previous section using ordinal versions of these variables. Full results for the cardinal estimations are again provided in the appendix (see Table A.5).

Table 2 reveals several interesting results. One striking aspect is that the sign and statistical significance nearly always remain the same when we switch from ordinal to cardinal: out of 16

pairs of comparison (4 variables and 4 health outcomes), there are only 2 sign reversals, i.e. the effect of drinking on mental health turns from positive, significant under ordinality (+0.002) to negative, insignificant under cardinality (-0.0003) whilst the effect of smoking on difficulties turns from positive, significant under ordinality (+0.1) to negative, insignificant under cardinality (-0.01). There is no case where a significant and positive effect changes into a significant and negative effect, or vice versa. At first glance, this suggests limited robustness of the results with respect to cardinality.

Table 2: The Relationships between Income, Lifestyle Variables and Health Outcomes in the HRS Data 1992-2002 with Cardinal versus Ordinal Treatment

	Stated Health (+)		Difficulties with Tasks (-)		Mental Health (+)		Serious Illnesses (-)	
	Ordinal	Cardinal	Ordinal	Cardinal	Ordinal	Cardinal	Ordinal	Cardinal
Log income at t	0.1161**	0.0395**	-0.0698**	-0.0493**	0.0855**	0.0791**	-0.0451**	-0.0064**
	(0.0034)	*(0.0027)*	*(0.0034)*	*(0.0054)*	*(0.0033)*	*(0.0051)*	*(0.0032)*	*(0.0021)*
No. of drinks at t	0.0081**	0.0043**	-0.0104**	-0.0080**	0.0023**	-0.0003	-0.0087**	-0.0048**
	(0.0008)	*(0.0008)*	*(0.0008)*	*(0.0015)*	*(0.0008)*	*(0.0013)*	*(0.0007)*	*(0.0006)*
Regular exercise at t	0.4326**	0.1824**	-0.4400**	-0.3809**	0.1922**	0.1479**	-0.2349**	-0.0582**
	(0.0093)	*(0.0075)*	*(0.0099)*	*(0.0146)*	*(0.0099)*	(0.0140)	*(0.0093)*	*(0.0055)*
Smoking at t	-0.1827**	-0.0688**	0.1028**	-0.0152	-0.1658**	-0.1312**	-0.0277**	-0.1478**
	(0.0109)	*(0.0131)*	*(0.0113)*	*(0.0257)*	*(0.0114)*	*(0.0228)*	*(0.0110)*	*(0.0111)*

** indicates significant at 95%. Standard errors are reported in parentheses.

On closer inspection, an important difference shows up with respect to the monetary tradeoffs implied by the estimates of the lifestyle variables. These tradeoffs are calculated as the ratio of the coefficient of a variable to the income coefficient, which can be interpreted as shadow values of the lifestyle measure. Large changes in tradeoffs can be found across the serious illnesses specifications. For instance, the shadow value of another drink under ordinality is 0.2 (=-0.0087/-0.045), while under cardinality it is 0.8 (=-0.0048/-0.0064). The differences are less extreme for the stated health specifications. For stated health the shadow value of smoking under ordinality is -1.7 (=-0.1827/0.1161) while it is -1.6 under cardinality (=-0.0688/0.0395). In summary therefore, the are differences between ordinality and cardinality though mainly in terms of ratios and not in terms of sign and significance. These results are still somewhat surprising because such changes in coefficients and shadow values were not found for life satisfaction (Ferrer et al., 2004).

4. Does it matter whether we control for fixed effects?

An important statistical issue in health economics is whether there are unobserved, fixed (time-invariant), health-relevant respondent characteristics that lead to improved health and that are also related to the explanatory variables. The presence of such unobserved heterogeneity creates spurious non-causal relationships. Take for instance self-esteem, which is a variable not available in the HRS. We know that self-esteem greatly improves the immune system and therefore improves health. However, it may well be the case that self-esteem also reduces problems with drinking and smoking, improves the odds of getting better-paying jobs, and causes individuals to exercise more. If that were true, then the absence of self-esteem in our models would have rendered all the results in the previous sections of this paper spurious because we would have over-estimated the effects of our control variables on health. This type of problem is often referred to as the selection problem and one way to deal with it is to include fixed effects in the estimation procedures.

There are numerous occasions in survey-based health research where selection has been shown to be important. Frijters et al. (2005) for instance find that the cross-sectional relationship between income and self-reported health is much stronger than the effect over time once fixed effects are controlled for. Jones and Schurer (2007) find the same. Ferrer et al. (2004) also find that controlling for fixed effects makes a meaningful difference for happiness findings, indicating the importance of these unobserved factors that affect both happiness and other variables (including income).

In Table 3 we report the coefficients of longitudinal models for the 5 health outcome measures, controlling for fixed individual traits.[5] We exclude death which, by its very nature, does not lend itself to a fixed-effects analysis since people die only once. For BMI we estimate simple fixed-effects least-squares. For the remaining 4 ordinal health variables, we rely on the recently developed conditional fixed effects logit model (Ferrer et al., 2004), which has been used to study the effect of income on health satisfaction in the German Socio Economic Panel (Frijters et al., 2005). Specifically, this model is of the form:[6]

$$\begin{aligned} H_{it}^{*} &= x_{it}\beta + \delta_{t} + f_{i} + \varepsilon_{it} \\ H_{it} &= k \Leftrightarrow H_{it}^{*} \in [\lambda_{k}, \lambda_{k+1}] \end{aligned} \qquad (1)$$

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[5] In regards to the results for other explanatory variables included in the regressions, please see Table A.6 in the appendix.

[6] The model still has serious limitations, such as that the error term is presumed to be serially uncorrelated, that the thresholds are essentially taken to be common for all individuals, that there are no nonlinearities in the effect of independent variables, and that the individual fixed effect is independent of changes in other variables. All of these assumptions are questionable.

where H_{it}^{*} is a latent health variable corresponding to one of the self-assessed measures in our data; H_{it} is an observed ordinal indicator of health; λ_k is the cut-off point (increasing in k) for the attitudinal answers; x_{it} is observable time-varying characteristics; δ_t denotes time-varying general circumstances; f_i is an individual fixed characteristic; and ε_{it} is a time-varying logit-distributed error term that is orthogonal to all characteristics.

Our conditional estimator for δ_t and β maximises the following conditional likelihood:

$$L[I(H_{i1} > k_i),..,I(H_{iT} > k_i) \mid \sum_t I(\mathrm{H}_{it} > k_i) = c] = \frac{e^{\sum_{t=1}^{T} I(H_{it} > k_i) x_{it}\beta}}{\sum_{H \in S(k_i,c)} e^{\sum_{t=1}^{T} I(\mathrm{H}_{it} > k_i) x_{it}\beta}} \quad (2)$$

which is the likelihood of observing which of the *T* stated health outcomes of the same individual are above k_i, given that there are *c* out of the *T* outcomes that are above k_i. Here, $S(k_i, c)$ denotes the set of all possible combinations of $\{H_{i1},..,H_{iT}\}$ such that $\sum_t I(\mathrm{H}_{it} > k_i) = c$. Also, H_{it} is used to denote the random variable and H_{it} (in italics) the realization.

From equation (2), we see that the fixed effects have dropped out of this likelihood, yielding estimates for only δ_t and β. This model is an extension of the fixed-effect logit model by Chamberlain (1980). When some individuals only report values between 'bad' and 'very bad', for example, and others only between 'good' and 'very good', then using the same threshold for everyone cannot record changes for both groups of individuals. Those individuals then have to be dropped from the estimation procedure. With individual specific thresholds, all individuals whose health outcomes differ over time can be included. The most important advantage of this adaptation of the Chamberlain model is therefore that it allows us to use the vast proportion of the observations. This model is estimated by Maximum Likelihood in Gauss.

Table 3: The Relationships between Income, Lifestyle Variables and Health Outcomes in the HRS Data 1992-2002 with Fixed Effects Models

	Stated Health (+)	Difficulties with Tasks (-)	Mental Health (+)	Serious Illnesses (-)	BMI (-)
Log income at t	0.0097	-0.0067	0.0321**	0.0062	0.0218**
	(0.0094)	*(0.0091)*	*(0.0090)*	*(0.0387)*	*(0.0078)*
No. of drinks at t	0.0047	0.0010	-0.0026	-0.0230**	0.0050**
	(0.0029)	*(0.0031)*	*(0.0029)*	*(0.0088)*	*(0.0024)*
Regular exercise at t	0.3061**	-0.2979**	0.0625**	0.1480	-0.1068**
	(0.0250)	*(0.0258)*	*(0.0254)*	*(0.1034)*	*(0.0205)*
Smoking at t	0.2428**	-0.2768**	0.1375**	-0.4757**	-0.6180**
	(0.0535)	*(0.0536)*	*(0.0535)*	*(0.2182)*	*(0.0441)*

** indicates significant at 95%. Standard errors are reported in parentheses.

As with happiness and health satisfaction, we find that it matters whether we control for fixed effects or not. In various cases, we see reversals of sign compared to the results in Table 1.

We find that a higher income is no longer unambiguously health-improving when we add fixed effects. The effect of income on serious illnesses, for instance, has switched from -0.045 (Table 1) to a positive and insignificant coefficient of 0.0062. W also find it is no longer the case that more drinks improve all indicators of health. The effect of an increase in the number of alcoholic drinks consumed on mental health reverses in sign, becomes insignificant for stated health, and not only reverses in sign but becomes significantly positive for BMI. The effect of exercise on health outcomes also changes with the addition of fixed effects: regular exercise no longer reduces the number of serious illnesses but increases them.

The biggest changes arise for smoking. With fixed effects, smoking no longer significantly reduces stated health (by -0.18) but significantly improves it (by 0.24). Similarly, smoking no longer reduces mental health and increases the number of difficulties with tasks, but improves mental health and reduces the number of difficulties. Only in terms of its effect on BMI are the results qualitatively similar for smoking when fixed effects are added.

Adding fixed effects is found to make a substantive difference for all of the explanatory variables and the majority of the health outcomes. Moreover, nearly all semblance of robustness across health measures disappears: with fixed effects there is no explanatory variable that consistently significantly improves or worsens all health outcomes simultaneously.

5. Robustness of effects in the short-run versus the long-run.

The final robustness issue we address is whether the short-run effects of the explanatory variables differ from their long-run effects. Usually in cross-sectional analyses, one simply includes the contemporaneous indicator of income or life-style choices as an explanatory variable. Since these control variables are highly correlated over time (income or lifestyle behaviours do not change very quickly), the estimated effects represent an 'average' effect, including the short-run effect and the long-run effect. When we include fixed effects, we focus on the effects of changes in the control variables on changes in the outcome variables, which is a short-run effect. Fixed effect analyses therefore usually beget the short-run effect and take out any long-run effect.

In this section we want to untangle the time profile of effects. Since cross-sectional results and fixed-effects results differ strongly, there is a good reason to suspect robustness problems in terms of short-run versus long-run impacts. The literature also gives us good reasons to expect this. For instance, many of the hazards of smoking are long-term in the sense that smoking has been found to have a cumulative effect (Peto,1986). This leads us to expect a difference between the short-run and long-run effects of smoking.

In Table 4, we re-run the same specifications reported in Table 1 of the paper but we add three lags to each of the explanatory variables. Since waves occur once every two years, this means that the third lag refers to the value of the explanatory variable six years ago. This leads to a large loss of observations, since we need to drop three waves in order to create these historical variables.[7] We will interpret the coefficient on the third lag of these variables as the long-run effect and compare it with the coefficients on the shorter-run variables.

[7] The resulting sample size for the *pooled total sample* after dropping the first three waves and the full set of results for this section are provided in Table A.7 in the appendix.

Table 4: The Long-Run and Short-Run Relationships between Income, Lifestyle Variables and Health Outcomes in the HRS Data 1992-2002

	Stated Health (+)	Difficulties with Tasks (-)	Mental Health (+)	BMI (-)	Serious Illnesses (-)	Death (-)
Log income at t	0.0661**	-0.0424**	0.0682**	0.0040	-0.0076	-0.0353**
	(0.0063)	*(0.0064)*	*(0.0063)*	*(0.0133)*	*(0.0177)*	*(0.0062)*
Log income at t-1	0.0598**	-0.0451**	0.0367**	-0.0202	-0.0215	-0.0261**
	(0.0063)	*(0.0063)*	*(0.0063)*	*(0.0133)*	*(0.0165)*	*(0.0062)*
Log income at t-2	0.0483**	-0.0344**	0.0284**	-0.0434**	-0.0171	-0.0162**
	(0.0058)	*(0.0058)*	*(0.0058)*	*(0.0121)*	*(0.0145)*	*(0.0057)*
Log income at t-3	0.0515**	-0.0347**	0.0330**	-0.0268**	-0.0111	-0.0198**
	(0.0055)	*(0.0055)*	*(0.0055)*	*(0.0113)*	*(0.0137)*	*(0.0054)*
No. of drinks at t	0.0047**	-0.0071**	0.0020	-0.0054	-0.0120**	-0.0058**
	(0.0016)	*(0.0017)*	*(0.0016)*	*(0.0034)*	*(0.0048)*	*(0.0016)*
No. of drinks at t-1	0.0010	-0.0019	-0.0016	-0.0138**	0.0122**	-0.0015
	(0.0017)	*(0.0018)*	*(0.0018)*	*(0.0033)*	*(0.0037)*	*(0.0017)*
No. of drinks at t-2	0.0008	-0.0032	0.0013	-0.0147**	0.0057	-0.0027
	(0.0021)	*(0.0021)*	*(0.0020)*	*(0.0038)*	*(0.0059)*	*(0.0020)*
No. of drinks at t-3	0.0031	-0.0008	0.0015	-0.0232**	-0.0148**	0.0000
	(0.0020)	*(0.0021)*	*(0.0021)*	*(0.0045)*	*(0.0068)*	*(0.0000)*
Regular exercise at t	0.3872**	-0.4098**	0.2172**	-0.3375**	-0.3686**	-0.2405**
	(0.0151)	*(0.0156)*	*(0.0157)*	*(0.0325)*	*(0.0489)*	*(0.0149)*
Regular exercise at t-1	0.2170**	-0.2942**	0.1157**	-0.2525**	-0.1140**	-0.1849**
	(0.0151)	*(0.0156)*	*(0.0157)*	*(0.0336)*	*(0.0462)*	*(0.0150)*
Regular exercise at t-2	0.1694**	-0.1431**	0.0912**	-0.0807**	0.0175	-0.0795**
	(0.0152)	*(0.0158)*	*(0.0159)*	*(0.0313)*	*(0.0473)*	*(0.0151)*
Regular exercise at t-3	0.0993**	-0.0750**	0.0548**	-0.0024	0.0012	-0.0239
	(0.0156)	*(0.0163)*	*(0.0164)*	*(0.0300)*	*(0.0600)*	*(0.0155)*
Smoking at t	0.0581*	-0.0806**	0.0058	-0.8424**	0.0288	-0.1023**
	(0.0338)	*(0.0340)*	*(0.0341)*	*(0.0696)*	*(0.0847)*	*(0.0331)*
Smoking at t-1	-0.0742*	0.0447	-0.0794**	-0.4576**	0.0331	-0.0536
	(0.0388)	*(0.0392)*	*(0.0393)*	*(0.0689)*	*(0.1003)*	*(0.0380)*
Smoking at t-2	-0.0133	0.0058	0.0057	-0.2775**	-0.0484	-0.0023
	(0.0380)	*(0.0387)*	*(0.0380)*	*(0.0687)*	*(0.0968)*	*(0.0383)*
Smoking at t-3	-0.1654**	0.1235**	-0.1247**	-0.2490**	0.2963**	0.1166**
	(0.0317)	*(0.0323)*	*(0.0324)*	*(0.0657)*	*(0.0812)*	*(0.0313)*

* indicates significant at 90%; ** indicates significant at 95%. Standard errors are reported in parentheses.

From Table 4 we see substantial differences in the short-run and long-run effects for most of the control variables. Only for income do we find robust results - the coefficients of the contemporaneous variable and the lags have the same sign (except for the insignificant contemporaneous effect on BMI) and are generally of the same order of magnitude and significance.

For alcohol consumption, we can see both sign reversals and reversals of significance. For instance, whilst the contemporaneous number of drinks consumed has a significantly negative effect on the number of illnesses (-0.012), the number of drinks in the previous wave has a

significantly positive effect on the number of illnesses (+0.012). The long-run effect of more drinks on the probability of deaths (the effect of 3 waves previous) is +0.000 whilst the contemporaneous effect is significantly negative at -0.0058.

For smoking we find opposite signs for the contemporaneous effect versus the long-run effect for stated health, difficulties, mental health and death. For exercise we find no long-run effect on the number of serious illnesses and the probability of death, but strong short-run effects.

6. Conclusions

In this paper we have investigated the robustness of the determinants of various health measures using the HRS, which follows individuals biannually from 1992 to 2002. We examine 4 dimensions of robustness, i.e. were different health outcomes affected in the same way by our four key control variables; did it matter whether health variables were measured in ordinal or cardinal scale; was it important to control for fixed effects; and whether short-run effects were similar to long-run effects. Although our models controlled for many covariates, the key control variables we focussed on for this robustness exercise were income, smoking, drinking, and regular exercise. Our health outcomes included mortality and 5 other health measures (self-stated health, doctor-assessed health, mental health, BMI, and self-stated difficulty with chores).

We found that the some key control variables affected different health measures differently, particularly smoking. Smoking had a negative effect on mortality but improved self-stated health (both in the short and in the long-run), reduced the problems individuals have with chores, improved mental health, reduced the number of measured serious illnesses, and strongly reduced Body Mass Index (BMI).

We found that treating health variables as ordinal versus cardinal didn't make an enormous difference, but still a more marked difference than initially expected: we found sign reversals for 2 out of 16 variable-outcome combinations. Also, the monetary tradeoffs or shadow prices (the impact of a lifestyle choice divided by the income coefficient) differed substantially for about half the variable-outcome combinations.

We found that controlling for fixed traits made quite a substantial difference, especially for income and smoking. In the case of income, adding fixed effects took away significance for most health outcomes and reversed the sign on the number of serious illnesses (from reducing the number of serious illnesses without fixed effects to increasing them with fixed effects).

Finally, we found that short-run effects differed from long-run effects. With drinking and smoking, the long-run effect had the opposite sign of the short-run effect for most of the health outcomes. Also, while all short-run effects of exercise were significant, long-run effects became insignificant in the case of death and the number of serious illnesses.

In conclusion, our findings imply a lack of robustness in survey-based health research. Even when controlling for the same variables and using people from the same survey, we find large discrepancies in coefficients across different methodologies. The implication is that care should be taken not to generalise the findings of one health outcome to any other health outcome; care should be taken with respect to whether fixed traits are controlled for; and a distinction should be made between short-run and long-run effects.

There are at least two robustness issues this paper could not address. The first is whether subtle differences in the wording of questions matter, such as when health questions are framed relative to age or not. The second is whether the answers one gets from surveys tally with those of true experiments and hence whether any of the results reported in the analyses of surveys are causal. In order to answer the latter question, one would need data that combines an experimental intervention protocol on the explanatory variables of interest with 'standard' survey information about health status for a sufficiently large group of people followed over time.

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The Appendix

Table A.1: Descriptive Statistics of the Variables Used in the Regressions

Variable	Mean	Standard Deviation
Age	59.4534	6.4609
Female	0.5655	0.4957
White	0.8088	0.3933
Black	0.1549	0.3618
Hispanics	0.0845	0.2782
Years of education	12.1634	3.2039
No. of times married	1.3309	0.6962
No. of times divorced	0.4182	0.6884
Regular exercise at *t*	0.3681	0.4823
Regular exercise at *t-1*	0.3621	0.4806
Regular exercise at *t-2*	0.3418	0.4743
Regular exercise at *t-3*	0.3032	0.4597
Smoker at *t*	0.2175	0.4126
Smoker at *t-1*	0.2222	0.4158
Smoker at *t-2*	0.2271	0.4190
Smoker at *t-3*	0.2326	0.4225
No. of drinks at *t*	2.2656	5.9492
No. of drinks at *t-1*	2.2577	5.9353
No. of drinks at *t-2*	2.2413	5.8164
No. of drinks at *t-3*	2.2127	5.7375
Total household wealth	287386	875651
Log of household income at *t*	10.3301	1.4593
Log of household income at *t-1*	10.3433	1.4465
Log of household income at *t-2*	10.3467	1.4489
Log of household income at *t-3*	10.3433	1.4707
No. of kids	3.4110	2.1976
No. of siblings	2.9530	2.4928
Years of tenure in longest reported job	15.0338	11.5154
Total years of work	31.4340	13.9493
Managerial operator	0.1267	0.3327
Professional operator	0.1388	0.3457
Sales	0.0910	0.2876
Clerical/admin	0.1513	0.3583
Services: cleaning	0.0152	0.1222
Services: security	0.0149	0.1213
Services: food prep.	0.0326	0.1776
Health services	0.0241	0.1534
Personal services	0.0654	0.2472
Farming/fishing/forest	0.0278	0.1644
Mechanics/repair	0.0315	0.1748
Construction	0.0288	0.1674
Precision production	0.0332	0.1792
Machine operator	0.0707	0.2564
Transport operator	0.0432	0.2032
Other operators	0.0241	0.1533
No. of observations	58422	

Table A.2: The Correlation Matrix for the Components of Difficulties with Chores

Whether the individual had difficulty with	Dressing	Bathing	Eating	Getting in or out of bed	Walking several blocks	Sitting for two hours	Getting up from a chair	Climbing several flights of stairs	Lifting 10lbs	Extending arms	Pushing or puling large objects
Dressing	1.0000										
Bathing	0.4690	1.0000									
Eating	0.3302	0.3446	1.0000								
Getting in or out of bed	0.4275	0.4171	0.2880	1.0000							
Walking several blocks	0.3349	0.3177	0.1807	0.3242	1.0000						
Sitting for two hours	0.2298	0.1927	0.1122	0.2720	0.3228	1.0000					
Getting up from a chair	0.2771	0.2267	0.1370	0.2963	0.4089	0.4234	1.0000				
Climbing several flights of stairs	0.2238	0.2140	0.1159	0.2329	0.4970	0.2816	0.3976	1.0000			
Lifting 10lbs	0.3008	0.3135	0.1826	0.3260	0.4648	0.3264	0.3620	0.4040	1.0000		
Extending arms	0.2990	0.2973	0.1899	0.3245	0.3332	0.2884	0.3164	0.2777	0.3939	1.0000	
Pushing or pulling large objects	0.2942	0.2986	0.1775	0.3150	0.4497	0.3331	0.3703	0.4022	0.5901	0.4251	1.0000

Table A.3: The Correlation Matrix for the Components of Mental Health

Whether the respondent	Felt depressed	Everything was an effort	Sleep was restless	Was happy	Felt lonely	Felt sad	Could not get going	Enjoyed life
Felt depressed	1.0000							
Everything was an effort	0.4273	1.0000						
Sleep was restless	0.3366	0.3038	1.0000					
Was happy	-0.4168	-0.2568	-0.2207	1.0000				
Felt lonely	0.4556	0.3038	0.2740	-0.3248	1.0000			
Felt Sad	0.5619	0.3230	0.3135	-0.3765	0.4934	1.0000		
Could not get going	0.3435	0.4013	0.3248	-0.2318	0.2848	0.3111	1.0000	
Enjoyed life	-0.3328	-0.2218	-0.1845	0.5356	-0.2785	-0.3241	-0.2077	1.0000

Table A.4: The Full Set of Results for Ordinal, Cross-sectional, Aggregate Analyses

	Self-Assessed Health		Difficulties with Chores		Mental Health		Serious illness		Death	
	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
Age	-0.0165	-20.01	0.0189	22.06	-0.0093	-10.78	0.0419	49.96	0.0401	16.40
No. of times married	0.0267	2.39	-0.0420	-3.67	0.0922	7.96	-0.0165	-1.48	-0.0002	-0.01
No. of times divorced	-0.0945	-8.53	0.1358	11.93	-0.1822	-15.86	0.1356	12.31	0.1011	3.48
Regular exercise at *t*	0.4326	46.32	-0.4400	-44.28	0.1922	19.32	-0.2349	-25.17	-0.3228	-10.51
Smoker at *t*	-0.1827	-16.71	0.1028	9.06	-0.1658	-14.50	-0.0277	-2.51	0.2734	9.49
No. of drinks at *t*	0.0081	10.84	-0.0104	-12.74	0.0023	2.96	-0.0087	-11.42	-0.0008	-0.36
Total household wealth	0.0000	12.45	0.0000	-10.02	0.0000	9.09	0.0000	-9.41	0.0000	-5.51
Log of household income at *t*	0.1161	34.59	-0.0698	-20.69	0.0855	25.18	-0.0451	-13.68	-0.0164	-1.98
No. of kids	-0.0191	-8.97	0.0137	6.26	-0.0054	-2.42	0.0116	5.47	-0.0069	-1.20
No. of siblings	-0.0296	-16.36	0.0122	6.47	-0.0232	-12.20	0.0020	1.11	-0.0022	-0.42
Years of tenure in longest reported job	0.0018	4.11	-0.0035	-7.49	0.0036	7.49	-0.0007	-1.66	0.0054	4.13
Total years of work	0.0020	4.88	-0.0046	-10.87	0.0061	14.20	-0.0026	-6.24	-0.0084	-7.67
Managerial operator	0.6323	34.23	-0.6685	-32.99	0.4381	21.50	-0.5006	-26.88	-0.3424	-5.27
Professional operator	0.6477	36.76	-0.6183	-32.43	0.4480	23.09	-0.4576	-25.89	-0.5310	-7.36
Sales	0.5927	29.08	-0.6188	-27.96	0.4175	18.66	-0.5124	-24.83	-0.2919	-4.32
Clerical/admin	0.5739	33.88	-0.4612	-25.91	0.3302	18.16	-0.4036	-23.69	-0.5679	-8.18
Services: cleaning	0.2651	5.64	-0.1871	-3.88	0.1521	3.07	-0.1628	-3.45	-0.2388	-1.61
Services: security	0.3650	7.98	-0.5801	-11.63	0.2188	4.42	-0.2622	-5.71	-0.4050	-2.44
Services: food prep.	0.2824	8.33	-0.3392	-9.61	0.1351	3.80	-0.3424	-9.93	-0.5067	-3.87
Health services	0.3411	9.13	-0.3326	-8.55	0.1445	3.71	-0.2592	-6.88	-0.2195	-1.89
Personal services	0.2536	11.03	-0.3730	-15.39	0.1679	6.91	-0.3279	-14.03	-0.4187	-4.87
Farming/fishing/forest	0.2446	7.05	-0.4380	-11.64	0.1695	4.55	-0.4965	-13.95	-0.1868	-1.67
Mechanics/repair	0.3428	9.87	-0.5328	-14.01	0.2824	7.46	-0.4163	-11.76	-0.1475	-1.44
Construction	0.3577	10.20	-0.5571	-14.39	0.3363	8.76	-0.4724	-13.17	-0.4090	-3.05
Precision production	0.3680	10.55	-0.4442	-11.89	0.2507	6.66	-0.3275	-9.25	-0.2404	-2.17
Machine operator	0.2506	9.75	-0.4452	-16.25	0.1198	4.43	-0.3769	-14.38	-0.2567	-3.17
Transport operator	0.3333	11.96	-0.6025	-19.70	0.3077	10.14	-0.3765	-13.36	-0.4689	-4.36
Other operators	0.2415	6.01	-0.5555	-12.62	0.2015	4.73	-0.4118	-10.02	-0.2859	-2.14
Constant									-3.8303	-22.93
Log L	-82190.7		-95047.5		-85920.8		-87591.7		-5247.7	
No. of observations	58422		58422		58422		58422		58422	

Table A.5: The Full Set of Results for Cardinal, Cross-sectional, Aggregate Analyses

	Self-Assessed Health		Difficulties with Chores		Mental Health		Serious illness		BMI	
	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
Age	-0.0333	-35.44	0.0835	45.79	-0.0429	-26.16	0.0993	122.34	0.0401	13.06
No. of times married	0.0208	1.26	-0.0939	-2.91	0.1878	6.92	0.0000	0.00	0.0371	0.57
No. of times divorced	-0.1193	-7.26	0.3567	11.16	-0.3741	-13.90	0.1733	10.48	0.0096	0.15
Regular exercise at *t*	0.1824	24.22	-0.3809	-26.04	0.1479	10.53	-0.0582	-10.41	-0.1336	-6.53
Smoker at *t*	-0.0688	-5.22	-0.0152	-0.59	-0.1312	-5.73	-0.1478	-13.24	-0.7984	-19.17
No. of drinks at *t*	0.0043	5.23	-0.0080	-5.02	-0.0003	-0.23	-0.0048	-7.33	-0.0026	-1.10
Total household wealth	0.0000	6.30	0.0000	-4.10	0.0000	3.34	0.0000	-3.05	0.0000	0.27
Log of household income at *t*	0.0395	14.17	-0.0493	-9.10	0.0791	15.32	-0.0064	-3.04	0.0073	0.95
No. of kids	-0.0236	-7.35	0.0286	4.57	-0.0127	-2.41	0.0166	5.12	0.0854	6.83
No. of siblings	-0.0255	-10.49	0.0372	7.86	-0.0355	-8.63	0.0032	1.48	0.0340	4.12
Years of tenure in longest reported job	0.0011	1.61	-0.0066	-4.79	0.0042	3.69	-0.0024	-3.16	0.0093	3.14
Total years of work	0.0075	11.44	-0.0222	-17.40	0.0163	15.63	-0.0146	-18.85	0.0139	4.40
Managerial operator	0.3476	19.48	-0.6239	-17.99	0.4019	12.41	-0.1429	-10.31	-0.1043	-2.04
Professional operator	0.3568	19.63	-0.6088	-17.24	0.4338	13.32	-0.1142	-7.92	-0.1508	-2.83
Sales	0.3211	16.36	-0.6272	-16.43	0.4198	11.76	-0.1647	-10.85	-0.0888	-1.59
Clerical/admin	0.2839	16.62	-0.5058	-15.23	0.3724	12.10	-0.1245	-9.28	-0.1249	-2.52
Services: cleaning	0.1292	2.96	-0.4189	-4.94	0.2143	2.68	-0.0622	-1.87	0.0776	0.64
Services: security	0.2604	5.68	-0.6297	-7.06	0.2765	3.33	-0.1295	-3.62	0.1369	1.04
Services: food prep.	0.1773	5.12	-0.5928	-8.81	0.2339	3.74	-0.1401	-5.18	-0.2759	-2.77
Health services	0.1660	4.27	-0.7004	-9.26	0.2522	3.61	-0.1562	-5.10	0.0553	0.49
Personal services	0.1395	6.05	-0.4610	-10.28	0.2548	6.10	-0.1216	-6.76	-0.0431	-0.65
Farming/fishing/forest	0.1895	5.40	-0.5748	-8.42	0.3085	4.86	-0.1801	-6.56	-0.0656	-0.65
Mechanics/repair	0.2489	6.82	-0.6327	-8.92	0.3466	5.30	-0.1764	-6.08	-0.1300	-1.21
Construction	0.1969	5.71	-0.6746	-10.07	0.4248	6.81	-0.2149	-7.98	0.0389	0.39
Precision production	0.2393	6.83	-0.6051	-8.89	0.3128	4.93	-0.1335	-4.90	-0.0183	-0.18
Machine operator	0.1510	5.81	-0.6638	-13.14	0.2545	5.43	-0.1797	-8.82	-0.0436	-0.58
Transport operator	0.2465	8.66	-0.7428	-13.43	0.4598	8.95	-0.1452	-6.51	0.0410	0.50
Other operators	0.1855	4.94	-0.6449	-8.83	0.2981	4.34	-0.1432	-4.96	-0.2014	-1.90
Constant	3.5646	58.50	-1.7532	-14.80	1.7211	15.85	-3.8203	-75.68	24.2468	127.95
No. of observations	58422		58422		58422		58422		58422	

Table A.6: The Full Set of Results for Fixed-Effects, Aggregate Analyses

	Self-Assessed Health		Difficulties with Chores		Mental Health		Serious illness		BMI	
	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
Age	-0.0733	-15.87	0.1127	24.72	-0.1001	-22.09	1.6794	47.28	0.0286	7.66
No. of times married	-0.1540	-1.41	0.0877	0.74	0.4889	4.70	-1.0962	-3.52	0.3159	3.62
No. of times divorced	0.0875	0.83	0.0230	0.21	-0.0916	-0.91	-1.0680	-2.98	0.0366	0.43
Regular exercise at *t*	0.3061	12.24	-0.2979	-11.53	0.0625	2.46	0.1480	1.43	-0.1068	-5.19
Smoker at *t*	0.2428	4.53	-0.2768	-5.16	0.1375	2.57	-0.4757	-2.18	-0.6180	-13.99
No. of drinks at *t*	0.0047	1.61	0.0010	0.32	-0.0026	-0.89	-0.0230	-2.59	0.0050	2.01
Total household wealth	0.0000	0.90	0.0000	1.53	0.0000	-1.37	0.0000	1.99	0.0000	1.44
Log of household income at *t*	0.0097	1.03	-0.0067	-0.73	0.0321	3.56	0.0062	0.16	0.0218	2.79
No. of kids	-0.0221	-1.20	-0.0002	-0.01	0.0262	1.42	0.1728	1.84	0.0227	1.50
No. of siblings	-0.0136	-1.22	0.0210	1.89	-0.0202	-1.83	0.0028	0.05	0.0199	2.20
Years of tenure in longest reported job	-0.0001	-0.02	0.0069	1.36	-0.0184	-3.57	-0.0600	-3.63	0.0009	0.23
Total years of work	-0.0491	-7.10	0.0117	1.68	0.0095	1.40	-0.1298	-4.69	0.0549	10.10
Managerial operator	0.3835	5.92	-0.3745	-5.37	0.1246	1.85	-0.5385	-1.72	-0.0343	-0.66
Professional operator	0.4747	6.79	-0.4727	-6.48	0.3056	4.26	-0.7545	-2.25	-0.0654	-1.19
Sales	0.3497	5.03	-0.4535	-6.17	0.2242	3.13	-0.7304	-2.32	-0.0418	-0.73
Clerical/admin	0.3543	5.61	-0.3307	-5.24	0.2203	3.53	-0.4838	-1.64	-0.0753	-1.49
Services: cleaning	0.1831	1.23	-0.2335	-1.61	0.3715	2.47	-0.1278	-0.22	0.0249	0.20
Services: security	0.5323	3.19	-0.4791	-2.78	0.1314	0.78	-1.5411	-1.84	0.0875	0.65
Services: food prep.	0.4342	3.56	-0.4422	-3.59	0.2529	2.10	-0.6328	-1.17	-0.3098	-3.04
Health services	0.1944	1.38	-0.6069	-4.22	0.2637	1.99	-0.8101	-1.17	-0.1000	-0.86
Personal services	0.3297	3.96	-0.2696	-3.26	0.2252	2.77	-0.6452	-1.66	-0.1032	-1.52
Farming/fishing/forest	0.3574	2.84	-0.4112	-3.15	0.2463	1.96	-0.4681	-0.82	-0.0551	-0.53
Mechanics/repair	0.4628	3.48	-0.3369	-2.38	0.0360	0.26	-0.6799	-1.17	-0.1265	-1.15
Construction	-0.0198	-0.16	-0.3945	-3.04	0.2804	2.21	-0.8796	-1.45	0.0418	0.41
Precision production	0.4392	3.54	-0.4566	-3.55	0.1443	1.14	-0.8469	-1.58	0.0039	0.04
Machine operator	0.2205	2.39	-0.3628	-3.82	0.3108	3.34	-1.0314	-2.21	-0.0324	-0.42
Transport operator	0.5046	4.99	-0.7353	-6.78	0.5275	4.85	-0.7536	-1.72	-0.0328	-0.39
Other operators	0.4152	3.19	-0.4600	-3.33	0.0707	0.54	-0.1754	-0.29	-0.1852	-1.72
Log L	-19531.01		-18897.63		-19132.02		-1322.3359			
No. of observations	49666		47261		47365		34696		58422	

Table A.7: The Full Set of Results for Cross-sectional, Short-run and Long-run Effects

	Self-Assessed Health		Difficulties with Chores		Mental Health		Serious illness		Death		BMI	
	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
Age	-0.0055	-4.05	0.0068	4.89	0.0048	3.44	0.0313	23.17	0.0348	8.33	-0.0137	-2.38
No. of times married	-0.0576	-3.38	0.0188	1.09	0.0178	1.03	0.0508	3.05	0.0407	0.92	-0.1943	-2.03
No. of times divorced	0.0038	0.23	0.0535	3.16	-0.1033	-6.08	0.0557	3.40	0.0677	1.51	0.2705	2.8
Regular exercise at *t*	0.3872	25.59	-0.4098	-26.21	0.2172	13.83	-0.2405	-16.11	-0.3686	-7.54	-0.3375	-10.38
Regular exercise at *t-1*	0.2170	14.33	-0.2942	-18.85	0.1157	7.36	-0.1849	-12.34	-0.1140	-2.47	-0.2525	-7.51
Regular exercise at *t-2*	0.1694	11.14	-0.1431	-9.06	0.0912	5.75	-0.0795	-5.28	0.0175	0.37	-0.0807	-2.58
Regular exercise at *t-3*	0.0993	6.35	-0.0750	-4.60	0.0548	3.35	-0.0239	-1.54	0.0012	0.02	-0.0024	-0.08
Smoker at *t*	0.0581	1.72	-0.0806	-2.37	0.0058	0.17	-0.1023	-3.09	0.0288	0.34	-0.8424	-12.11
Smoker at *t-1*	-0.0742	-1.91	0.0447	1.14	-0.0794	-2.02	-0.0536	-1.41	0.0331	0.33	-0.4576	-6.64
Smoker at *t-2*	-0.0133	-0.35	0.0058	0.15	0.0057	0.15	-0.0023	-0.06	-0.0484	-0.50	-0.2775	-4.04
Smoker at *t-3*	-0.1654	-5.21	0.1235	3.82	-0.1247	-3.85	0.1166	3.73	0.2963	3.65	-0.2490	-3.79
No. of drinks at *t*	0.0047	3.02	-0.0071	-4.30	0.0020	1.29	-0.0058	-3.73	-0.0120	-2.50	-0.0054	-1.58
No. of drinks at *t-1*	0.0010	0.60	-0.0019	-1.06	-0.0016	-0.91	-0.0015	-0.89	0.0122	3.28	-0.0138	-4.2
No. of drinks at *t-2*	0.0008	0.39	-0.0032	-1.52	0.0013	0.64	-0.0027	-1.34	0.0057	0.97	-0.0147	-3.85
No. of drinks at *t-3*	0.0031	1.52	-0.0008	-0.38	0.0015	0.73	0.0000	-0.01	-0.0148	-2.18	-0.0232	-5.2
Total household wealth	0.0000	3.13	0.0000	-2.03	0.0000	2.40	0.0000	-3.55	0.0000	-3.25	0.0000	-0.82
Log of household income at *t*	0.0661	10.42	-0.0424	-6.67	0.0682	10.79	-0.0353	-5.70	-0.0076	-0.43	0.0040	0.3
Log of household income at *t-1*	0.0598	9.43	-0.0451	-7.14	0.0367	5.80	-0.0261	-4.22	-0.0215	-1.30	-0.0202	-1.52
Log of household income at *t-2*	0.0483	8.35	-0.0344	-5.96	0.0284	4.89	-0.0162	-2.86	-0.0171	-1.18	-0.0434	-3.58
Log of household income at *t-3*	0.0515	9.43	-0.0347	-6.34	0.0330	6.03	-0.0198	-3.69	-0.0111	-0.81	-0.0268	-2.37
No. of kids	-0.0150	-4.65	0.0096	2.92	-0.0021	-0.65	0.0068	2.13	-0.0198	-2.17	0.1388	6.86
No. of siblings	-0.0235	-8.56	0.0086	3.07	-0.0186	-6.58	0.0005	0.17	-0.0224	-2.55	0.0026	0.26
Years of tenure in longest reported job	0.0020	2.93	-0.0035	-5.00	0.0037	5.26	-0.0015	-2.34	-0.0015	-0.74	0.0104	2.39
Total years of work	-0.0011	-1.73	-0.0031	-4.93	0.0050	7.90	-0.0013	-2.12	0.0027	1.61	0.0080	1.93

Table A.7 (Continued)

Managerial operator	0.4787	15.85	-0.5171	-15.81	0.2869	8.86	-0.3933	-13.11	-0.4165	-3.51	-0.1294	-1.5
Professional operator	0.4950	17.81	-0.4997	-16.73	0.3270	10.93	-0.3890	-14.11	-0.5261	-4.48	-0.2581	-2.94
Sales	0.4910	15.15	-0.5300	-15.18	0.3093	8.91	-0.4735	-14.62	-0.3440	-3.02	-0.1210	-1.33
Clerical/admin	0.5030	18.76	-0.4045	-14.47	0.2618	9.29	-0.3558	-13.38	-0.6892	-5.53	-0.1904	-2.39
Services: cleaning	0.0328	0.42	-0.0189	-0.24	-0.0125	-0.16	-0.0156	-0.20	-0.2185	-0.87	-0.0465	-0.24
Services: security	0.2986	4.05	-0.4581	-5.81	0.1234	1.58	-0.2168	-2.97	-0.5428	-1.90	-0.0030	-0.01
Services: food prep.	0.2248	4.04	-0.2442	-4.27	0.0771	1.35	-0.3239	-5.81	-0.7681	-2.77	-0.4434	-2.56
Health services	0.3414	5.74	-0.2546	-4.15	0.0965	1.59	-0.2484	-4.19	-0.2954	-1.44	0.0055	0.03
Personal services	0.1767	4.78	-0.2304	-6.02	0.1223	3.18	-0.2951	-7.97	-0.5686	-3.50	-0.0580	-0.54
Farming/fishing/forest	0.0895	1.58	-0.2023	-3.35	-0.0087	-0.15	-0.3552	-6.24	-0.2122	-1.01	-0.0585	-0.35
Mechanics/repair	0.1482	2.43	-0.3400	-5.17	0.1107	1.71	-0.2618	-4.29	-0.0470	-0.27	-0.0172	-0.09
Construction	0.1561	2.63	-0.2641	-4.13	0.1686	2.66	-0.3371	-5.65	-0.3519	-1.53	-0.1893	-1.16
Precision production	0.2152	3.56	-0.2415	-3.82	0.0914	1.45	-0.1420	-2.36	-0.2002	-1.03	-0.2052	-1.18
Machine operator	0.0867	1.92	-0.2103	-4.48	0.0183	0.39	-0.2486	-5.50	-0.1818	-1.29	-0.0416	-0.32
Transport operator	0.2249	5.05	-0.3924	-8.24	0.2098	4.41	-0.2000	-4.53	-0.5376	-2.99	0.1666	1.29
Other operators	0.0617	0.95	-0.3430	-4.91	0.1715	2.50	-0.3280	-4.99	-0.4774	-1.75	-0.0772	-0.45
Log L	-35066.6		-43826.3		-40239.5		-40535.2		-2191.6			
No. of observations	25590		25590		25590		25590		17744		25590	