Taking the Pulse of Nations:
A Biometric Measure of Well-being

David G. Blanchflower
Bruce V. Rauner '78 Professor of Economics
Dartmouth College, Hanover, NH 03755-3514
Adam Smith School of Business, University of Glasgow and NBER
blanchflower@dartmouth.edu

Alex Bryson
Professor of Quantitative Social Science
UCL Social Research Institute
University College London, 20 Bedford Way, London WC1H 0AL
a.bryson@ucl.ac.uk

21st March 2022

Abstract

A growing literature identifies associations between subjective and biometric indicators of wellbeing. These associations, together with the ability of subjective wellbeing metrics to predict health and behavioral outcomes, have spawned increasing interest in wellbeing as an important concept in its own right. However, some social scientists continue to question the usefulness of wellbeing metrics. We contribute to this literature in three ways. First, we introduce a biometric measure of wellbeing – pulse – that hs been little used. Using nationally representative data on 165,000 individuals from the Health Survey for England and Scottish Health Surveys we show that its correlates are similar in a number of ways to those for happiness, and that it is highly correlated with wellbeing metrics, as well as self-assessed health. Second, we examine the determinants of pulse rates in mid-life (age 42) among the 9,000 members of the National Child Development Study , a birth cohort born in a single week in 1958 in Britain. Third, we track the impact of pulse measured in mid-life (age 42) on health and labor market outcomes at age 50 in 2008 and age 55 in 2013. The probability of working at age 55 is negatively impacted by pulse rate a decade earlier. The pulse rate has an impact over and above chronic pain measured at age 42. General health at 55 is lower the higher the pulse rate at age 42, while those with higher pulse rates at 42 also express lower life satisfaction and more pessimism about the future at age 50. Taken together, these results suggest social scientists can learn a great deal by adding pulse rates to the metrics they use when evaluating people's wellbeing.

JEL Codes: I10; J1
Key words: pulse; wellbeing; mental health; general health; life satisfaction; paid work; life-course; birth cohort; NCDS.

Acknowledgements:
Alex Bryson thanks the Health Foundation for funding (grant number 789112). We thank Andrew Steptoe for his comments and the ESRC Data Archive for access to the National Child Development Study data.

1. Introduction

For decades economists eschewed the study of subjective wellbeing and were dismissive of endeavors to understand its correlates or use wellbeing metrics in economic analysis. They were content to leave the analysis of individuals' reports of their own subjective well- and ill-being to psychologists. That changed when, in 1978, Richard Freeman showed that job satisfaction was a strong predictor of quits (Freeman, 1978). For the first time economists became interested in the potential that happiness and life satisfaction might have in predicting economic behavior. It was apparent from Freeman's work, and indeed subsequent studies on quit behavior (eg. Green, 2010), that wellbeing scores variously measured contained information which could help predict economic behaviors.

Economists' interest grew as it became increasingly apparent that how people felt about themselves and the situations they faced could help explain departures from standard models of rational economic behavior. These insights, captured in the work of psychologist Daniel Kahneman and recognized in his 2002 Nobel Prize in economics, marked the advent of behavioral economics. At the same time economists began to argue that "*for many purposes, happiness or reported subjective wellbeing is a satisfactory empirical approximation to individual utility*" (Frey and Stutzer: 2002: 408). Evidence in support of this proposition came from new research measuring experienced utility, initially captured using day reconstruction methods (DRM) with time use data, and more recently in experience sampling methods (ESM) relying on responses to smartphone prompts. Both types of study have indicated that periods of work are ranked low relative to other activities in daily life, consistent with the standard assumption in neoclassical labor supply theory that, holding income constant, work is a disutility (Kahneman et al., 2004; Bryson and MacKerron, 2017).

The centrality of subjective wellbeing to new economic thinking is perhaps best encapsulated in the work of Richard Layard who argued that the happiness of its citizens should be a key objective for government, and should drive policymaking (Layard, 2005). This challenge has been taken up subsequently by governments and is reflected in the work of the Sarkozy's Commission on the Measurement of Economic Performance and Social Progress in France, prompting the OECD's Better Life Initiative for Measuring Well-being and Progress and annual progress reports from the World Happiness Report (https://worldhappiness.report/).

In this paper we argue that wellbeing indicators remain important for economists, in part because they are correlated with and can predict health and labor market outcomes, but also in their own right. However, we argue that these should be supplemented with a biometric indicator, pulse rate, which has been examined relatively little in the literature as it is included in relatively few surveys. Like unhappiness, pulse is relatively easy to measure, but it has the advantages of being a cardinal scale and a biomarker which, as the literature in Section Two illustrates, is associated, and predictive of, a range of health conditions.

Our empirical analyses tackle three issues. First, using nationally representative data for the Health Surveys for England and Scotland and the National Child Development Study (NCDS), we show that pulse rate equations look similar to wellbeing equations. They have similar correlates: pulse rates are higher among women, single people, the widowed, the unemployed and disabled, the least educated, smokers and drinkers, and those with low income. We also find that those with

higher BMI have lower wellbeing consistent with the findings of Wootton, et al (2008) that a higher BMI has a causal relationship with lower happiness and life satisfaction. Pulse rates also vary by area being lowest in prosperous areas and higher in deprived areas. A pulse equation looks much like a GHQ36 equation. This helps validate happiness and unhappiness measures. However, unlike mental and general health, pulse rate falls monotonically with age.

Second, we consider the predictive value of pulse for wellbeing, general health, employment and optimism about the future in subsequent years. We do so with pulse rate data from 9000 members of the NCDS, a birth cohort who were born in a single week in 1958 in Britain. We track the impact of pulse rate measured in mid-life (age 42) on health and labor market outcomes five to ten years later. We find that pulse measured in mid-life is predictive of wellbeing, employment and optimism about the future five to ten years later, even when controlling for lagged dependent variables, health-related behaviors and other biomarkers such as BMI, height and birth weight.

The remainder of the paper proceeds as follows. Section Two reviews the literatures on happiness metrics and their correlates, the association between pulse, happiness and unhappiness, and the literatures on the role of wellbeing indicators – subjective and biometric – in predicting health, labor market and attitudinal outcomes. Section Three introduces our data and estimation methods. Section Four presents results before we discuss the implications of our findings in Section Five.

2. Literature

We discuss four related literatures. First, we review the debate about the validity of wellbeing as indicated by its predictive capacity. Second, to establish whether pulse equations look like unhappiness equations we review the demographic, behavioral and biometric correlates in the literature.[1] Third, we consider the literature to date on the relationship between pulse and other wellbeing metrics. Fourth, we review the single study we found examining the association between pulse and labour market status.

The debate regarding the validity of wellbeing metrics has been reignited recently by Bond and Lang (2019) who find that key empirical regularities in the wellbeing literature cannot be replicated using non-parametric identification techniques due to assumptions regarding the underlying functional form of the ordered responses which are usually elicited in survey questions about wellbeing. They directly challenge Ferrer-i-Carbonell and Frijters' (2004) claim, based on the fact that the correlates of wellbeing are similar regardless of functional form assumptions, that these assumptions are innocuous. In turn, others have challenged this critique. For instance, Chen et al. (2021) argue the critique does not hold if one focuses on ranking median happiness as opposed to mean happiness, while Montgomery (2022) shows the critique can be addressed using anchoring vignettes or memories. There are a series of other contributions to this debate including Kaiser and Vendrik (2020), Allin and Hand (2017), Lindqvist, Östling and Cesarini (2020), and Liu and Netzer (2020).

However, a broad literature suggests wellbeing metrics have predictive validity because they predict important outcomes for individuals over time. In addition to the association between job satisfaction and quit behavior (Freeman, 1978; Green, 2010) mentioned above, economic studies

[1] Since ours are individual-level data we do not discuss the role of job quality or experiences in the workplace which are also known to affect worker wellbeing. For a review of these literatures see Bryson et al. (2014).

also point to the value of wellbeing in improving workplace performance. Using linked employer-employee panel data for Britain, Bryson et al. (2017) show that increases in mean workplace job satisfaction were positively associated with improvements in managerial assessments of workplace performance. Their differencing estimator overcomes potential confounding from fixed workplace traits since it relies on within-workplace variance over time. They also perform tests to discount the possibility of reverse causality, concluding:

"*The findings suggest that there is a prima facie case for employers to maintain and raise levels of job satisfaction among their employees. They also indicate that initiatives to raise aggregate job satisfaction should feature in policy discussions around how to improve levels of productivity and growth*" (p. 1017)

At the individual level, Oswald et al.'s (2015) laboratory experiment which randomly assigned happiness through a comedy intervention found happiness was causally linked to improved labor productivity in a real effort setting. Most of the literature on the predictive power of wellbeing data focuses on health-related outcomes. Happy people Duchenne smile more (Sheldon, Corcoran and Sheldon, 2021). Subjective wellbeing has been causally linked to longevity (Diener and Chan, 2011), wound healing (Christian et al., 2006) and improved cardiovascular health.[2] There is also evidence that the taking of anti-depressant medications is hump-shaped in age, tracking the hill-shape observed in unhappiness data as reported in Blanchflower and Oswald (2016), Blanchflower and Graham (2021a) and Blanchflower and Bryson (2021b). This is another type of validation of wellbeing data.

Subjective wellbeing is multi-dimensional. One might therefore expect to see differences in the correlates of, for example, experienced utility in the moment on the one hand, and eudemonic wellbeing on the other, since the latter involves individuals evaluating their experiences over a longer time frame. This is apparent, for example, with respect to paid employment, discussed below. Notwithstanding this, there are a number of empirical regularities that have emerged from the literature.

Perhaps the most striking, and one of the least well-understood, is the mid-life dip in wellbeing. In their review of the literature, Blanchflower and Graham (2021a) identify 375 studies indicating that wellbeing is U-shaped in age, and that the drop is substantial, akin to an event such as losing a spouse or becoming unemployed.[3] Interestingly, the happiness of great apes (assessed by keepers) is similarly U-shaped in age (Weiss et al., 2012).

The literature examining the wellbeing of men and women is inconsistent, with studies producing conflicting results (see Batz and Tay, 2018 who review individual studies and meta-analyses and Stevenson and Wolfers 2009). There is emerging evidence to suggest that women are more likely to be at the extremes of the happiness spectrum when compared with men such that women are both more likely than men to be happy, but also more likely to be unhappy. For example, the UK Office of National Statistics includes four well-being questions in its main labor market survey the

[2] For reviews of the literature see De Neve et al. (2013) and Steptoe (2019)'s more circumspect reflections on the state of the literature.

[3] The number of studies identified has since increased to 578 and counting see https://cpb-us-e1.wpmucdn.com/sites.dartmouth.edu/dist/5/2216/files/2021/11/575-u-shapes.pdfc

Labour Force Survey (for a discussion see Allin, P. and D.J. Hand, 2017). It reports that in the raw data females have higher levels of life satisfaction; happiness and worthwhileness as well as higher levels of anxiety.[4]

The more highly educated are healthier than the less educated, even when one nets out the positive effect of income on health. There is some debate as to whether this education effect is causal, with some maintaining that a causal effect is apparent and leads to healthier behaviours (Viinikainen et al., 2021). However, higher education is often correlated with lower life satisfaction and satisfaction with other facets of life, perhaps because the more highly educated have greater expectations of what their lives will be (Kristoffersen, 2018). Plus happy people live longer (Hudomiet et al, 2021).

Whilst higher education can translate into higher income, income has its own independent association with wellbeing. The relationship between income and evaluative wellbeing is log-linear whereas early research suggested the relationship between income and experienced wellbeing was hill or hump shaped, rising up to a certain point beyond which the marginal returns to income diminish (Kahneman and Deaton, 2010). However, Killingsworth (2021) has recently revisited the issue and concludes that, based on 1,725,994 experience-sampling reports from 33,391 employed adults in the United States, both experienced and evaluative wellbeing increase linearly with log(income), directly contradicting the earlier research. Of particular note for our study, Johnston et al. (2009) find no evidence of an income/health gradient using self-reported hypertension as a wellbeing metric but a sizeable gradient when using objectively measured hypertension. The authors conclude that self-reported health measures may underestimate the true income-related inequalities in health.

There is evidence that happiness depends on relative rather than absolute income (Easterlin (1974, 2015) and Frank (2004) and as a consequence happiness over time tends to be flat in the United States (Blanchflower and Oswald, 2004). Height is known to be positively correlated with income and taller worlers earn more (Bossavie, Alderman Giles and Mete, 2021. Case and Paxson, 2008. and Blanchflower and Sergant, 1994). However Komlos and Lauderdale (2007) note there has been a relative decline in height in the United States where heights stabilized at mid-century and a two-decade period of stagnation set in with the birth cohorts 1955-1974, concurrent with continual rapid increases in heights in western and northern Europe. The authors note that Americans had been the tallest in the world for more than two centuries until World War II, but by the end of the 20th century had fallen behind many European countries.

There are a number of states that people enter which event studies indicate raise their happiness although habituation to the new state can lead to some attenuation in the effect, whereas leaving that state can lead to reduced wellbeing, although studies indicate some mean reversion after a

[4] For example for the period September 2012-September 2017 the ONS reported the average scores for men and women as follows for the four variables scored on a 10-point scale;
1) Life satisfaction, M=7.40 F=7.49;
2) Happiness M=7.27 F=7.33;
3) Worthwhileness M=7.58 F=7.82
4) Anxiety M=2.94 F=3.16.
https://www.ons.gov.uk/peoplepopulationandcommunity/wellbeing/datasets/personalwellbeingestimatesbyageandsex

period. For instance, marriage leads to increased life satisfaction, whilst divorce or widowhood reduces life satisfaction for a while before individuals become habituated to their new state, which leads to mean reversion, though there is some heterogeneity across individuals (Lucas et al., 2003). Similar effects are observed with respect to negative health shocks, such as disabling injuries or accidents, which result in substantial falls in happines and life satisfaction followed by some (albeit incomplete) mean reversion (Oswald and Powdthavee, 2008).

Associations between paid employment and wellbeing also vary according to the wellbeing dimension under consideration. It is invariably positively and significantly associated with life satisfaction (Bryson et al., 2014), and the loss of paid work through unemployment has a large negative impact on life satisfaction (Lucas et al., 2004). The positive association with paid work persists even controlling for income, suggesting the wellbeing effects of paid work are not confined to the utility derived from income. However, the wellbeing effects of jobs differ with job quality: those with poor quality jobs suffer greater anxiety and stress, for example (Bryson et al., 2016). Furthermore, paid work is negatively correlated with individuals' momentary wellbeing (Kahneman et al., 2004; Bryson and Mackerron, 2017). In Bryson and Mackerron's (2017) study work comes second bottom only to being sick in bed in terms of momentary happiness, something which the authors interpret as evidence of the disutility of work in the moment.

Conversely, event studies show losing a job and becoming unemployed is particularly problematic. Indeed, it is one of the few events from which individuals' eudemonic and reflexive wellbeing does not recover, until it is reversed through re-employment (Clark and Georgellis, 2013).[5] There is some evidence that happiness deteriorates with downturns in the business cycle, though the effects tend to be short-lived (Deaton, 2012). Using repeat cross-section data from the Health Survey for England over the period 1991-2010 Katikireddi et al. (2012) show the mental health of men, measured with the GHQ score, in Britain deteriorated after the Great Recession of 2008, but women's mental health was unaffected.

Many studies indicate that poor health behaviours such as smoking and drinking are linked to lower wellbeing. For example, in their study using the Health Surveys for England for 1998-2006, Blanchflower et al. (2011) find happiness is negatively associated with smoking. Conversely, good heath behaviours, such as the consumption of fruit and vegetables, are positively associated with happiness The same is true of physical exercise, which is associated with positive affect even in healthy people (Buecker et al., 2020).

The literature on links between wellbeing and biometric wellbeing is still relatively new. It tends to find clear associations between biometric wellbeing measures and contemporaneous wellbeing. For instance, BMI is associated with lower happiness (Blanchflower et al., 2011). Associations in longitudinal studies are less clear-cut. Using the data we use in this study, Blanchfower and Bryson (2021a) show chronic pain in mid-life is associated with depression, emotional and psychiatric problems a decade later. Yet, using the Young Finns Study (N=1905), Böckerman et al. (2017)

[5] The unemployed are able to find coping strategies, however. They exploit their free time by shifting towards more enjoyable activities, subject to their budget constraints, thus closing the momentary wellbeing gap on those in paid employment who do not have the same free time (Knabe et al., 2010).

found no robust association between eight biomarkers measured in childhood (1980) and happiness in adulthood (2001).[6]

3. The Association Between Pulse and Wellbeing

The literature on factors leading to high blood pressure are discussed in Godoy et al (2007). They note that blood pressure reflects conditions during a person's early years. Adverse socioeconomic conditions during childhood increase the risk of coronary heart disease in adulthood. Impaired fetal development, maternal smoking during pregnancy, absence of breast-feeding, and high salt consumption as an infant all appear to have a positive association with blood pressure as an adult. Huxley et al. (2000) conclude from literature reviews that birth weight has a negative association with adult systolic blood pressure. This is confirmed by Law and Shiell (1996), and Salmi and Hannawi (2020).[7]

Few studies though consider the correlation between pulse and wellbeing. Among those that do are studies seeking to establish whether affect is associated with underlying health. These studies are motivated by the literature showing raised heart rate – and higher blood pressure – are risk factors for coronary heart disease (Kannel et al., 1987). There is also emerging evidence that wellbeing may be a protective mechanism against cardiovascular disease (Sin, 2016).

In the study for Finland, Böckerman et al. (2017) found a positive correlation between pulse in childhood (1980) and happiness in adulthood (2001) with a one standard deviation increase in pulse associated with a 0.6 point increase in a 5-point happiness scale. Although the correlation remains positive and statistically significant when conditioning on other biomarkers, contemporaneous education and earnings, and family income as a child, it loses statistical significance when conditioning on physical activity and childhood consumption of fruit, vegetables, and carbohydrates.

A series of studies by Andrew Steptoe and colleagues using samples from the Whitehall II studies of British civil servants suggest positive wellbeing is associated with health-relevant biological processes. These studies include investigations of links between heart rate and wellbeing both contemporaneously and in a three year follow-up.

In their study of 216 middle-aged men and women from the Whitehall II study Steptoe and Wardle (2005) and Steptoe et al. (2005) found greater happiness – assessed through repeated measurements over the course of the working day – was associated with a lower heart rate among men, but not women. The association was apparent controlling for age, grade of employment, smoking, BMI, physical activity levels and GHQ36 scores. Happiness was not associated with ambulatory systolic blood pressure. A follow up on a non-random subset of cases (N=162) found happiness at baseline predicted lower heart rate 3 years later among men. The follow up also found a significant inverse association between happiness and systolic blood pressure. Commenting on

[6] Genome-wide studies have recently investigated genetic variants associated with happiness (Okbay et al., 2016) while Weiss et al. (2002) show that wellbeing is heritable in great apes.

[7] Lipowicz (2007) found that there was a rise in hypertension during the transition years after the fall of the Berlin Wall, in Poland. This was true irrespective of age, marital status, education, degree of urbanization, lifestyle variables (smoking, drinking alcohol, and physical activity), and BMI the risk of hypertension after 1989 was higher than before transformation.

the gender differences in results they say: "*the explanation of the gender difference in heart rate is not clear, but observational epidemiological studies have shown consistent associations between mortality and heart rate more in men than women*".

In a large study of Whitehall II participants (n=4,754) in their sixties tracked 5 years later, Ikeda et al. (2020) examine links between aortic stiffness –an aspect of cardiovascular disease – and affective wellbeing and eudaimonia. Aortic stiffness is measured by aortic pulse wave velocity (PWV). They find eudaimonic wellbeing items relating to control, autonomy, personal growth and self-realization was correlated with lower PWV at baseline and PWV 5 years later captured with the interaction of wellbeing and time lapsed before next measurement, but only in men, while affective wellbeing (the pleasure in life sub-scale of CASP-19) is not associated with PWV.

This study, like others, suggests a negative correlation between happiness and cardiac function in men but not women. They say: "*In the present study, eudaimonic wellbeing in men, but not in women, was associated with a favorable atherosclerosis risk profile, characterized by lower BMI and HR and lower hypertension medication use. However, our present findings were maintained after adjusting for an array of social, behavioral, and biologic factors, suggesting that other mechanisms linking wellbeing with these biological alterations may explain the observed sex differences*". One of the controls in their models is resting heart rate, but little attention is paid to the link between pulse rate and aortic stiffness. However, in their supplementary material, it seems heart rate falls as eudaemonia rises in both men and women (Ikeda et al., 2020: Table S3).

Wells and Townsend (2020) note that there are three aspects of pulse that are potentially related to cardiovascular function. These are rate, regularity and quality.[8] In our empirical estimates we focus on pulse rate. Sloan et al. (2017) examine correlations between wellbeing and heart rate variability or regularity: they find no association between heart rate variability and positive affect and eudaimonia. However, Bhattacharyya et al. (2008) find positive affect is associated with healthier levels of heart rate variability.

One hundred years ago Addis (1922) showed pulse rose with work load. Some studies examine the heart rates when subjects are under strain. For instance, Troubat et al. (2009) record changes in heart rate and metabolism among chess players and show heart rate rises during mental stress.

In their work Shedler et al. (1993) examined the response of the heart to distinguish between people who were genuinely distressed (according to a clinician) yet appeared 'healthy' based on their responses to a battery of mental health questions (a state they term "illusory mental health"), and those who reported distress and were judged distressed by a clinician (the "manifestly distressed"). They measured pulse responses to stress using heart rate and a slightly different metric (rate pressure product, which combines heart rate and blood pressure).

In laboratory experiments the authors show that those with illusory mental health showed greater coronary reactivity, that is, greater heart response under stress as compared to baseline non-stress spells, than those who were manifestly distressed subjects. The authors suggest "this is consistent with the hypothesis that the mental health scales were not assessing mental health in these subjects, but instead were assessing defensive denial" (p. 1127). The study is important in the context of

[8] Pulse pressure – which is the difference between diastolic and systolic blood pressure – is a different measure again.

our study because it warns of the dangers in over-reliance on self-reports of mental wellbeing, and the value of heart rate measures in checking for underlying mental health.

In their single-site study of employees in a mid-size firm in California Wright et al. (2009) examine the role of psychological wellbeing[9] in predicting cardiovascular health, which they measure in terms of employees' diastolic blood pressure, systolic blood pressure and pulse rate. They combine these three measures into a pulse product measure which is defined as the difference between SBP and DBP multiplied by the puse rate and divided by 100. They find pulse product was negatively related to wellbeing, even after controlling for other cardiovascular health risk factors whereas SBP and DBP were not significantly related to psychological wellbeing.

We found only one paper that links pulse and labour market status. Chandola and Zhang (2018) followed 1116 individuals aged 35-75 over three years to examine the value of re-employment in a poor quality job versus remaining unemployed. They found those who transitioned into poor quality jobs had greater adverse levels of biomarkers than those remaining unemployed, but there were no significant differences in pulse.[10]

4. Data and Estimation

In the first part of our analyses we use pooled cross-sectional time series data from the Health Survey for England for 1998-2019 and the Scottish Health Surveys of 1998, 2003 and 2008-2019 to examine the correlates of pulse rates. The HSE monitors trends in the nation's health and care. It provides information about adults aged 16 and over, and children aged 0 to 15, living in private households in England. The survey consists of an interview, followed by a visit from a nurse who takes some measurements and blood and saliva samples. Each survey in the series includes core questions, and measurements such as blood pressure, height and weight measurements and analysis of blood and saliva samples. In addition there are modules of questions on specific topics that vary from year to year. The SHeS series was established in 1995 to provide data about the health of the population living in private households in Scotland. It was repeated in 1998 and 2003 and has been carried out annually since 2008.

We begin with models containing demographic traits only, then extend them to include health behaviours and biomarkers. We compare these models with ones containing identical co-variates. Our wellbeing outcomes are the GHQ36[11], self-assessed general health, life satisfaction and the Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS).[12]

---

[9] Measured with the 8-item Index of Psychological Well-Being developed by Berkman (1971).

[10] The adverse effects were apparent with regards to allostatic load, triglycerides, C-reactive protein, fibrinogen and cholesterol.

[11] The GHQ36 score is obtained from twelve separate question coded one through four which are then added. The higher the score the worse is mental health – each scored =0 better than usual; 1=same as usual; 2 less than usual and 3 = much less than usual. The variables are 1) Able to concentrate 2) Lost sleep over worry; 3) Felt playing useful part in things; 4) Felt capable of making decisions; 5) Felt constantly under strain; 6) Felt could not overcome difficulties; 7) Able to enjoy day-to-day activities; 8) Been able to face problems; 9) Been feeling unhappy and depressed; 10) Been losing confidence in self; 11) Been thinking of self as worthless and 12) Been feeling reasonably happy which is scored 0 "more so than usual' 1 "about the same as usual"; 2 "less so than usual" and 3 "much less than usual". The GHQ36 score is the sum of these twelve variables and hence takes values between 0 and 36.

[12] WEMWBS was developed to enable the measuring of mental wellbeing in the general population and the evaluation of projects, programmes and policies which aim to improve mental wellbeing. The 14-item scale has 5 response categories, summed to provide a single score. The items are all worded positively and cover both feeling and

With the exception of Table 1, which includes individuals of all ages, we confine our analyses to those aged under 70 given our interest in the importance of pulse rates for those of working age. We then turn to the NCDS Biomedical Survey, conducted when cohort members were between the ages of 42 and 44 years, to establish the correlates of pulse rates and other health-related outcomes (self-assessed general health, anxiety and sleep problems).

In the final part of the paper we use the longitudinal data in the NCDS to establish the long-run consequences of pulse rates measured at age 42-44 in the Biomedical Survey on the probabilility of working, health status, optimism and life satisfaction roughly 5-10 years later.

Throughout the pulse rate is the number of times the heart beats per minute and is measured by a nurse. In both the HSE and the SHeS the pulse variable we use is taken as the average of three readings and if three are not all available, the average of two or just a single reading if that is all that is present. In the HSE we have pulse data available every year from 1998-2018 with a mean of 70.22 and SD=10.68 and a sample size of 142,310. In the SHeS we have data available for 1998; 2003 and 2008-2019; pulse has a mean of 69.94 and an SD of 11.32 with a sample size of 25,278. The pulse variable in the NCDS is also taken by a nurse, as part of a biomedical survey conducted when cohort members were aged between 42 and 44. Once again our pulse rate measure is the average of three readings. The variable has a mean of 71.7 with an SD of 10.6 and there are 9,299 observations.

It turns out that pulse rate equations look much like (un)happiness equations.

5. Results

5.1. Cross-section data

The demographic correlates of pulse rates in the Health Survey for England are presented in column 1 of Table 1. The model, which is run on over 140,000 individuals from the pooled cross-sectional data for HSE from 1998-2018, accounts for roughly 4 percent of the variance in pulse rates across the data.

Pulse rates decline through age until people reach their eighties. Pulse rates are lower among men, in London and the South East. They are higher among the temporarily sick, the permanently disabled and the unemployed. Pulse rates are lower among the more highly educated. Married respondents have lower pulse rates than the never married.

In the rest of Table 1 we examine three other dependent variables:

a) The General Health Questionnaire (GHQ36) score has been widely used in the mental health literature as an indicator of psychological morbidity (Goldberg et al, 1997 and Hu et al, 2007). The GHQ36 ranges from 0 through 36 and is available for 1998-2010; 2012; 2014; 2016 and 2018. It has a mean of 10.69 and an SD of 4.94: a higher score means worse mental health.

functioning aspects of mental wellbeing, thereby making the concept more accessible. The WEMWBS score using the English and Scottish Health Surveys was also examined in Bell and Blanchflower (2021) and Blanchflower, Oswald and Stewart-Brown (2013).

b) The Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS) is a positive affect score ranging between 14 and 70 and has a mean of 51.2 and an SD of 8.9, is available for 2010-2016.

c) The general health variable in column 4 has five options – very bad (1.9%); bad (5.6%); fair (18.8%); good (41.7%) and very good (32.1%) and has a mean of 3.96, and SD of .95. It is available every year from 1998-2018 except 2015.

The performance of the variables in the pulse rate equation is mirrored closely in column 2 for GHQ36 score, and the positive affect measures in columns 3 and 4 for the Warwick-Edinburgh Wellbeing Scale and general health, both in terms of the signs and significance of the control variables (though, of course, higher positive coefficients for pulse and higher GHQ denote poorer wellbeing while higher positive coefficients for WEMWBS and general health denote higher wellbeing). We see, for example, that being unemployed is associated with a higher pulse rate and a higher GHQ36 score and lower WEMWBS and general health. The main difference across the equations relates to age. While is that the GHQ36 score peaks in middle age (45-49), as does poor general health (50-54) - as is normally the case in subjective wellbeing equations (Blanchflower and Graham 2021a, 2021b) – WEMWBS peaks at age 65-69, and pulse tends to fall with age, right through to one's early 80s. But, broadly speaking, the pulse rate equations look remarkably like happiness and unhappiness equations.

Table 2 estimates additional pulse rate and GHQ36 models using data again from the Health Surveys for England which extend the models in Table 1 to include additional covariates relating to Body Mass Index, medication, health behaviours and, in columns 2 and 4, income. The adjusted-R^2 doubles relative to Table 1, rising to around 0.10. BMI enters positiviely in both pulse and GHQ36 equations. Unsurprisingly, taking beta blockers is associated with lower pulse rates and GHQ36 scores. However taking blood pressure medication is associated with higher pulse rates and GHQ36 scores. Smokers have higher pulse rates, with pulse rates rising with the recency and intensity of smoking. Those who drink alcohol every day also have higher pulse rates but, perhaps surprisingly, those who drink alcohol less frequently have lower pulse rates than non-drinkers. Pulse rates fall as income rises. These results are largely replicated in the GHQ scores in columns 3 and 4, except with respect to drinking alcohol where the highest GHQ scores are recorded by non-drinkers.

Table 3 replicates the Table 1 results using data from the Scottish Health Surveys (SHS) of 1998-2003 and 2008-2019, but for those of working age only (as in Table 2). Sample sizes are smaller than using HSE but include the same four dependent variables as used in Table 1. As with the HSE pulse rates are lower for men, the more educated and the married and decline with age (the non-significant quadratic age term is omitted from the pulse equation). The disabled and the unemployed once again have higher pulse rates. Similarly general health, and WEMWBS are positively correlated with education, work, and marriage.

It seems that there are broad similarities between the determnants of pulse rates and those of other wellbeing variables in cross-sectional data.

4.2. Longitudinal data from the NCDS

It is possible that a high pulse rate could cause poor labor market outcomes or poor labor market outcomes may generate worry and anaxiety which lead to high pulse rates. We examine how high pulse rates lead to subsequent outcomes many years hence using longitudinal data where the direction of causation is clear. Weexamine pulse rates at age 42 and then look at subsequent outcomes many years later. This includes work and health status at age 55 and measures of wellbeing at age 50. It seems hard to argue that poor work experience at age 55 impacts pulse rates a dozen years earlier, especially when it is possible to control prior characteristics including socio-economic characteristics at birth, along with a host of other controls for health and prior labor market experience. It seems then that concerns over causality in this case are misplaced given that we make use of long-lagged controls.

We now consider the longitudinal data on pulse rates and how it impacts subsequent outcomes using the British National Child Development Study (NCDS), a birth cohort of everyone born in a week in March 1958. Cohort members have been followed into their early sixties. We use follow up data through to age fifty-five. There have been ten major sweeps – at birth (Perinatal Mortality Study, 1958); age 7 (1965, NCDS1); 11 (1969, NCDS2); 16 (1974, NCDS3); age 23 (1981, NCDS4); age 33 (1991, NCDS5); age 42 (2000, NCDS6); age 46 (2004, NCDS7); age 50 (2008, NCDS8); age 55 (2013, NCDS9) and NCDS10, ages 61-64 is currently in the field.[13]

We have pulse rates available just once at age 42 in the Biomedical Survey (BIOS) as part of NCDS6 taken in 2000. We examine its determinants and then show it has predictive power years later.

Table 4 uses data that are all provided in the BIOS. The pulse equation in column 1 looks much like those reported in Tables 1-3. Pulse rates are higher among those with a higher BMI, smokers and frequent alcohol drinkers. Pulse is lower for those who drink 2-3 times a week compared to thos who never drink. In keeping with the results on income discussed above, we find pulse rates are higher if individuals have difficulty paying their bills. Consistent with the finding above that those who are sick or disabled have higher pulse, we find pulse rises with the intensity of pain cohort members suffer.[14]

Table 4 presents models containing identical controls for three other outcomes capturing wellbeing, namely self-reported general health (where higher scores mean higher wellbeing), sleep problems and anxiety. General health is coded 1-4 (mean=3.0); sleep problems is a 1,0 dummy if the respondent had problem sleeping last month (mean=.37) and anxious is a 1,0 dummy if the respondent is anxious, nervous and tense (mean=.22). These equations are similar in most respects to the pulse equation.

Table 5 builds on the pulse rate equations in Table 4 with the addition of controls for education, region, and labor force status. Although they are jointly statistically significant, they do not add greatly to the explained variance in the model. Column 2 drops the chronic pain variable which increases the sample size and then in column 3 we add controls for the respondent's father's occupation at the time of their birth in 1958 and reported then. Estimates seem very stable and

[13] https://cls.ucl.ac.uk/cls-studies/1958-national-child-development-study/

[14] For more evidence on the correlates and impact of chronic pain see Blanchflower and Bryson (2021).

look much like happiness equations. It is nevertheless striking to see that one's father's occupation when you were born over four decades earlier can still impact one's pulse rate.

The question then is whether pulse rates have predictive power and it turns out they do. But first, in Table 6 we use the HSE (panel a)) and SHeS (panel b) to assess the correlation between pulse rates and contemporaneous measures of work (1 if working, zero otherwise), GHQ36 and general health, having controlled for age, gender, region, education, marital status and year. In all of them pulse rates are significant and have similar signs – negative in work and health status equations and positive in GHQ scores.

Part c) adds two further variable – WEMWBS and life satisfaction, scored from 1-10 - and as with the general health scores the pulse rate enters negatively and significantly.

Table 7 estimates the probability of paid work at age 55. At that point in their life cycle 81.2% NCDS respondents were employed. In column 1 we see work probabilities are higher in the South East and the West Midlands, and as expected among men, and the more educated. Column 2 then adds the pulse rate at age 42 which is significant and negative and, notably with the same coefficient of -.0022 as found in Table 6 for both the HSE and the SHeS. Several other variables at age 42 are also added including two pain variables and difficulty paying bills which all have significant impacts. The impact of these variables which were recorded thirteen years earlier, including the pulse rate, continues even when we include controls for labor market status from NCDS7 taken at age 40 in 1998 (columns 3 and 4) – noting that labor market status is not available in the BIOS survey.

The pulse rate variable is also significant and negative in column 4 as we add controls for fibrinogen and C-reactive protein (Blanchflower et al., 2011). In column 5 we add the occupation of the respondent's mother's husband (not necessarily their father) and there is little impact on the pulse coefficient which is almost identical to that in column 4 at -.0025. We further experimented in Table 7 including systolic and diastolic blood pressure from the BIOS and BMI in NCDS9 as controls in these work equations and none were significant. This was true for both men and women.

In Table 8 we estimate the association between pulse rate at age 42 and general health status *thirteen* years later. All equations include controls for education, region and labor force status and difficulty paying bills at age 42. We also include controls for short and long lasting pain at age 42 and birth weight and pulse rates all at 42 and, all worsen subsequent health.

Of note is that birth weight in ounces reported in the Perinatal Mortality Study in 1958 enters significantly negative in all specifications. This is consistent with evidence discussed above (see Huxley, et al, 2000) that birth weight is negatively correlated with adult blood pressure. Results are largely unchanged in column 2 when health status at age 50 from NCDS8 is added or in column 3 when mother's husband's occupation in 1958 is added. Similarly, little changes when two life satisfaction variables that are coded 0-10 are added:

Q1 "How satisfied are you with the way life has turned out so far?'
Q2. "How satisfied do you expect to be in ten years' time?

In all four columns we included controls for systolic and diastolic blood pressure. Systolic was always insignificant but diastolic was significantly negative in column 1 but its significance disappeared once controls for health at age 50 were included. This stands in contrast to the pain and pulse rate variables which remained significantly negative.

In Table 9 we then move to using data from NCDS8 at age 50 in 2005 to capture the association between pulse at age 42 using the two life satisfaction variables Q1 and Q2 described above at age 50 from NCDS8 in 2008. Both are scored from 0 to 10 (mean=7.29 and 7.68 respectively). There are no life satisfaction scores available in NCDS9. Controls are included for education, labor force status and region. A higher pulse rate 8 years earlier and long lasting pain enter negatively and significantly in both life satisfaction equations with and without controls for father's social class reported at the time of the respondent's birth in 1958. Difficulty paying bills at age 42 continued to impact outcomes eight years later. We included controls for systolic and diastolic blood pressure and birth weight and they were always insignificant

6. Conclusions

A number of papers point to the value of using biometric markers of wellbeing in addition to happiness measures because self-reports of wellbeing can be unreliable (Shedler et al., 1993; Johnston et al., 2009; Lauderdale and Rathouz, 2003). In this paper we have emphasized the potential value of pulse rate as an objective metric of wellbeing. We have shown that it is highly correlated with various subjective wellbeing metrics, and that it shares many of the same determinants. We show that it is predictive of subsequent wellbeing – self-assessed health, satisfaction with the way life has turned out and expected life satisfaction in 10 years time – and that it is also predictive of subsequent labour market status, which itself has important implications for individuals' wellbeing. The value of pulse rate as a wellbeing metric is that, unlike wellbeing metrics, it is recorded on an objective cardinal scale.

For some time individuals have been encouraged to take their pulse rates in stressful situations such as students in classroom settings as a way of assessing their health (Romano, 1992). Even golfers are wearing devices to measure their pulse rate, which appear to get very high at crucial moments.[15] It is now much easier to do so through smart devices (Gyrard and Sheth, 2020). It seems sensible, therefore, for health professionals and academics alike to pay more attention to these data, and perhaps for individuals to have greater regard to their pulse rates, alongside other biomarkers such as blood pressure and BMI. Taken together, these results suggest social scientists can learn a great deal by adding pulse rates to the metrics they use when evaluating people's wellbeing.

[15] The PGA Tour has partnered with Whoop, a fitness and recovery tracker, to show live heart rates. It is reported that Rory McIlroy's heart rate on the 72nd hole of the 2021 Wells Fargo Championship at Quail Hollow, that he won, spiked at 140bpm following the tee shot. It settled back to 115 as he addressed his approach to the green but following his putt to win, it reached 151.
https://www.golfwrx.com/654185/rory-mcilroys-heart-rate-hit-stunning-high-on-72nd-hole-at-wells-fargo/

References

Addis, T. 1922. Blood pressure and pulse rate reactions. *Archives of Internal Medicine*, 30, 246.

Allin, P. and D.J. Hand, 2017. New statistics for old?—measuring the wellbeing of the UK, *Journal of the Royal Statistical Society, Part A*, 180(1): 3-43.

Bell, D.N.F and D.G. Blanchflower, 2021. The U-shape of happiness in Scotland. *Scottish Journal of Political Economy*, May 17th 2021

Bhattacharyya, M. R., Whitehead, D. L., Rakhit, R., and Steptoe, A. 2008. Depressed mood, positive affect, and heart rate variability in patients with suspected coronary artery disease. *Psychosomatic Medicine, 70*, 1020-1027.

Batz, C., and Tay, L. 2018. Gender differences in subjective well-being. in E. Diener, S. Oishi, & L. Tay Eds.), *Handbook of well-being*. Salt Lake City, UT: DEF Publishers. DOI:nobascholar.com https://www.nobascholar.com/chapters/30/download.pdf

Berkman, P. L. 1971. Measurement of mental health in a general population survey. *Journal of Epidemiology*, 94: 105-111.

Blanchflower, D.G. 2021. Is happiness U-shaped everywhere? Age and subjective well-being in 145 countries. *Journal of Population Economics*, 34, pp. 575–624.

Blanchflower, D.G. 2020. Unhappiness and age. *Journal of Economic Behavior and Organization*, 176: 461-488.

Blanchflower, D.G. 2009 International evidence on well-being", in Measuring the subjective well-being of nations: national accounts of time use and well-being edited by Alan B. Krueger, NBER and University of Chicago Press.

Blanchflower, D. G. and Bryson, A. 2021a. The consequences of chronic pain in mid-life: evidence from the National Child Development Survey. NBER Working Paper #29278

Blanchflower, D. G. and Bryson, A. 2021b. Biden, Covid, and mental health in America, NBER Working Paper #29040.

Blanchflower, D.G., Christakis, N.A and Oswald, A.J. 2011. An introduction to the structure of biomarker equations', working paper.

Blanchflower, D. G. and Graham, C. 2021a. The mid-life dip in well-being: a critique. *Social Indicators Research*.

Blanchflower, D. G. and Graham, C. 2021b. The U-shape of happiness: A response. *Perspectives on Psychological Science*, 1-21.

Blanchflower, D. G. and Oswald, A.J. 2016. Antidepressants and age: a new form of evidence for U-shaped well-being through life', *Journal of Economic Behavior and Organization*, 127: 46-58.

Blanchflower, D. G., A.J. Oswald and S.Stewart-Brown, 2013. Is psychological well-being linked to the consumption of fruit and vegetables? *Social Indicators Research*, 114: 785-801.

Blanchflower, D. G., and J. Sargent 1994. Obesity and stature in adolescence and earnings in young adulthood, *Archives of Pediatrics and Adolescent Medicine*, 148: 681-687.

Böckerman, P, Bryson, A., Viinikainen, J., Hakulinen C. and Hintsanen, M, et al. (2017). The biometric antecedents to happiness', *PlosOne* 12 (9): e0184887.

Böckerman, P, Bryson, A. Viinikainen, J., Hakulinen, C.. Pulkki-Raback, L. Raitakari O. and Pehkonen, J. 2017. Biomarkers and long-term labour market outcomes: the case of creatine', *Journal of Economic Behavior and Organization*, 142: 259-274.

Bond, T.N. and Lang, K. 2019. The sad truth about happiness scales, *Journal of Political Economy*, 127, 4: 1629-1640.

Bossavie, L., H. Alderman, J. Giles and C. Mete 2021. The effect of height on earnings: Is stature just a proxy for cognitive and non-cognitive skills? Economics and Human Biology, 43:101046

Bryson, A., Erhel, C. and Salibekyan, Z. 2016. Job quality. Chapter 6 in Amossé, T., Bryson, A., Forth, J. and Petit, H. eds.) *Comparative Workplace Employment Relations: An Analysis of Britain and France*, Palgrave Macmillan, pp. 179-210.

Bryson, A., Forth, J. and Stokes, L. 2014. *Does Worker Wellbeing Affect Workplace Performance?* Department for Business, Innovation and Skills, BIS/14/1120.

Bryson, A., Forth, J. and Stokes, L. 2017. Does worker wellbeing affect workplace performance?", *Human Relations*, 70, 8, 1017-1037.

Bryson, A. and MacKerron, G. 2017. Are you happy while you work?', *The Economic Journal*, 127, 599: 106-125.

Buecker, S., Simacek, T., Ingwersen, B., Terwiel, S. and Simonsmeier, B. A. 2020. Physical activity and subjective well-being in healthy individuals: a mea-analytic review. *Health Psychology Review*.

Case, A. and C. Paxson, 2008. Stature and status: Height, ability, and labor market outcomes *Journal of Political Economy*, 116(3): 499–532.

Chandola, T. and Zhang, N. 2018. Re-employment, job quality, health and allostatic load biomarkers: prospective evidence from the UK Household Longitudinal Study. *International Journal of Epidemiology*, 47-57.

Chen, L-Y., Oparina, E. Powdthavee, N., and Srisuma, S. 2021. Robust ranking of happiness outcomes: a median regression perspective, Papers 1902.07696, arXiv.org, revised Apr 2021.

Christian, L. M., Graham, J.E. Padgett, D.A. Glaser R. and Kiecolt-Glaser, J. K. 2006. Stress and wound healing. *Neuroimmunomodulation, 13*, 337-346.

Clark, A. E. and Georgellis, Y. 2013. Back to baseline in Britain: adaptation in the British household panel survey', *Economica*, 80 319): 496-512.

De Neve, J-E., Diener, E.. Tay, L. and Xuereb, C. 2013. The objective benefits of subjective well-being" in Helliwell, J., Layard, R., and Sachs, J., eds. *World Happiness Report 2013*. New York: UN Sustainable Development Solutions Network.

Deaton, A. 2012. The financial crisis and the wellbeing of Americans. *Oxford Economic Papers*, 64, 1: 1-26.

Diener, E., and Chan, M. 2011. Happy people live longer: Subjective well-being contributes to health and longevity. *Applied Psychology: Health and Wellbeing, 3*, 1-43.

Easterlin, R. 2015. Happiness and economic growth — the evidence. In Wolfgang Glatzer et al., (eds.), *Global Handbook of Quality of Life*, Springer: 283-299.

Easterlin, R. 1974. Does economic growth improve the human lot? *In Nations and Households in Economic Growth: Essays in Honor of Moses Abramovitz*, ed. Paul David and Melvin Reder (Academic Press, 1974).

Ferrer-i-Carbonell, A. and Frijters, P. 2004. How important is methodology for the estimates of the determinants of happiness?' *The Economic Journal*, 114, 497: 641-659.

Frank, R. 2004. How Not to Buy Happiness. *Dædalus*, 133(2): 69-79.

Freeman, R.B. 1978. Job satisfaction as an economic variable. *American Economic Review*, 68, 2: 135-41.

Frey, B.S. and Stutzer, A. 2002. What can economists learn from happiness research?', *Journal of Economic Literature*, 40, 2: 402–35.

Godoy, R., E. Goodman and N. Jha (2007). Blood pressure and hypertension in an American colony (Puerto Rico) and on the USA mainland compared, 1886–1930. *Economics and Human Biology*, 5, 255-279.

Goldberg, D. P., Gater, T., Sartorious, N., Ustun, T. B., Piccinelli, M., Gureje, O., et al. 1997. The validity of two versions of the GHQ in the WHO study of mental illness in general health care. *Psychological Medicine*, 27: 191–197.

Green, F. 2010. Well-being, job satisfaction and labour mobility', *Labour Economics*, 17: 897-903

Gyrard, A. and Sheth, A. 2020. IAMHAPPY: Towards an IoT knowledge-based cross-domain wellbeing recommendation system for everyday happiness. *Smart Health*, 15: 100083.

Hu, Y. J., Stewart-Brown, S., Twigg, L., & Weich, S. 2007. Can the 12-item General Health Questionnaire be used to measure positive mental health? *Psychological Medicine*, 37: 1005–1013. Hudomiet, P., M.D. Hurd and S. Rohwedder 2021. The age profile of life satisfaction after Age 65 in the U.S.., Journal of Economic Behavior and Organization, 189:431-442.

Huxley, R.R., Shiell, A.W., Law, C.M., 2000. The role of size at birth and postnatal catch-up growth in determining systolic blood pressure: a systematic review of the literature. *Journal of Hypertension*, 18: 815–831.

Ikeda, A., Steptoe, A., Shipley, M., Wilkinson, I. B., McEniery, C.M, Tanigawa, T., Singh-Manoux, A., Kivimaki, M., and Brunner, E. J. 2020. Psychological wellbeing and aortic stiffness longitudinal study. *Hypertension*, 76: 675-682.

Johnston, D. W., Propper, C. and Shields, M. A. 2009. Comparing subjective and objective measures of health: evidence from hypertension for the income/health gradient. *Journal of Health Economics*, 28: 540-552.

Kaiser, C.F. and M.C.M. Vendrik, 2020. How threatening are transformations of happiness scales to subjective wellbeing research? IZA DP # 13905.

Kahneman, D. and Deaton, A. 2010. High income improves evaluation of life but not emotional wellbeing. *Proceedings of the National Academy of Sciences*, 107: 16489-16493.

Kahneman, D., Krueger, A.B. D.A. Schkade, D.A. Schwarz, N. and Stone, A.A. 2004. A survey method for characterizing daily life experience: the day reconstruction method. *Science*, 306, 5702: 1776–1780.

Kannel, W. B., Kannel, C. Paffenbarger, R.S. Jr., and Cupples, L. A. 1987. Heart rate and cardiovascular mortality: the Framingham Study. *American Heart Journal*, 113: 1489–1494.

Katikireddi, S. V., Niedzwiedz C.L. and Popham, F. 2012. Trends in population mental health before and after the 2008 recession: a repeat cross-sectional analysis of the 1991-2010 Health Surveys of England. *BMJ Open*, doi:10.1136/bmjopen-2012-001790.

Killingsworth, M. A. 2021. Experienced well-being rises with income, even above $75,000. *Proceedings of the National Academy of Sciences*, 118, 4: e2016976118.

Knabe, A., Rätzel, S., Schöb R. and Weimann, J. 2010. Dissatisfied with life but having a good day: time-use and well-being of the unemployed. *The Economic Journal*, 120, 547: 867-889.

Komlos, J. and B.E. Lauderdale 2007. Underperformance in affluence the remarkable relative decline in American Heights in the second half of the 20th-Century. *Social Science Quarterly*, June, 88, 2: 283-304.

Kristoffersen, I. 2018. Great expectations: education and subjective wellbeing. *Journal of Economic Psychology*, 66, June: 64-78.

Lauderdale, D. S. and Rathouz, P. J. (2003). Does bone mineralization reflect economic conditions? An examination using a national US sample, *Economics & Human Biology*, 1: 91-104.

Law, C.M., Shiell, A.W. 1996. Is blood pressure inversely related to birth weight? The strength of evidence from a systematic review of the literature. *Journal of Hypertension*, 14: 935-941.

Layard, R. 2005. *Happiness: Lessons from a New Science*, Penguin.

Lindqvist, E., R. Östling and D. Cesarini, 2020. Long-Run Effects of Lottery Wealth on Psychological Well-Being, *The Review of Economic Studies*, 87(6): 2703–2726,

Liu, S. and N. Netzer, 2020. Happy times: identification for ordered response data, University of Zurich, Working Paper #371

Lipowicz, A. (2007), 'Hypertension among Polish males during the economic transition,' *Economics and Human Biology*

Lucas, R. E., Clark, A.E.. Georgeillis, Y. and Diener, E. 2003. Reexamining adaptation and the set point model of happiness: reactions to changes in marital status. *Journal of Personality and Social Psychology*, 84, 3: 527-539.

Lucas, R. E., Clark, A.E.. Georgeillis, Y. and Diener, E. 2004. Unemployment Alters the Set Point for Life Satisfaction, Psychological Science, 15, 1: 8-13

Montgomery, M. (2022), 'Reversing the gender gap in happiness,' *Journal of Economic Behavior and Organization*, forthcoming.

Nilsson, P.M., Nilsson, J.A.. Hedblad B., and Berglund G. 2001. Sleep disturbance in association with elevated pulse rate for prediction of mortality – Consequences of mental strain? *Journal of Internal Medicine*, 250: 521-529.

Okbay, A. et. al. 2016. Genetic variants associated with subjective well-being, depressive symptoms, and neuroticism identified through genome-wide analyses. *Nature Genetics*, 48: 624-633.

Oswald, A. J. and Powdthavee, N. 2008. Does happiness adapt? A longitudinal study of disability with implications for economists and judges. *Journal of Public Economics*, 92, 5/6: 1061-1077.

Oswald, A. J., Proto, E., and Sgroi, D. 2015. Happiness and productivity. *Journal of Labor Economics*, 33, 4: 789-822.

Romano, J. L. 1992,. Psychoeducational interventions for stress management and wellbeing. *Journal of Counseling and Development*, 71, 2: 199-202.

Ryff, C. D., Love, G. D.,Urry, H. L., Muller, D., Rosenkranz, M. A., Friedman, E. M., Davidson, R. J. and Singer, B. 2006. Psychological well-being and ill-being: do they have distinct or mirrored biological correlates? *Psychotherapy and Psychosomatics*, 75: 85-95.

Salmi, I.A. and Hannawi, S. 2020. Birth weight is inversely correlated with blood pressure: population based study, *Journal of Hypertension*, 38: 2205–2214.

Shedler, J., M. Mayman and Manis, M. 1993. The illusion of mental health. *American Psychologist*, 48, 11: 1117-1131.

Sheldon, K.M., M. Corcoran and M. Sheldon, 2021. Duchenne smiles as honest signals of chronic positive mood. *Perspectives on Psychological Science*, February 12.

Sin, N. L. 2016. The protective role of positive well-being in cardiovascular disease: review of current evidence, mechanisms, and clinical implications. *Current Cardiology Reports*, 18: 106.

Sloan R.P., Schwarz E., McKinley P.S., Weinstein M., Love G., et al. 2017. Vagally-mediated heart rate variability and indices of well-being: results of a nationally representative study. *Health Psychology*, 36:73–81.

Stevenson, B. and J. Wolfers 2009, The paradox of declining female happiness. *American Economic Journal: Economic Policy*, 2: 190-225.

Stevenson, B., Wolfers, J. 2008. Economic growth and subjective well being: reassessing the Easterlin paradox. *Brookings Papers on Economic Activity*, Spring): 1-87.

Steptoe, A. 2019. Happiness and health. *Annual Review of Public Health*, 40: 339-359.

Steptoe A. and Wardle, J. 2005. Positive affect and biological function in everyday life. *Neurobiology of Aging*, 26 Suppl. 1):108–112.

Steptoe A., J. Wardle, J. and Marmot, M. 2005. Positive affect and health-related neuroendocrine, cardiovascular and inflammatory processes. *Proceedings of the National Academy of Sciences*, 102:6508–12.

Troubat N, M.A. Fargeas-Gluck M. Tulppo and Dugue B. 2009. The stress of chess players as a model to study the effects of psychological stimuli on physiological responses: An example of substrate oxidation and heart rate variability in man. *European Journal of Applied Physiology*, 343-349.

Viinikainen, J. Bryson, A., Bockerman, P., Kari, J., Lehtimaki, T., Raitakari, O., Viikari, J. and Pehkonen, J. 2021. Does better education mitigate risky health behaviour? A Mendelian randomization study. mimeo.

Weiss, A., J.E. King and Enns, R. M. 2002. Subjective well-being is heritable and genetically correlated with dominance in chimpanzees Pan troglodytes. *Journal of Personality and Social Psychology*, 83, 5: 1141-1149.

Weiss, A., J.E. King, M. Inoue-Murayama, T. Matsuzawa and Oswald, A. J. 2012. Evidence of a midlife crisis in great apes consistent with the U-shape in human wellbeing. *Proceedings of the National Academy of Sciences*, 109, 49: 19949-19952.

Weiss A, M. Boaz Y. Beloosesky et al. 2009. Pulse pressure predicts mortality in elderly patients. *Journal of General Internal Medicine*, 24 8): 893–896.

Wells, C. L. and Townsend, M. 2020. Management of the acutely ill and medically complex older patient. Chapter 14 in D. Avers and R. A. Wong eds.) *Guccione's Geriatric Physical Therapy*.

Wootton, R.E., R.B Lawn, L.A.C. Millard, N.M. Davies A.E Taylor, M.R Munafò, N.J. Timpson, O.S.P. Davis, G.D. Smith, and C.M.A. Haworth 2018, Evaluation of the causal effects between subjective wellbeing and cardiometabolic health: mendelian randomisation study. *British Medical Journal*, 362, 25 Septembe

Wright, T. A., R. Cropanzano, D.G. Bonett and Diamond, W. J. 2009. The role of employee psychological well-being in cardiovascular health: When the twain shall meet. *Journal of Organizational Behavior*, 30: 193–208.

Table 1. OLS estimates of pulse rates, GHQ36, WEMWBS and General Health, English Health Surveys, 1998-2019

	Pulse rates	GHQ36	Mental health	General health
18-19	-0.16 (0.57)	0.38 (3.66)	0.66 (1.80)	-0.05 (3.38)
20-24	-0.75 (2.96)	0.94 (9.95)	0.61 (1.75)	-0.12 (7.87)
25-29	-1.17 (4.36)	1.30 (12.84)	0.61 (1.64)	-0.11 (7.27)
30-34	-1.56 (5.83)	1.40 (13.72)	0.28 (0.74)	-0.13 (8.11)
35-39	-1.76 (6.54)	1.69 (16.53)	-0.04 (0.10)	-0.19 (11.92)
40-44	-1.76 (6.56)	1.77 (17.21)	-0.02 (0.05)	-0.24 (14.75)
45-49	-1.73 (6.38)	1.83 (17.51)	-0.25 (0.68)	-0.30 (18.42)
50-54	-2.14 (7.87)	1.77 (16.91)	0.08 (0.20)	-0.35 (21.80)
55-59	-2.60 (9.45)	1.30 (12.22)	0.80 (2.12)	-0.34 (20.87)
60-64	-3.13 (11.13)	0.56 (5.09)	2.77 (7.24)	-0.26 (15.29)
65-69	-4.13 (14.24)	-0.24 (2.11)	4.71 (12.03)	-0.13 (7.33)
70-74	-4.72 (15.80)	-0.39 (3.28)	4.53 (11.26)	-0.15 (8.21)
75-79	-5.18 (16.78)	-0.29 (2.36)	4.57 (11.02)	-0.20 (10.74)
80-84	-5.29 (16.11)	-0.11 (0.81)	3.81 (8.65)	-0.25 (12.98)
85-89	-4.79 (12.93)	0.38 (2.54)	2.75 (5.57)	-0.30 (13.73)
90+	-4.93 (10.57)	-0.06 (0.30)	2.92 (4.59)	-0.13 (4.95)
Year	-0.05 (8.81)	-0.01 (2.54)	0.03 (1.80)	0.00 (11.47)
Male	-2.54 (40.38)	-0.76 (29.23)	0.11 (1.41)	-0.01 (1.99)
NW & Merseyside	-0.08 (0.59)	-0.11 (1.79)	0.14 (0.90)	0.08 (8.91)
Yorks & Humber	0.42 (2.87)	-0.16 (2.60)	-0.01 (0.05)	0.05 (5.16)
West Midlands	-0.31 (2.10)	-0.11 (1.73)	0.24 (1.37)	0.07 (7.85)
East Midlands	-0.65 (4.41)	-0.08 (1.22)	-0.08 (0.49)	0.06 (6.38)
Eastern	-0.89 (6.15)	-0.30 (4.86)	0.47 (2.86)	0.12 (13.25)
London	-0.91 (6.20)	-0.08 (1.37)	0.44 (2.54)	0.08 (8.74)
South East	-0.91 (6.69)	-0.34 (5.82)	0.83 (5.33)	0.14 (16.49)
South West	-1.12 (7.75)	-0.28 (4.53)	0.26 (1.53)	0.15 (16.33)
Black	1.05 (5.59)	-0.65 (9.09)	2.15 (8.49)	-0.15 (14.04)
Asian	2.95 (23.51)	-0.15 (3.10)	0.52 (3.14)	-0.24 (33.12)
Mixed	1.17 (3.68)	-0.04 (0.35)	-0.34 (1.14)	-0.13 (7.43)
Other	0.91 (2.34)	-0.37 (2.33)	-0.28 (0.59)	-0.20 (8.81)
missing	1.13 (1.59)	-0.24 (0.83)	0.84 (0.67)	-0.06 (1.62)
Work	0.38 (1.75)	-0.66 (7.94)	-0.22 (0.72)	-0.01 (0.76)
Govt scheme	1.49 (1.77)	-0.30 (0.89)	-0.78 (0.67)	-0.13 (2.69)
Unpaid work	0.66 (1.00)	0.32 (1.22)	-1.60 (1.95)	-0.19 (4.63)
Waiting take up job	2.11 (4.32)	0.61 (2.94)	-2.24 (4.40)	-0.26 (9.09)
Unemployed	2.38 (7.80)	1.47 (12.61)	-3.55 (8.63)	-0.27 (14.95)
Unemployed temp sick	4.63 (12.30)	6.51 (38.54)	11.80 (28.21)	-1.63 (73.86)
Permanently disabled	2.88 (11.59)	3.54 (35.59)	-4.13 (12.18)	-0.96 (63.89)
Retired	1.79 (7.37)	0.70 (7.32)	-2.71 (8.15)	-0.51 (35.11)
Home worker	2.15 (8.86)	0.17 (1.83)	-1.69 (4.79)	-0.28 (19.39)
Never went to school	0.51 (1.08)	0.95 (4.80)	-3.53 (3.87)	-0.48 (17.73)
ALS <=14	1.11 (4.63)	0.63 (6.79)	-2.93 (7.29)	-0.43 (29.44)
ALS 15	0.70 (3.14)	0.08 (0.93)	-2.22 (6.09)	-0.24 (17.81)

ALS 16	0.61 (2.82)	-0.10 (1.17)	-1.66 (4.67)	-0.10 (7.63)
ALS 17	0.46 (2.00)	-0.16 (1.79)	-0.95 (2.59)	-0.03 (2.04)
ALS 18	-0.17 (0.75)	-0.20 (2.27)	-0.21 (0.57)	0.02 (1.15)
ALS>=19	-0.60 (2.78)	-0.24 (2.98)	0.48 (1.35)	0.10 (7.55)
Als other	-0.52 (0.42)	0.87 (1.79)	-0.31 (0.15)	-0.15 (3.40)
Married	-0.91 (10.08)	-0.54 (14.40)	1.89 (18.42)	0.12 (22.43)
Separated	0.57 (2.76)	1.12 (13.26)	-0.54 (2.12)	-0.03 (2.55)
Divorced	0.59 (4.29)	0.41 (7.06)	-0.37 (2.25)	-0.03 (3.57)
Widowed	0.37 (2.44)	-0.23 (3.57)	0.59 (3.08)	0.07 (7.88)
Constant	167.19	22.37	-4.10	-3.10
Adjusted R^2	.04	.08	.09	.20
N	148,762	149,470	54,887	213,110

T-statistics in parentheses: excluded: 16-17; North East; single; in education FT; not yet finished school; white. GHQ36 is scored between 0 and 36 with a mean of 10.68. Mental health is the Warwick-Edinburgh Mental Wellbeing Scale score (WEMWBS) which takes the values from 14-70 with a mean of 51.2. General health is scored from 1-5 with a mean of 3.96.
WEMWBS is available for 2010-2016 and 2019; pulse and general health for 1998-2019; GHQ36 for 1998-2006; 2008-10; 2012; 2014; 2016 and 2018.
Source: Health Survey for England.

Table 2. OLS pulse rate and GHQ36 regressions, Health Survey for England, 1998-2019 – all ages

	Pulse rates		GHQ36	
BMI	0.23 (37.15)	0.23 (36.80)	0.03 (10.22)	0.03 (9.92)
Taking beta blocker	-9.088 (71.30)	-9.81 (69.04)	-0.05 (0.67)	-0.05 (0.77)
N/a beta blocker	-0.49 (6.42)	-0.48 (6.25)	-0.85 (28.59)	-0.85 (27.49)
Taking BP medications	1.43 (13.47)	1.42 (13.41)	-0.04 (0.08)	-0.01 (0.12)
Used to smoke occasionally	-0.39 (2.91)	-0.40 (2.93)	0.26 (4.42)	0.26 (4.36)
Used to smoke regularly	0.18 (2.37)	0.15 (2.00)	0.27 (7.91)	0.26 (7.50)
Current smoker	3.35 (39.68)	3.26 (38.39)	0.80 (22.36)	0.75 (20.90)
Drink 5 or 6 days a week	-1.64 (9.93)	-1.60 (9.68)	-0.03 (0.43)	-0.01 (0.21)
3 or 4 days a week	-2.00 (16.80)	-1.98 (16.68)	-0.13 (2.63)	-0.13 (2.53)
Once or twice a week	-1.69 (15.84)	-1.74 (16.27)	-0.13 (2.95)	-0.16 (3.43)
Once or twice a month	-1.41 (11.34)	-1.49 (12.04)	0.12 (2.29)	0.08 (1.52)
Once every couple months	-1.12 (7.69)	-1.24 (8.49)	0.11 (1.80)	0.06 (0.89)
Once or twice a year	-1.00 (7.00)	-1.14 (7.94)	0.18 (2.93)	0.11 (1.70)
Not at all in last 12 months	-.13 (0.37)	-0.26 (0.78)	0.43 (2.82)	0.35 (2.34)
Male	-2.54 (38.96)	-2.53 (38.79)	-0.68 (24.08)	-0.68 (24.00)
2nd quintile		-0.10 (0.89)		-0.32 (6.30)
3rd income quintile		-0.38 (3.29)		-0.54 (10.76)
4th income quintile		-0.66 (5.63)		-0.62 (12.07)
Top income quintile		-1.21 (9.88)		-0.70 (13.04)
Income missing		-0.45 (4.01)		-0.44 (9.21)
Constant	184.20	187.60	38.71	41.66
Adjusted R^2	.0983	.0991	.0897	.0911
N	133,790	133,790	128,635	128,635

Notes: all equations also include year dummies, education, 11 age dummies, region, race, year labor force and marital status. Their coefficients and t-statistics not reported. Excluded – drink almost every day; never smoked at all; doesn't take beta blockers and 1st quintile. T-statistics in parentheses

Table 3. OLS regressions. Scottish Health Survey, 1998, 2003, 2008-2019

	Pulse rates	Pulse rates	GHQ36	Mental health	General health
Male	-2.64 (18.19)	-2.65 (14.74)	-0.79 (21.53)	0.13 (1.89)	-0.02 (2.72)
Borders	-0.78 (1.85)	-1.03 (1.97)	-0.28 (2.58)	0.63 (2.96)	0.13 (5.49)
Dumfries & Galloway	-0.30 (0.71)	0.31 (0.53)	-0.20 (1.76)	0.18 (0.79)	0.03 (1.24)
Fife	-0.36 (0.96)	-0.28 (0.59)	-0.12 (1.41)	0.30 (1.91)	0.02 (1.26)
Forth Valley	-0.10 (0.27)	-0.28 (0.58)	0.17 (1.76)	-0.02 (0.08)	0.02 (0.79)
Grampian	-0.84 (2.37)	-0.94 (2.09)	-0.35 (4.26)	0.44 (2.93)	0.06 (3.71)
Glasgow and Clyde	-0.63 (1.97)	-0.38 (0.95)	0.10 (1.31)	-0.09 (0.60)	0.02 (1.05)
Highland	-0.84 (2.35)	-1.01 (2.25)	-0.25 (2.65)	1.05 (5.44)	0.02 (1.09)
Lanarkshire	0.20 (0.53)	0.11 (0.26)	-0.06 (0.72)	-0.04 (0.23)	-0.02 (1.13)
Lothian	-0.81 (2.47)	-0.48 (1.17)	-0.09 (1.16)	0.36 (2.40)	0.06 (3.64)
Orkney	-0.91 (2.78)	-1.19 (2.39)	-0.33 (3.12)	0.71 (3.12)	0.11 (5.25)
Shetland	-1.05 (2.16)	-0.69 (0.97)	-0.26 (2.16)	0.81 (3.44)	0.10 (4.11)
Tayside	-1.48 (3.60)	-0.96 (2.03)	-0.06 (0.60)	0.13 (0.74)	0.09 (4.69)
Western Isles	-0.32 (0.71)	0.10 (0.16)	-0.46 (4.15)	1.12 (5.08)	0.08 (3.58)
Never went to school	0.13 (0.08)	-1.81 (0.92)	1.26 (2.49)	-3.64 (2.94)	-0.29 (3.21)
ALS <=14	0.75 (1.32)	0.21 (0.28)	0.40 (2.45)	-2.82 (7.80)	-0.36 (0.68)
ALS 15	-0.33 (0.67)	-0.33 (0.49)	0.07 (0.52)	-2.06 (6.45)	-0.22 (7.38)
ALS 16	-0.50 (1.02)	0.04 (0.06)	-0.19 (1.35)	-1.66 (5.31)	-0.10 (3.40)
ALS 17	-1.44 (2.83)	-0.85 (1.26)	-0.28 (1.93)	-0.92 (2.89)	-0.01 (0.31)
ALS 18	-0.58 (2.93)	-0.90 (1.27)	-0.31 (2.04)	-0.44 (1.36)	-0.01 (0.20)
ALS>=19	-2.54 (5.17)	-1.70 (2.58)	-0.28 (2.00)	-0.25 (0.79)	-0.07 (2.39)
Work	1.05 (2.20)	0.85 (1.42)	-0.53 (4.47)	-0.10 (0.42)	0.03 (1.13)
Permanently disabled	4.77 (7.96)	4.55 (6.32)	5.96 (41.05)	-9.74 (35.42)	-1.57 (57.70)
Unemployed	2.88 (4.80)	1.78 (2.33)	1.66 (10.95)	-2.91 (9.85)	-0.24 (8.39)
Retired	0.83 (1.47)	0.75 (1.07)	0.17 (1.23)	-0.77 (2.87)	-0.23 (8.60)
Looking after home	3.60 (6.56)	2.27 (3.22)	1.14 (8.25)	-1.63 (6.00)	-0.16 (5.78)
Something else	2.35 (3.99)	2.19 (2.15)	0.89 (5.69)	-2.10 (6.08)	-0.29 (7.97)
Married	-0.43 (2.11)	-0.40 (1.63)	-0.45 (9.05)	1.49 (16.00)	0.07 (7.22)
Separated	1.32 (3.25)	1.22 (2.24)	1.29 (11.96)	-1.39 (6.41)	-0.05 (2.36)
Divorced	1.10 (3.53)	1.33 (3.41)	0.63 (7.91)	-0.74 (4.81)	-0.07 (4.30)
Widowed	0.46 (1.40)	0.08 (0.19)	0.22 (1.77)	-0.08 (0.51)	-0.07 (4.02)

2nd income quintile		-0.60 (1.98)	-0.42 (6.16)	0.89 (7.30)	0.03 (1.73)
3rd income quintile		-0.51 (1.65)	-0.62 (8.92)	1.70 (13.78)	0.12 (10.74)
4th income quintile		-0.81 (2.58)	-0.81 (11.45)	2.06 (16.23)	0.21 (17.94)
Top income quintile		-1.20 (3.77)	-0.84 (11.54)	2.72 (20.84)	0.26 (21.82)
Income missing		0.57 (2.10)	-0.45 (7.01)	1.41 (10.86)	0.10 (9.36)
Constant	74.21	74.31	11.11	48.72	4.31
Adjusted R^2	.0442	.0467	.1204	.1379	.2504
N	25,146	25,146	75,830	59,158	82,853

Notes: missing categories; in education; single; not yet finished school; Ayrshire and Arran and top income quintile. Includes 16 age dummies and year. T-statistics in parentheses. T-statistics in parentheses. Pulse rates have mean of 11.32 and a standard deviation of 11.33. GHQ36 is coded from 0-36 with a mean of 10.92. Mental health is theWarwick-Edinburgh Mental Wellbeing Scale is coded from 14-70 with a mean of 49.90. Self-assessed health is very bad (1); bad (2); fair (3); good (4) very good (5) and has a mean of 3.95 SD=.98

Table 4. OLS rgressions of Pulse Rates, General Health, Sleep Problems and Anxiety at age 42, NCDS Biomedical Survey

	Pulse rates	General health	Sleep problems	Anxious
Male	-2.82 (11.49)	0.06 (4.47)	-0.08 (7.16)	-0.08 (8.29)
BMI	0.33 (11.57)	-0.03 (17.63)	0.00 (0.67)	0.00 (1.84)
Short pain	0.06 (0.17)	-0.12 (5.91)	0.06 (3.88)	0.03 (2.33)
Chronic pain	0.64 (2.57)	-0.27 (19.19)	0.15 (12.95)	0.05 (4.92)
Ex-smoker	-0.12 (0.44)	-0.05 (3.53)	0.01 (1.12)	0.01 (0.86)
Current smoker	4.07 (13.81)	-0.26 (15.38)	0.02 (1.82)	0.03 (2.66)
Drink frequency				
Drink <=1 a month	-0.75 (1.40)	0.14 (4.54)	-0.02 (0.76)	-0.06 (3.05)
2-4 times a month	-1.06 (2.08)	0.22 (7.49)	-0.01 (0.61)	-0.07 (3.58)
2-3 times a week	-1.51 (3.06)	0.24 (8.62)	-0.02 (0.77)	-0.07 (3.62)
>=4 times a week	-.69 (1.37)	0.24 (8.23)	0.01 (0.34)	-0.05 (2.72)
Drink missing	-1.29 (0.64)	-0.06 (0.52)	-0.12 (1.03)	-0.15 (1.51)
Difficulty paying bills				
Great difficulty	-3.03 (2.20)	0.31 (3.88)	-0.15 (2.32)	-0.11 (1.94)
Some difficulty	-2.95 (2.50)	0.40 (5.87)	-0.16 (3.04)	-0.10 (2.18)
Slight difficulty	-2.86 (2.46)	0.49 (7.34)	-0.22 (4.09)	-0.16 (3.39)
Very little difficulty	-2.69 (2.35	0.63 (9.55)	-0.26 (5.05)	-0.17 (3.81)
Missing	-3.93 (1.43)	0.49 (3.19)	-0.48 (3.76*)	-0.13 (1.18)
Constant	1.11	3.03	.55	.39
Adjusted R^2	.0543	.1721	.0389	.0206
N	8,161	8,092	8,165	8,164

Excluded: very great difficulty paying bills; drink not in the last 12 months; never smoked
T-statistics in parentheses. Pulse rates mean=71.7.
Sleep variable is – problems trying to get to sleep last month Yes/no? mean=.37
Anxious = anxious nervous and tense for no reason Yes/no? mean=.22
General health- how would you describe your health generally 1=poor (2%); 2=fair (17%); 3=good (64%) and 4=excellent (17%).

Table 5. OLS regressions of pulse rates at age 42, NCDS, Biomedical Survey

	All controls	Minus chronic pain	Plus father's 1958 occupation
Male	-2.79 (9.61)	-2.72 (9.79)	-2.86 (10.04)
BMI	0.31 (10.50)	0.30 (0.45)	0.30 (10.24)
Chronic pain	0 .42 (1.68)		
Ex-smoker	-0.10 (0.36)	0.00 (0.01)	-0.047(0.17)
Current smoker	3.90 (2.26)	3.86 (2.68)	3.74 (1.92)
Drink frequency			
Drink <=1 a month	-0.62 (1.09)	-0.37 (0.68)	-0.65(1.14)
2-4 times a month	-0.99 (1.83)	-0.88 (1.71)	-1.11 (2.04)
2-3 times a week	-1.31 (2.50)	-1.07 (2.15)	-1.33 (2.51)
>=4 times a week	-0.41 (0.75)	-.19 (0.38)	-0.40 (0.74)
Difficulty paying bills			
Great difficulty	-3.00 (2.00)	-2.87 (1.92)	-3.17 (2.05)
Some difficulty	-2.90 (2.25)	-2.93 (2.28)	-3.52 (2.64)
Slight difficulty	-2.62 (2.05)	-2.62 (2.06)	-3.12 (2.37)
Very little difficulty	-2.22 (1.76)	-2.28 (1.81)	-2.61 (2.01)
Yorks & Humber	-0.68 (1.10)	-0.53 (0.88)	-0.73 (1.17)
East Midlands	-0.56 (0.88)	-0.85 (1.37)	-1.13 (1.79)
East Anglia	-1.06 (1.42)	-0.94 (1.31)	-1.04 (1.41)
South East	-0.50 (0.94)	-0.54 (1.06)	-0.75 (1.43)
South West	-0.85 (1.38)	-0.87 (1.46)	-0.90 (1.47)
West Midlands	-0.13 (0.21)	-0.25 (0.42)	-0.25 (0.40)
North West	0.41 (0.68)	0.37 (0.64)	0.12 (0.21)
Wales	0.27 (0.37)	0.08 (0.12)	-0.08 (0.11)
Scotland	-0.07 (0.11)	-0.06 (0.10)	-0.29 (0.47)
CSEs 2-5	-0.38 (0.88)	-0.32 (0.78)	-0.37 (0.87)
GCSE A-C	-0.40 (1.09)	-0.23 (0.65)	-0.36 (1.00)
AS levels or 1 A level	-0.86 (0.54)	-1.01 (0.66)	-0.33 (0.21)
2+ A levels	0.27 (0.53)	0.40 (0.81)	0.23 (0.45)
Diploma	-0.40 (0.63)	-0.07 (0.12)	-0.02 (0.02)
Degree	-1.65 (3.70)	-1.60 (3.77)	-1.60 (3.55)
Higher degree	-0.87 (1.19)	-0.99 (1.39)	-1.11 (1.50)
PT paid employee	0.27 (0.74)	0.36 (1.02)	0.32 (0.88)
FT self-employed	-0.30 (0.75)	-0.26 (0.68)	-0.34 (0.88)
PT self-employed	-0.69 (0.81)	-0.83 (1.05)	-0.60 (0.73)
Unemployed seeking work	1.34 (1.33)	1.15 (1.19)	1.23 (1.23)
FT education	0.47 (0.22)	0.13 (0.06)	-0.52 (0.24)
Government scheme	-5.94 (1.15)	-5.96 (1.16)	-6.08 (1.18)
Temporarily sick/disabled	5.56 (2.08)	4.36 (1.79)	4.16 (1.71)
Permanently sick/disabled	2.45 (3.52)	2.63 (4.04)	2.42 (3.66)
Looking after home/family	-0.02 (0.04)	0.49 (0.89)	0.50 (0.88)
Wholly retired	0.97 (0.76)	2.45 (0.98)	2.52 (1.01)
Other	1.77 (1.44)	2.08 (1.80)	1.83 (1.56)
1st marriage	-0.38 (0.95)	-0.41 (1.07)	-0.49 (1.24)
Remarried >=2nd	-0.45 (0.91)	-0.50 (1.07)	-0.58 (1.21)

Legally separated	-0.78 (0.87)	-0.37 (0.44)	0.04 (0.05)
Divorced	-0.46 (0.94)	-0.30 (0.64)	-0.24 (0.49)
Widowed	0.88 (0.73)	0.35 (0.30)	0.49 (0.41)
Father's occupation 1958			
Semi-skilled			0.16(0.36)
Unskilled worker			-0.40 (0.86)
Armed forces			-0.43 (0.63)
Admin, prof, manager			-0.71 (1.68)
Shopkeepers			-3.21 (3.88)
Clerical workers			-1.68 (2.84)
Shop assistants			-0.08 (0.14)
Personal service			-0.60 (0.57)
Foremen			-0.55 (0.66)
Farmers			-0.41 (0.47)
Farm workers			-0.42 (0.63)
Higher admin etc.			0.03 (0.05)
Single no husband			-0.27 (0.32)
Constant	68.81	69.07	70.34
Adjusted R^2	.0612	.0591	.0627
N	7533	8139	7721

Notes: type of worker refers to mother's husband in 1958 (n490); drink frequency, region, height and weight are from biomedical survey at age 42 (2002-2004). Labor force and marital status and education are from NCDS7 in 2000 at age 42. T-statistics in parentheses.

Table 6. Association between pulse rates and work, health and GHQ score in English and Scottish Health Surveys, OLS if age<70

a) English Health Survey, 1998-2019

	Work	GHQ36	General health
Pulse rate*10	-.03 (23.84)	.19 (12.79)	-.09 (37.48)
Personal controls	Yes	Yes	Yes
Adjusted R^2	0.27	0.04	0.11
N	104,793	86,764	104,776

Personal controls are age bands, gender, year, region, race, education and marital status. Work is a 1,0 dummy.
GHQ score available in 1998-2006, 2008-2010, 2012, 2014, 2016, 2018

b) Scottish Health Survey, 2002-2019

	Work	GHQ36	General health
Pulse rate * 10	-.02 (8.94)	.19 (6.44)	-.09 (17.90)
Personal controls	Yes	Yes	Yes
Adjusted R^2	0.40	0.05	0.09
N	25,146	24,224	21,440

Personal; controls are age bands, gender, region, education, marital status and year. Work is a 1,0 dummy

c) Scottish Health Survey, 2009-2019

	WEMWBS	Life satisfaction
Pulse rate	-0.03 (4.92)	-.01 (7.41)
Personal controls	Yes	Yes
Adjusted R^2	0.06	0.09
N	9,839	12,545

Personal; controls are age, gender, region, education, marital status and year. Work is a 1,0 dummy
T-statistics in parentheses.

Table 7. Linear Estimation of the Probability of working in NCDS9, age 55, in 2013

	(1)	(2)	(3)	(4)	(5)
Pulse rate at 42 *100		-0.22 (5.33)	-0.16 (4.23)	-0.17 (4.20)	-0.25 (5.74)
Chronic pain at 42		-0.07 (7.67)	-0.03 (2.94)	-0.03 (2.85)	-0.07 (7.20)
Short pain at 42		-0.02 (1.69)	-0.01 (0.97)	-0.02 (1.57)	-0.02 (1.59)
Great difficulty paying bills at 42		0.15 (2.60)	0.02 (0.41)	0.03 (0.48)	0.14 (2.33)
Some difficulty paying bills at 42		0.25 (5.08)	0.06 (1.33)	0.07 (1.37)	0.23 (4.67)
Slight difficulty paying bills at 42		0.31 (6.52)	0.08 (1.76)	0.09 (1.78)	0.30 (6.06)
Very little difficulty paying bills at 42		0.29 (6.07)	0.05 (1.10)	0.05 (1.11)	0.27 (5.63)
Male	0.10 (11.82)	0.08 (8.77)	0.02 (1.78)	0.02 (1.50)	0.08 (8.41)
Yorks & Humber	0.05 (2.44)	0.04 (1.71)	0.03 (1.30)	0.02 (0.71)	0.04 (1.45)
East Midlands	0.05 (2.41)	0.04 (1.71)	0.02 (0.67)	0.01 (0.29)	0.04 (1.41)
East Anglia	0.05 (1.80)	0.02 (0.71)	0.00 (0.14)	-0.01 (0.27)	0.02 (0.64)
South East	0.07 (4.01)	0.05 (2.70)	0.03 (1.50)	0.02 (0.90)	0.05 (2.43)
South West	0.07 (3.27)	0.05 (2.24)	0.02 (0.95)	0.00 (0.06)	0.05 (1.98)
West Midlands	0.08 (3.54)	0.06 (2.59)	0.04 (1.83)	0.02 (0.93)	0.06 (2.31)
North West	0.06 (2.62)	0.04 (1.79)	0.02 (1.09)	0.01 (0.41)	0.04 (1.50)
Wales	0.04 (1.75)	0.03 (1.14)	0.01 (0.38)	0.01 (0.33)	0.03 (0.92)
Scotland	0.06 (2.93)	0.05 (2.15)	0.02 (1.04)	0.01 (0.53)	0.05 (1.87)
CSE D-E	0.11 (0.63)	0.26 (1.23)	0.15 (0.46)	0.16 (0.50)	0.26 (1.20)
CSE, 2-5, Other Scottish	0.11 (7.42)	0.09 (5.12)	0.03 (1.72)	0.03 (1.87)	0.09 (5.12)
GCSE, A-C, good O levels	0.13 (10.88)	0.11 (7.77)	0.04 (3.32)	0.04(2.61)	0.11 (7.61)
AS levels or 1 A level	0.17 (3.05)	0.13 (2.16)	0.07 (1.32)	0.03 (0.51)	0.15 (2.40)
2+ A levels, Scot higher/6th	0.13 (7.30)	0.09 (4.80)	0.03 (1.74)	0.03 (1.47)	0.10 (4.73)
Diploma	0.12 (5.88)	0.10 (4.20)	0.03 (1.22)	0.02 (0.90)	0.10 (4.23)
Degree level	0.15 (10.71)	0.11 (6.94)	0.04 (2.68)	0.03 (1.77)	0.11 (6.69)
Higher degree	0.19 (8.49)	0.14 (5.66)	0.06 (2.85)	0.06 (2.57)	0.14 (5.38)
Fibrinogen at age 42				-0.02 (1.88)	
C Reactive Protein at age 42				0.00 (0.46)	
Labor force status in NCDS7	No	No	Yes	Yes	No
Father's occupation PMS 1958	No	No	Yes	No	Yes
Constant	0.59	0.56	0.90	0.97	0.59
Adjusted R^2	.03	.05	.26	.24	.05
N	9,000	6,913	6,654	5,577	6,650

T-statistics in parentheses. Work is a 1,0 dummy from nd9ecact mean=.81

Table 8. Self-reported health status in NCDS9, age 55 estimated by OLS

Pulse rate at 42 *100	-0.77 (6.82)	-0.28 (2.94)	-0.27 (2.82)	-0.25 (2.62)
Chronic pain at 42	-0.37 (14.63)	-0.14 (6.46)	-0.14 (6.45)	-0.14 (6.21)
Short pain at 42	-0.14 (6.82)	-0.02 (0.53)	-0.0167 (0.54)	-0.02 (0.57)
BMI at 42	-0.03 (11.48)	-0.01 (5.58)	-0.014(5.44)	-0.02 (6.09)
Male	0.07 (2.41)	0.02 (0.98)	0.02 (0.88)	0.03 (1.17)
Birth weight ozs * 100	0.03 (1.92)	0.03 (2.13)	0.31 (2.14)	0.03 (2.09)
Systolic bp at 42 * 10	0.02 (1.63)	0.01 (0.96)	0.01 (0.95)	0.01 (1.17)
Diastolic bp at 42 *100	-0.57 (2.75)	-0.28 (1.59)	-0.28 (1.60)	-0.31 (1.74)
Life turned out so far (50)				0.041 (4.55)
Life in 10 years (50)				0.02 (2.53)
Education controls at 55	Yes	Yes	Yes	Yes
Region at 55	Yes	Yes	Yes	Yes
Labor force status at 55	Yes	Yes	Yes	Yes
Health at age 50	No	Yes	Yes	Yes
Father's occupation 1958	No	No	Yes	Yes
Constant	4.79	4.70	4.69	4.7
Adjusted R^2	.23	.46	.46	.47
N	6,504	6,184	6,184	6,143

Notes: T-statistics in parentheses.
Health status measured as 1=poor (6%); 2=fair (=14%); 3=good (32%); 4=very good (34%) and excellent =5 (13%)

Table 9. Life satisfaction in NCDS8 at 50 estimated by OLS

	Life turned out		Life in 10 years	
Pulse rate at 42 *100	-0.60 (3.22)	-0.60 (3.19)	-0.91 (4.83)	-0.90 (4.80)
Chronic pain at 42	-0.27 (6.22)	-0.03 (6.35)	-0.24 (5.64)	-0.25 (5.79)
Short pain at 42	-0.10 (1.54)	-0.09 (1.52)	-0.05 (0.73)	-0.05 (0.77)
Male	-0.05 (1.07)	-0.05 (1.03)	-0.21 (4.57)	-0.21 (4.51)
Paying bills at 42				
Great difficulty	1.25 (5.07)	1.26 (5.09)	0.95 (3.89)	0.95 (3.87)
Some difficulty	1.49 (7.11)	1.49 (7.13)	1.09 (5.29)	1.09 (5.26)
Slight difficulty	1.94 (9.37)	1.94 (9.37)	1.25 (6.13)	1.25 (6.10)
Very little difficulty	2.46 (4.49)	2.46 (12.06)	1.72 (8.55)	1.71 (8.51)
Education controls at 50	Yes	Yes	Yes	Yes
Region at 50	Yes	Yes	Yes	Yes
Labor force status at 50	Yes	Yes	Yes	Yes
Father's occupation (1958)	No	Yes	No	Yes
Constant	4.21	5.84	7.07	7.06
Adjusted R^2	.11	.11	.09	.09
N	7,436	7,436	7,013	7,013

T-statistics in parentheses.

Life satisfaction defined in Q1 and Q2 above coded 0-10. Mean life turned out=7.29 and life in 10 years=7.68.