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IZA DP No. 14574

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ISSN: 2365-9793

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ABSTRACT

Health, Retirement and Economic Shocks*

We explore the effects of retirement on both physical and mental ill-health and whether these change in the presence of economic shocks. We employ inverse probability weighting regression adjustment to examine the mechanisms influencing the relationship between retirement and health and a difference-in-differences approach combined with matching to investigate whether the health effects of retirement are affected by the Great Recession. We estimate these models on data drawn from the English Longitudinal Study of Ageing (ELSA) and find that retirement leads to a deterioration in both mental and physical health, however there seems to be considerable effect heterogeneity by gender and occupational status. Our findings also suggest that retiring shortly after the Great Recession appears to improve mental and physical health, although only among individuals working in the most affected regions. Overall, our results indicate that the health effects of retirement might be influenced by the presence of economic shocks.

JEL Classification: J14, J26, I10

Keywords: retirement, health, Great Recession, ELSA

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* We would like to thank the UK Data Service for providing the data. We thank participants to the 2020 UK Health Economist's Study Group (HESG) winter meeting in Newcastle, the 2021 LolaHESG (lowlands Health Economic Study Group) conference and attendants to seminars at Lancaster University, UK, and the PHE Public Health Research and Science Conference 2021, for valuable comments. We also would like to thank Katharina Janke and members of the Health Economics at Lancaster (HEAL) research group for their useful suggestions. Mario Martinez-Jimenez gratefully acknowledges funds from the NIHR School of Public Health Research (SPHR), Liverpool and Lancaster Collaboration for Public Health Research (LiLaC). Eugenio Zucchelli acknowledges support from the Tomás y Valiente Fellowship funded by the Madrid Institute for Advanced Study (MIAS), Universidad Autónoma de Madrid, Spain; grants SI1/PJI/2019-00326 and H2019/HUM-5793 funded by the Comunidad de Madrid, Spain; as well as grants PID2019-111765GB-I00 and PID2019- 105688RB-I00 funded by the Spanish Ministry of Science, Innovation and Universities.

1. INTRODUCTION

There is a large and growing body of evidence on the health effects of retirement. Yet, findings are still mixed and previous papers have rarely focused on either the mechanisms governing this relationship or whether the effects of retirement on health could significantly change in the presence of economic shocks, a potentially increasing phenomenon (e.g. Behncke, 2012; Eibich, 2015; Belloni et al. 2016; Fitzpatrick et al., 2018). However, only one paper from Belloni et al. (2016) appears to estimate the impact of retirement on mental health exploiting the Great Recession as an economic shock. The authors find that retirement improves mental health, although only among blue-collar men living in the most severely affected regions. While this paper suggests a positive effect of retirement on mental health within a specific population sub-group, it does not appear to investigate the different causal pathways linking retirement to changes in (mental) health nor to explore corresponding effects on physical health. Overall, and despite their policy relevance, the direction of the impact of retirement on health as well as the specific factors influencing such effects have not been established conclusively.

In addition, the literature on the impact of economics shocks on health also presents varying and inconclusive results (e.g. Di Tella, MacCulloch, and Oswald, 2001; Catalano, 2013; Modrek et al, 2013; Karanikolos et al, 2013). Ruhm's (2000) seminal work on the effects of macroeconomic conditions on health shows that in the US mortality appears to be procyclical and this is confirmed by other studies using data from different countries, including Spain (Granados et al., 2005); Germany (Neumayer, 2004); France (Buchmueller et al., 2007); Canada (Ariizumi and Schirle, 2012); and Mexico (Gonzalez and Quast, 2011). However, a more recent strand of the literature finds that mortality is either countercyclical or unaffected by macroeconomic shocks (Ruhm, 2015). For instance, Tekin et al. (2013) find no evidence that the recent Great Recession had a significant influence on health or health-behaviours.

The main objective of this paper is to examine the effects of retirement on both physical and mental health by: I) focusing on the mechanisms driving the relationship between retirement and health, and II) exploring whether the health effects of retirement may vary in the presence of a severe economic shock. Accordingly, we use rich panel data drawn from eight waves (2002-2018) of the English Longitudinal Study of Ageing (ELSA) and explore the effects of retirement on a wide range of physical and mental health conditions. Specifically, we estimate inverse probability weighting regression adjustment, allowing the identification of both the effects of retirement on health and the potential mechanisms affecting such relationship (Cattaneo, 2010). In addition, we employ a kernel propensity score marching difference-in-differences approach to identify whether the health effects of retirement might be affected by the Great Recession (e.g. Heckman et al., 1998; Blundell & Costas Dias, 2000). In this case, the combined use of matching with difference-in-differences allows building more comparable treatment and control groups and producing more accurate estimates on the role played by the Great Recession (Ho et al., 2007).

We find that retirement has a statistically significant effect on several measures of health: it appears to have a negative impact upon mental health, especially among women, while increasing the probabilities of having a stroke and being diagnosed with pulmonary disease, particularly among men and blue-collar workers. Furthermore, retirement seems to increase the likelihood of reporting lower levels of self-reported health and having health limitations (i.e. difficulties with mobility). As for potential mechanisms, results from inverse probability weighting regression adjustment models suggest that low levels of education; physical inactivity and living in deprived areas are among the key factors affecting changes in mental health following retirement. Also, key mediating factors driving the relationship between retirement and physical health are: age; gender; and broader environmental characteristics of the geographical areas where individuals reside (e.g. population density and deprivation levels).

Our findings also suggest that the health effects of retirement may differ in the presence of economic shocks. When we explore the short-term health effects of retirement immediately after the Great Recession, we find that retirement improves mental health and decreases the probability of suffering from angina and heart attacks. While mental health effects appear to be stronger among male individuals living in the most affected regions, improvements in physical health are mostly concentrated among women also residing in the most severely hit areas. Overall, these results suggest that the health effects of retirement might be affected by economic shocks.

This paper offers several contributions to the literature. First, we extend the literature on the health effects of retirement by exploring the potential mechanisms driving the relationship between retirement and changes in physical and mental health. While the association between retirement and health is well-documented, there is sparse evidence on the mechanisms driving it. Second, we provide new evidence of the impact of retirement on health shortly after the Great Recession, a quite recent economic shock, and assess whether the health effects of retirement are influenced by changes in macroeconomic conditions. This is especially relevant in policy terms as most OECD countries are currently experiencing rapid trends of population ageing (OECD, 2019) with increasing larger proportions of individuals near retirement age coupled with a succession of economic shocks, such as the Great Recession and the one induced by the ongoing COVID-19 pandemic. Hence, it would be important to provide timely and robust evidence to policy makers around the main factors influencing retirement choices during periods of frequent economics shocks, which will inevitably reoccur. Third, whereas most previous studies looking at the health effects of the Great Recession employed data from European countries, we focus on England, one of the most severely affected economies during such period.

Fourth, our difference-in-differences approach combined with matching allows estimating both short- and long-term impacts of retirement on health following the Great Recession.

2. BACKGROUND

2.1 Literature

Empirical studies on the causal impact of retirement on health often present conflicting results. This might be due to heterogeneity of effects; different methodological approaches; and the data used. More specifically, studies applying an instrumental variable (IV) approach (often exploiting statutory retirement age) tend to find positive impacts of retirement on health (e.g. Charles, 2004; Bound and Waidmann, 2007; Neuman, 2008), whereas studies employing panel data methods tend to find negative effects (e.g. Dave et al., 2006; Bamia et al., 2007). Relevant to this study, Behncke (2012) employs nonparametric matching and instrumental variable approaches on three waves of ELSA and finds that retirement increases the risk of being diagnosed with chronic conditions and the probability of reporting lower levels of self-assessed health. However, Gorry et al. (2018) use eligibility to social security as an instrument for retirement on US data from the Health and Retirement Study and find that retirement actually improves self-reported general health, mental health, and life satisfaction. Moreover, results from Coe and Zamarro (2011), obtained exploiting country-specific early and full retirement ages as instruments for retirement and data from SHARE, suggest that that retirement leads to a 35 percent decrease in the probability of reporting ill-health (i.e. fair/bad/very bad health). Finally, Eibich (2015) and Rose (2020) use a Regression Discontinuity Design (RDD) based on financial incentives in the German and English pension systems, respectively. Both studies find that retirement improves subjective general health status.

Estimates on the impact of labour market status on health during economic shocks are also inconsistent (Browning and Heinesen, 2012; Tekin et al, 2013). A strand of studies finds that economic shocks can negatively affect health outcomes by increasing the stress associated with job loss and reducing monetary and non-monetary benefits (e.g. by reducing the availability of flexible-time, periods of leave but also mentoring and childcare related programs), and that these effects vary by age, gender and occupational status (e.g. Eliason and Storrie, 2009; Sullivan and von Wachter, 2009; Jofre-Bonet et al., 2018). Importantly, the literature has so far paid less attention to the impact of economic shocks on the health of older individuals. Yet, Stevens et al. (2015) find that the largest part of the procyclical variation in mortality appears to be driven by people living in nursing homes, a group with a very low attachment to the labour market. McInerney and Mellor (2012) estimate that during economic shocks the mental health of older individuals appears to deteriorate and that such individuals are also less likely to engage in healthy behaviours. However, Ruhm and Black (2000) also find that older individuals tend to engage less in potentially risky behaviours during periods of recessions. Overall, this may further suggest that the health effects of retirement vary by age and occupational status but also that the mechanisms linking economic shocks and health among older individuals are not entirely understood.

2.2 Mechanisms linking economic shocks, retirement and health

Little is known about the specific mechanisms driving the impact of retirement on health, especially during economic shocks. Standard models of health investment (e.g. Grossman, 1972; 2000) suggest that while the depreciation rate on an individual's health stock increases with age, individuals would still invest in their own health. More specifically, individuals may still invest in their health capital post-retirement, even though this will no longer increase their labour productivity or earnings, as "healthy time" also enters the utility function directly as a consumption good (Dave et al., 2006). According to this interpretation, the direction of the effect of retirement on health is ambiguous and would also depend on the marginal value of time after retirement. As a result, the identification of direction and size of the impact of retirement on health remains an open empirical question.

Several studies argue that changes in labour status could have an impact on an individual's health through health-behaviours or increased psychological distress due to income and wealth shocks. Yet, there is opposing evidence on such influences. For instance, Eibich (2015) reports that increased sleep duration, as well as more frequent physical exercise, seem to positively affect health after retirement. Also, retirees are more likely to quit smoking (Insler, 2014) and to experience lower levels of stress (Midanik et al., 1995). Other studies suggest negative or null effects of retirement on social interactions (Sugisawa et al., 1997); alcohol consumption (Zins et al., 2011); healthy eating and physical activity (Nooyens et al., 2005); cognitive ability and health care utilisation (Rose, 2020). In addition, retirement has also been considered a stressful 'life event' per se (Minkler, 1981). Stress can affect health-behaviours such as smoking, drinking, sleeping, eating, and exercising (Brannon et al., 2013) as well as mental health by increasing depression or anxiety, and this may ultimately have an impact on physical health (Scheier et al., 1995). Interestingly, Eibich (2015) also suggests that individuals who retire could experience an improvement in mental health, as they might be relieved from occupational stress. As such, we could also expect that retiring during or immediately after an economic shock could also result in improved mental health due to a reduction in job strain during a particularly stressful time for workers. However, this has not been comprehensively tested on empirical data.

3. Data

Data from the English Longitudinal Study of Ageing (ELSA) are used, including rich individual-level health and socioeconomic information on a representative sample of the English population aged 50 or above between 2002-2017 in order to investigate our empirical questions. ELSA currently includes eight waves through two-yearly interviews combined biomarkers collected during home visits by nurses every four years (i.e. at Waves 2, 4, and 6). The dataset covers extensive information on both mental and physical health; as well as detailed socioeconomic variables such as employment; wealth and pensions; and expectations about future health and paid work. Importantly, the main health variables are also complemented by information on participants' previous health conditions drawn from the Health Survey of England (HSE) between 1998-2001 (note that the original ELSA starting sample is drawn from the HSE). [1]

Given the objective of our analysis, we focus on a sample of individuals who are employed during the first wave (2002-2003). Specifically, our initial sample includes employees or self-employed who were in 'work' or in 'paid work during the last month' during the first wave. We exclude those individuals that despite being 'in paid work' also describe themselves as 'retired'; 'looking-after home or family'; 'semi-retired'; 'unemployed' or 'disabled'.[2] This results in a sample of 1,830 individuals who were employed in Wave 1. We focus on retirement between consecutive waves and define retirement when, conditional on being employed in the previous wave, individuals report being 'retired' and/or 'not in work during the last month' in the subsequent wave. *Voluntary first exits* from the labour market (i.e. we consider retirement as an "absorbing state") are considered, and remove individuals transitioning into unemployment. Accordingly, our retirement variable is a binary indicator taking value 1 if the individual retires between waves, 0 otherwise (if the individual is still working between consecutive waves). A balanced sample of individuals who are present in all waves is used.

Macroeconomic conditions are measured using the annual Unemployment Rate (UR) within each Government Office Region (GOR), the highest tier of the sub-national geographical division of England. The Office of National Statistics (ONS) reports each GOR's UR in 3 months intervals that we use to compute yearly URs.[3] Although we are aware that this might be subject to measurement errors and could underestimate real unemployment rates during periods of economic shocks, this may be the most accurate and consistent measure currently available.[4]

[Figure A5 around here]

3.1. Health outcomes and other key variables

A wide range of self-reported and diagnosed chronic health conditions included in ELSA are used, exploiting information on the *timing* of the diagnosis to define newly diagnosed conditions *after* retirement to ease concerns around reverse causality. Specifically, the following newly diagnosed

[1] ELSA is sampled from the Health Survey for England (HSE). More specifically, sample members recruited for wave 1 of ELSA (2002/2003) were individuals who previously took part to one of the previous three HSE (i.e. 1998, 1999, 2001) and were aged at least 50 or over at the time of the wave 1 ELSA interview (Steptoe et al., 2012).

[2] We exclude 785 respondents reporting that they are both 'in work' and 'retired'.

[3] Data are available at https://www.nomisweb.co.uk.

[4] We merge data from ELSA with ONS's UR using the GOR variable to obtain unemployment rate across regions over time. In 2017, the unemployment rate in some regions was still above their pre-2008 levels, reflecting the severity of the economic crisis. The broad time horizon of the data ensures variation in business cycle conditions across regions. This can be seen in Figure A5 (see Appendix) plotting the percentage point changes in unemployment rates for each regional unit analysed during our sample period—calculated as the difference between the maximum and the minimum unemployment rate for each region in our sample period.

conditions: heart attack and angina; stroke; asthma; musculoskeletal (osteoporosis or arthritis); pulmonary diseases and psychiatric diseases.[5] Finally, self-reported general health status variables are included (e.g. self-assessed health, life-satisfaction and loneliness) and biomarkers collected during nurse visits (e.g. body mass index, blood pressure and cholesterol levels).

The main measure of mental health is based on the 8-item version of the Centre for Epidemiological Studies Depression Scale (CES-D) (Radloff, 1977). This is a well-established and psychometrically validated measure of depression obtained using information on mental health symptoms experienced by respondents (e.g. Irwin et al., 1999). The 8-item version includes information on whether individuals in the previous week "felt depressed"; "felt that everything was an effort"; "had a restless sleep"; "were not happy"; "felt lonely"; "felt sad"; "could not get going"; and "did not enjoy life". Following the literature (Cable et al., 2017), we generate a dummy variable for depression taking value 1 if an individual reports 4 or more symptoms (0 otherwise).

The regressions also account for a wide range of further individual-level sociodemographic characteristics. These include: age; gender; marital status (married/cohabiting); having children living in the household; being born in the UK; and education levels using the International Standard Classification of Education (ISCED). In addition, geographical-level variables are included, such as dummies identifying the nine Government office regions (GOR); quintiles based on a multiple deprivation index and quintiles of population density by postcodes. Relevant to our study, ELSA also allows controlling for individual-level expectations around health and work status. Hence, we also account for individual expectations around the likelihoods of being alive at age 75 and having work-limiting health conditions before the age of 65. Pension related-characteristics such as: type of pension scheme (e.g. defined benefit vs defined contribution schemes) and total pension wealth are used. In addition, the models also include (pre-ELSA) health status variables drawn from the HES interview, such as self-assessed health and having limiting long-standing conditions. These are collected before the first wave of ELSA and thus may help defining baseline (initial) health status (i.e. before individuals turned 50 years old).

3.2. Descriptive statistics

Table 1 shows descriptive statistics for selected variables for different subsamples defined by occupational status, i.e. employed versus retired. The third column reports standard t-tests to explore statistically significant differences between means of observed variables in the two groups of

[5] Whether the respondent has been diagnosed with depression or anxiety by a physician. However, this variable might not truly reflect the mental health state, since many psychiatric conditions remain undiagnosed or individuals do not report them in a face-to-face interview.

individuals.[6] Overall, retirees present lower levels of health status before they retire. In particular, they report higher number of (pre-ELSA) long-standing conditions as identified by the variables collected in the HSE. Moreover, retired individuals are, on average, three years older than individuals who are still employed. There are also significant differences with regard to pensions: retired individuals are more likely to being aged above the state pension age compared to employees and they are less likely to have their pensions in defined contribution schemes. With respect to health habits, retired individuals are more likely to engage in moderate physical activity, but they are less likely to drink alcohol more than once a week.

[Table 1 around here]

4. EMPIRICAL APPROACH

4.1. Inverse probability weighting regression adjustment

Inverse probability weighting regression adjustment **(**IPWRA) are used to identify the health effects of retirement and exploring the mechanisms governing this relationship (Imbens and Wooldridge, 2009; Cattaneo, 2010). IPWRA is a quasi-experimental approach providing measurements of unobserved potential outcomes and involving a two-stage estimation, including a treatment model (first stage) and outcome models (second stage).[7] The first stage allows estimating selection into treatment (retirement) conditional on observables and to compute inverse probability weights. The second stage employs the estimated inverse probability weights produced during the first stage to: I) estimate weighted linear regression models of our outcomes (mental and physical health variables) for retired vs non-retired individuals and II) computes means of the treatment-specific predicted outcomes from the linear weighted regression outcomes models. The difference between these predicted outcomes provides the average treatment effect of interest, i.e. the effect of retirement on health. In addition, the estimates produced by the second stage outcome models allow investigating specific mechanisms affecting the relationship between retirement and health.

The effects of retirement on health are focussed on by looking only at first exits from the labour market, i.e. those individuals who re-entered into the labour market after an initial exit are excluded. Thus, individuals are defined as treated if their transition from work into retirement between consecutive waves is observed. Similarly, individuals who are still working are included in the control group.

The first stage (treatment model) involves the estimation of a probit model for the treatment (retirement) including a wide range of observed covariates:

[6] We have also performed standard t-tests adjusted by age. Results are available upon request.

[7] We make use of the Stata command *teffects ipwra* (Stata Corp, 2017). *teffects ipwra* estimates the average treatment effect, the average treatment effect on the treated, and the potential-outcome means from observational data by inverse-probability-weighted regression adjustment (Cattaneo, 2010).

$$p(X) = P(D = 1| X) = \varphi(\gamma + \beta FC_i + \eta X_i) \quad (1)$$

where φ is the cumulative standard normal distribution function and D is the corresponding treatment dummy variable. Covariates include gender (female); age; married/cohabiting; the presence of dependent children; being born outside UK; ISCED educational classification (never went to school or not yet finished; went to school until 14 or below; O level equivalent; A level equivalent; post-secondary non-tertiary and short-cycle tertiary[8]; university degree or equivalent); dummies for the nine English regions (GOR) (base category: South West); eight wave dummies (base category: wave 1, 2002/03); four dummies of quintiles of population density using the Quintile Population Density for Postcode Sectors (base category: most densely populated quintile); four dummies of deprivation area using the Quintile Index of Multiple Deprivation Score 2004 (base category: most deprived); being above of the State Pension Age (SPA); own assessment of the chance health will limit work at age 65; contribution pension; benefit pension; pension (private plus public) wealth/10000; reporting bad general health in the HSE; reporting having long-standing illness in the HSE; own assessment of the chance of being alive at age 75.[9]

Using model (1), the model can predict the conditional probability of retirement for each observation in the data, $p(retirement) = \hat{p}(X_i)$. This also allows generating inverse probability weights for each individual's weight which is equal to the inverse of the probability of the actual treatment they received. That is,

$$w_i = 1/\hat{p}(X_i) \quad if \quad D = 1$$

are used to weight observations in the treatment group, thus weights will be large when the probability of retiring is small. Similarly,

$$w_i = 1/(1 - \hat{p}(X_i)) \quad if \quad D = 0$$

weight observations in the control group, therefore weights will be large when the probability of being employed (not retiring) is small. Effectively, this assigns larger weights to treated individuals (retirees) with similar observables to untreated individuals (employees), thus building counterfactuals that are as comparable as possible to treated individuals.

[8] Post-secondary non-tertiary education refers to programmes providing learning experiences that build on secondary education and prepare for labour market entry and/or tertiary education. In contrast, the short-cycle tertiary education are those programmes that are typically practically-based, occupationally-specific and prepare for labour market entry.

[9] In order to account for a potential (selection) bias due to missing data, an additional missing data category is created for each variable. This also helps preserving the number of observations.

The second stage includes the estimation of linear weighted regressions (outcomes models). Importantly, here we use a different set of observed variables, including variables that may influence health status but not necessarily the decision to retire. More specifically, in addition to those included in the first stage we include the following set of variables: being a current smoker; drinking over the limit; never engaging in vigorous or moderate activities more than once a week; using any medications; and having health insurance.

Separate linear weighted regression models are estimated for individuals who retire and those who are still employed. This enables the exploration of the potential mechanisms influencing the relationship between retirement and health. Importantly, in these models' observations are weighted using the inverse probability weights w_i, generated from the predicted conditional probabilities of retiring during the first stage. The difference between the potential outcomes provides an estimate of the average treatment effect of retiring on physical and mental health:

$$\tau_{ATE} = N^1 \sum_{i=1}^{N} (\mathrm{E}[\mathrm{Y_i}|FC_i, X_i, D = 1] - E[[\mathrm{Y_i}|FC_i, X_i, D = 1]) \quad (2)$$

Note that this estimator is based on the assumptions of conditional independence, $(\mathrm{Y}_1, Y_0 \perp D|p(X))$, and common support, $0 < Pr(D = 1|X) < 1$. According to the conditional independence assumption (CIA), all variables affecting both the treatment and the outcomes of interest can be observed. This implies that conditional on the observables, the treatment is independent of potential outcomes. The common support assumption ensures that there is sufficient overlap in the observed characteristics of treated and untreated individuals to find adequate matches. Tests around these assumptions can be found in the Appendix. Finally, IPWRA estimators also present a doubly-robust property, implying that estimates will be consistent even if one of the two models are not correctly specified (Cattaneo, 2010).

4.2. Kernel propensity score matching difference-in-differences

A kernel propensity score matching difference-in-differences approach (KPSM-DD) is used to identify whether the Great Recession (GR) influenced the impact of retirement on health (Heckman et al., 1998). This method involves a two-stage difference-in-differences estimation that: I) computes Kernel-based propensity score matching weights using a treatment model to pre-process the data and build more comparable treatment and control groups; and II) estimate a difference-in-differences (DD) specification to identify the impact of retirement on health after the GR using the re-weighted and improved treatment and control groups.

The Great Recession hit the UK between the second quarter of 2008 and the second quarter of 2009, leading to higher unemployment and worsening labour market conditions (Bell et al., 2010). Accordingly, the years between 2004-2007 are used as the pre-recession period and the years between 2010-11 as the post-recession period. Following the previous literature exploring the effects of the GR (e.g. Parma et al., 2016; Thompson et al., 2019), the years 2008-09 are excluded to allow the recession enough time to influence the relationship between retirement and health (i.e. it is assumed that the health effects of retirement would not be instantaneously affected by the GR). Accordingly, since we want to investigate whether the GR affected the impact of retirement on health, the difference-in-differences estimate focuses on the effect of retiring during the post-recession years (2010-11).

In practice, the first stage of the KPSM-DD approach simply translates into the estimation of a probit model for our treatment (retirement), including the same set of covariates used for the IPWRA's treatment model (see Equation 1). This stage predicts the conditional probability of retiring for each observation in the data, $p(retirement) = \hat{p}(X_i)$, and produces corresponding weights for each individual. Thus, individuals in the treatment group (retirees) receive a weight of 1, while individuals in other groups receive a weight that is defined by the probability of them being in the treatment group (retirees) relative to the probability of them being in the group they actually belong to. The weighting strategy used here weights the four groups (treatment groups pre- and post-recession and control groups pre- and post-recession) to be as similar as possible based on a set of key observable characteristics. This can be thought of as weighting each of the four corresponding cells to reflect the covariate distribution in the treatment group during the pre-recession period, thus removing biases due to systematic differences in the observables between the four groups.

Our baseline DD specification is:

$$Y_{it} = \alpha + \beta_1 POST_t + \beta_2 TREAT + \beta_3 POST_t * TREAT + Year_i + Region_i + X_{it} + e_{it} \quad (3)$$

The dependent variable, Y_{it}, is the set of mental and physical health variables reported by individual i on a year t. $POST_t$ is a dummy variable that equals 1 for the post-recession period (2010-11), and 0 for the pre-recession period (2004-07). $TREAT$ is a dummy variable that equals 1 if the respondent retires between waves. The parameter of interest is β_3 corresponding to the interaction between binary variables identifying the treatment group ($TREAT$) and the post-recession period ($POST_t$), respectively. This specification controls for the same set of explanatory variables previously used for the IPWRA treatment model and also includes regional ($Region_i$) and years ($Year_i$) fixed effects.[10] In addition, we separately run Equation (3) using as the post-recession period variable ($POST_t$) the years between 2010-2017 to provide an average estimate on the health effects of retiring after the economic recession for a longer time period.

[10] We explore the common trend assumption by comparing trends in health outcomes during the years prior to the Great Recession (2004-2007) using the post-matching sample. See Figure A4 in the Appendix. Note that trends using the pre-matching sample for all the health outcomes are available from the corresponding author upon request.

5. RESULTS

Determinants of retirement

Table 3 reports the probit estimates corresponding to the first stage (treatment model) of the inverse probability weighted regression adjustment (IPWRA) estimator.[11] The table shows that women have a higher probability of retiring compared to men while increasing age appears to be positively associated with retirement (with some evidence of a non-linear relationship between retirement and age provided by the statistically significant second-order polynomial of the variable age). Individuals with dependent children in their household are also less likely to retire. Living in Yorkshire and the Humber, densely populated areas as well as the variable identifying the post Great Recession years (2010-13) present positive and statistically significant estimates and are thus linked to higher probabilities of retiring. As would be expected, being above the state pension age increases the probability of retiring. Furthermore, having a defined contribution pension scheme decreases the likelihood of retiring, while having a defined benefit pension scheme appears to have the opposite effect. Finally, the probability of retiring also increases for people expecting to have work-limiting health conditions before the age of 65.

[Table 3 around here]

Health effects of retirement

Figure 1 presents the average treatment effects on the treated (ATET) obtained in the second stage of the IPWRA estimation (as the difference between the predicted values of the outcome models). This provides an estimate of the effect of retiring on health.[12]

[Figure 1 around here]

Here, it is observed that overall retirement significantly increases the probability of experiencing physical and mental ill-health. More specifically, retirement increases the likelihood of becoming depressed by 2.1 percentage points (pp). Furthermore, retirement significantly increases the risks of being diagnosed with severe pulmonary diseases (1.6 pp), psychiatric diseases (1.8 pp), and having a stroke (0.9 pp). Table 4 further explores heterogeneity of the health effects of retirement by gender and type of occupation (blue- vs white-collar). Estimates appear to be larger among women (except for pulmonary diseases) and blue-collar workers. Specifically, women and blue-collar workers present increased probabilities of becoming depressed after retirement (2.5 pp and 3 pp, respectively). In addition, women show higher probabilities of having psychiatric diseases (3.5 pp) and men are at higher risk of pulmonary diseases (2.6 pp) after retirement.

[11] In the appendix we report a series of tests exploring the common support assumption and the improved covariate balance after matching, see figures A1-3 and Table 2.

[12] Additionally, we performed hypothesis testing on all our outcomes. This is because as the number of hypothesis tested increases, the proportion of type I errors (false positives) might increase as well. We thus apply an adjustment for multiple comparisons using a conservative approach based on Bonferroni-Holm (Holm, 1979), and compare the p-values generated by individual hypotheses with adjusted critical p-values.

[Table 4 around here]

Mechanisms linking retirement to health

Tables 5 and 6 report the full set of results produced by the second stage (outcome models) of the IPWRA estimation. These are reported by treatment and control groups (individuals who retired between waves vs those who are still in the labour market). These allow exploring the mechanisms influencing the relationship between retirement and health. In this case, we focus on those health outcomes that were previously found to be significantly affected by retirement according to the ATET, i.e. depression; stroke; pulmonary and psychiatric diseases. To unveil the potential mechanisms, estimated effects of key variables are compared between the two groups and identify those factors that appear to be driving the changes in physical and mental health after retirement among those who retired.

[Table 5 around here]

As for mental health, having no formal education degree (i.e. having no formal degree or having some early childhood/primary education); leading a sedentary life (i.e. never engaging in vigorous/moderate activities more than once a week); and living in the least deprived areas, appear to be all statistically significant factors in the relationship between retirement and depression (Table 6). More specifically, having no formal education and a sedentary lifestyle seem to increase the probability of being depressed by 9.8 and 5.2 pp, respectively. This might imply that less educated and physically inactive individuals are less able to cope with the changes brought by retirement. Also, living in the least deprived areas of England, according to the multiple deprivation index, seems to have a protective effect on depression after retirement (7 pp). This could suggest that a higher quality environment, including access to a wide range of services, may positively influence mental health after retirement. Also, while gender (women) and marital status (married/cohabiting) appear to affect the probability of depression among those who retired, this is also true for individuals who are still in the labour market as well (Table 5). However, gender seems to significantly increase the probability of developing psychiatric conditions (column 4 of Table 6) only among those who retired (6 pp).

An inspection of the main factors influencing poor physical health among those who retired appears to suggest that age, having a health condition requiring medications and broader environmental conditions could also play a role. For instance, suffering a stroke after retirement appears to be associated with being currently under medication (2.1 pp) and living in densely populated areas (3.4 pp). While the former variable might be simply suggesting a general state of ill-health or the presence of a health condition, the latter could be a proxy for a worse/low quality general environment. Finally, factors driving the probability of being diagnosed with pulmonary diseases after retirement are age and living in specific areas, namely the North East of England (compared to living in the South West of England), an historically economically deprived region.

As expected, baseline health conditions (those reported as part of the Health Survey of England before the start of ELSA), seem to influence most health outcomes. In particular, reporting fair or poor general health and having a long-standing condition before turning 50 years old are associated with increased probabilities of mental ill-health among both individuals who retired and those still in the labour market.

[Table 6 around here]

Health effects of retirement following the Great Recession

Table 7 shows estimates produced using the KPSM-DD estimator for both mental and physical health outcomes. Column 1 shows that retiring immediately after the Great Recession decreases the probabilities of depression (3.9 pp) and being diagnosed with angina/having a heart attack (3.3 pp). Our heterogeneity analysis by gender, areas and type of occupation (blue vs white-collar workers) also reveals that the positive effects on depression are larger among men and those living in severely hit regions.[13] In contrast, the decrease in the probability of being diagnosed with physical health conditions is mostly concentrated among women, also living in severely affected regions.

[Table 7 around here]

Table 8 provides estimates of the long-term health effects of retiring immediately after an economic shock. Interestingly, all the estimated effects are not statistically significant in this case (see Column 1), suggesting the absence of overall long-term health effects of retiring following an economic shock. Yet, after stratifying the sample by occupation type, our results indicate that blue-collar women living in severely hit regions are still experiencing decreases in the probability of being diagnosed with a series of physical health conditions. While the magnitude of such effects appears substantial and it is reasonable to believe this group of individuals might have experienced improvements in health, we should be cautious in placing emphasis to these results because of the corresponding small sample size.[14]

[Table 8 around here]

Robustness checks: further health outcomes and biomarkers

As a robustness check, results based on further health outcomes are presented, including biomarkers. Specifically, this additional set of variables is divided into three main groups: self-reported health, long-standing illnesses, and biomarkers. In the first group, a binary variable for *'poor'* self-reported health is included, which takes taking value 1 if an individual report "bad" or "very bad" general health, and 0 otherwise. Further binary variables for life satisfaction (taking value 1 if an individual agrees that "in most ways his life is close to his ideal") and loneliness (taking value 1 if the respondent feels "isolated

[13] We define living in a severely hit region as a dummy variable that takes value 1 if the region experiences an increase in the unemployment rate above the mean during our sample period, and 0 otherwise. Therefore, GOR are classified in two categories those above the mean are *'high'* unemployment areas, and those below the mean are *'low'* unemployment areas.

[14] In addition, Figure A4 in the Appendix appears to show slightly converging pre-treatment trends in treatment and control groups for the outcome osteoporosis/arthritis.

from others") are included. Within the second group of variables, a binary indicator is added for "difficulties with mobility" (taking value 1 in case of any difficulties with mobility).[15] Finally, we employ biomarkers such as a binary indicator of (pre-) obesity using information on body mass index (BMI) based on WHO guidelines (BMI $\geq$ 25); and variables for high waist circumference; high systolic and diastolic blood pressure; high cholesterol level; high triglyceride level; and high-sensitivity C-reactive protein level. These health indicators are sensitive to lifestyle changes and are all reliable predictors of cardiovascular-related diseases.

Columns 1-3 of Table 9 report ATET of the effects of retirement on health obtained using IPWRA for the full sample as well as broken down by gender and region. Here, it can be seen that retirement increases the probability of reporting poor SAH and having difficulties with mobility by 1.5 pp and 4.1 pp, respectively. The magnitude of these effects appears to be larger among men. In addition, a reduction in diastolic blood pressure can be observed also among men (4.8 pp).

[Table 9 around here]

Columns 4-6 of Table 9 include results from the KPSM-DD estimation on the impact of retirement on health following the Great Recession. Results show that retirement immediately after an economic shock does not appear to significantly affect reporting poor self-assessed health. Also, retiring immediately after an economic shock decreases the risk of having difficulties with mobility by 13.8 pp among women who live in severely hit regions.

Finally, the validity of the main findings is explored by repeating the estimation of the baseline IPWRA and KPSM-DD models while excluding the self-employed from our control group. This is because the initial control group includes all individuals, employees and self-employed, who were still in the labour market. However, the literature appears to suggest (e.g. Parker et al., 2007; Zwier et al., 2020) that the health effects of retirement might be systematically different for the self-employed, as they could potentially have more flexible working conditions and a higher degree of independence on their working schedule. In this case, results appear to be very similar across alternative definitions of control groups.[16]

6. Conclusions and discussion

This paper contributes to the literature on the effects of retirement on health by exploring the potential mechanisms driving this relationship and examining whether the health effects of retirement might be affected by economic shocks. Inverse probability weighting regression adjustment and a difference-in-

[15] This variable is an index we built using information from 10 binary variables about mobility, including the following questions: difficulty walking 100 yards; difficulty sitting 2 hours; difficulty getting up from chair after sitting long periods; difficulty climbing several flights stairs without resting; difficulty climbing one flight stairs without resting; difficulty stooping, kneeling or crouching; difficulty reaching or extending arms above shoulder level; difficulty pulling or pushing large objects; difficulty lifting or carrying weights over 10 pounds; and difficulty picking up 5p coin from table.

[16] Results are available upon request.

differences approach combined with matching are used on rich longitudinal data from ELSA. The former specification is used to examine the mechanisms linking retirement to changes in both physical and mental health, while the latter exploits the Great Recession to identify short- versus long-term impacts of retirement on health after a severe economic shock. Understanding the different pathways linking economic shocks, retirement and health among older individuals is crucial for devising targeted policies to ensure the well-being of an increasing larger proportion of the population, and increasing resilience in such affected populations most at risk from future, inevitable shocks.

Our results suggest that, overall, retirement appears to impact negatively on mental and physical health. Specifically, we find that retirement increases the risk of depression, stroke, pulmonary and psychiatric diseases. This is broadly in line with previous relevant studies (e.g. Dave et al., 2006; Bamia et al., 2007; Behncke, 2012). In addition, results presented here might offer an insight into the potential mechanisms driving the health effects of retirement. According to our analysis, the key factors affecting the relationship between retirement and health are: age; gender; physical inactivity; low levels of education as well as broader socioeconomic and environmental conditions of the area where the individual lives (e.g. North/South of England; density levels; deprivation quintiles). Importantly, only a small fraction of these factors, such as physical inactivity, seems to be easily modifiable via post-retirement policies, whereas the remaining factors would be only affected by more fundamental policy changes concerning education, housing, and area level socioeconomic status. Hence, a potentially important policy implication could be that the negative health effects of retirement should be mostly addressed by structural policies implemented well before retirement.

It should be noted that a potential limitation of our analysis of the mechanisms influencing the health effects of retirement is that regression adjustment inverse probability weighting relies on selection on observables. However, we employ rich data from ELSA, one of the most comprehensive longitudinal datasets currently available to investigate the relationship between health and labour market status within a population of older individuals in England.

Our findings also suggest that the health effects of retirement are affected by economic shocks. We find that that retiring after the Great Recession improves mental health and decreases the probability of suffering from angina and heart attacks, with some differences by gender. Interestingly, these results confirm evidence reported by Belloni et al. (2016) on mental health and might provide support to the view that leaving the labour market shortly after an economic shock with rapidly deteriorating working conditions, could improve mental health by reducing work-related stress. In addition, we also find that physical conditions concerning cardiovascular and heart diseases might improve. Since these conditions are strongly associated with chronic stress, this could also lend some further support to the hypothesis that leaving the labour market after an economic shock could improve health via reduced stress.

Overall, this is one of the first papers providing a systematic exploration of the mediating factors and mechanisms influencing the health effects of retirement by focusing on both mental and physical health. Building resilience into policies impacting upon vulnerable and at risk populations well in advance of any shock may pay rich health and economic dividends.

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Table 1. Descriptive statistics by employment status.

Variables	Means: Employed	Means: Retired	Test for Mean Differences*
Health status at HSE interview			
More than 1 long-standing condition	0.405 (0.491)	0.433 (0.496)	**
Fair or poor self-assessed health	0.132 (0.339)	0.123 (0.328)	
Socio-demographics			
Female	0.476 (0.499)	0.519 (0.500)	
Age	61.36 (5.310)	64.74 (5.421)	
Aged 50-60	0.487 (0.500)	0.211 (0.408)	***
Aged 61-70	0.452 (0.498)	0.662 (0.473)	***
Aged 71-80	0.057 (0.233)	0.117 (0.322)	***
Aged 81+	0.003 (0.055)	0.010 (0.099)	***
Married/Cohabitee	0.727 (0.445)	0.710 (0.454)	
Child lives in household	0.294 (0.456)	0.174 (0.380)	*
Birth in the UK	0.942 (0.233)	0.939 (0.239)	
Education			
never went or not yet finished	0.007 (0.081)	0.007 (0.084)	
went to school until 14 or below	0.015 (0.123)	0.024 (0.154)	**
O levels	0.450 (0.498)	0.455 (0.498)	
A levels	0.126 (0.332)	0.115 (0.320)	
Higher education below degree	0.161 (0.367)	0.165 (0.371)	
Degree	0.241 (0.428)	0.233 (0.423)	
Regional Characteristics			
Government office region (GOR)			
North East	0.049 (0.216)	0.046 (0.212)	
North west	0.109 (0.311)	0.101 (0.301)	
Yorkshire and the Humber	0.103 (0.305)	0.112 (0.315)	
East Midlands	0.116 (0.321)	0.103 (0.304)	
West Midlands	0.106 (0.308)	0.105 (0.307)	
East of England	0.152 (0.359)	0.160 (0.367)	
London	0.077 (0.267)	0.077 (0.268)	
South East	0.181 (0.385)	0.183 (0.387)	
South West	0.107 (0.309)	0.110 (0.313)	
Population Density for Postcode Sectors			
First quintile (least dense)	0.195 (0.396)	0.206 (0.404)	
Second quintile	0.246 (0.431)	0.239 (0.427)	

Third quintile	0.231 (0.421)	0.223 (0.416)	
Fourth quintile	0.178 (0.383)	0.195 (0.396)	
Fifth quintile (most dense)	0.141 (0.348)	0.128 (0.334)	
Index of Multiple Deprivation Score 2004			
First quintile (least deprived)	0.287 (0.452)	0.302 (0.459)	
Second quintile	0.273 (0.446)	0.255 (0.436)	
Third quintile	0.198 (0.399)	0.201 (0.401)	
Fourth quintile	0.159 (0.366)	0.167 (0.373)	
Fifth quintile (most deprived)	0.083 (0.275)	0.076 (0.264)	
Pension characteristics and financial variables			
Individual aged above the State Pension Age (SPA)	0.327 (0.469)	0.616 0.486()	***
Has a defined benefit pension scheme	0.232 (0.436)	0.236 (0.425)	
Has a defined contribution pension scheme	0.255 (0.436)	0.214 (0.478)	***
Total pension wealth/10000	18.08 (16.38)	17.72 (15.26)	
Health behaviours			
Ex-frequent or regular smoker	0.709 (0.454)	0.713 (0.453)	
Drinks alcohol more than once a week	0.623 (0.485)	0.587 (0.493)	**
Foes vigorous or moderate act more than once week	0.254 (0.436)	0.235 (0.424)	*
Private health insurance	0.213 (0.409)	0.115 (0.319)	***
Expectations about health and work			
Likelihood of being alive at age 75	0.068 (0.021)	0.065 (0.023)	***
Chances of health limiting work before age 65	0.648 (0.346)	0.167 (0.272)	***
Observations	6,257	1,812	

Note: T-test of equality of means between retired and employed. Significance levels: *** 1%, ** 5%, * 10%. Last column tests for mean differences in aged adjusted variables, where variables are balanced on age, age squared and four age dummies. * Results for the t-test adjusted by age are available upon request.

Table 2. Matching quality test.

	(1) Pseudo R^2	(2) LR X^2	(3) p-value	(4) Mean bias
Pre-matching	0.088	544.10	0.000	10.7
Post-matching	0.003	11.50	0.994	1.9

Table 3. IPWRA: Probit estimates for retirement (treatment model).

Variables	
Female	0.119*** (0.041)
Age	0.395*** (0.059)
Squared Age	-0.003*** (0.001)
Married or Cohabiting	0.020 (0.041)
Children lives in household	-0.251*** (0.045)
Country of birth in UK	0.091 (0.082)
Never went or not yet finished	0.137 (0.193)
Went to school until 14 or below	-0.038 (0.139)
O level	-0.039 (0.051)
A level	-0.047 (0.067)
Higher ed below degree	0.057 (0.060)
South East	-0.031 (0.071)
London	0.027 (0.099)
East England	0.041 (0.073)
West Midlands	0.013 (0.079)
East Midlands	0.022 (0.078)
Yorkshire and The Humber	0.180** (0.080)
North West	0.022 (0.082)
North East	0.128 (0.102)
Wave 2004/05	0.158* (0.087)
Wave 2006/07	-0.032 (0.086)
Wave 2008/09	0.102 (0.083)
Wave 2010/11	0.177** (0.082)
Wave 2012/13	0.230*** (0.083)
Wave 2014/15	0.082 (0.086)
Wave 2016/17	-
1st Quintile Population Density (Least dense)	0.261 (0.224)
2nd Quintile Population Density	0.139* (0.078)
3rd Quintile Population Density	0.132* (0.075)
4th Quintile Population Density	0.133* (0.074)
5th Quintile Population Density (2nd most dense)	0.217** (0.074)
1st Quintile Index of Multiple Deprivation Score 2004 (least deprived)	0.097 (0.082)

2nd Quintile Index of Multiple Deprivation Score 2004	0.020 (0.080)
3rd Quintile Index of Multiple Deprivation Score 2004	0.016 (0.081)
4th Quintile Index of Multiple Deprivation Score 2004 (2nd most deprived)	0.082 (0.081)
Individual aged above the State Pension Age (SPA)	0.265*** (0.052)
Chances of health limiting work before age 65 (26-50%)	0.086 (0.056)
Chances of health limiting work before age 65 (51-75%)	0.162** (0.066)
Chances of health limiting work before age 65 (76-100%)	0.135* (0.076)
Has a defined benefit pension scheme	0.124** (0.052)
Has a defined contribution pension scheme	-0.099** (0.049)
Total pension wealth/10000	0.001 (0.001)
Fair or poor self-assessed health (HES)	0.046 (0.058)
Has limiting long-standing illness (HES)	-0.056 (0.037)
Chances of being alive at age 75 answer (26-50%)	-0.036 (0.101)
Chances of being alive at age 75 answer (51-76%)	-0.171* (0.100)
Chances of being alive at age 75 answer (76-100%)	-0.124 (0.098)
Constant	-15.11*** (2.001)
Number of observations	6,610

Note: Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. This table reports results of the two-stage estimation of the inverse probability weighting regression adjustment (IPWRA) specification. In particular, this table reports results of the first-stage probit model on the determinants of being retirement compared to being still employed (treatment model). All models include incrementally pseudo-region and time fixed effects and the full battery individual-level observed characteristics. Missing categories created for chances of being alive at age 75, and chances of health limiting work before age 65.

Figure 1. IPWRA: Estimated ATET for mental and physical health outcomes using the full sample.

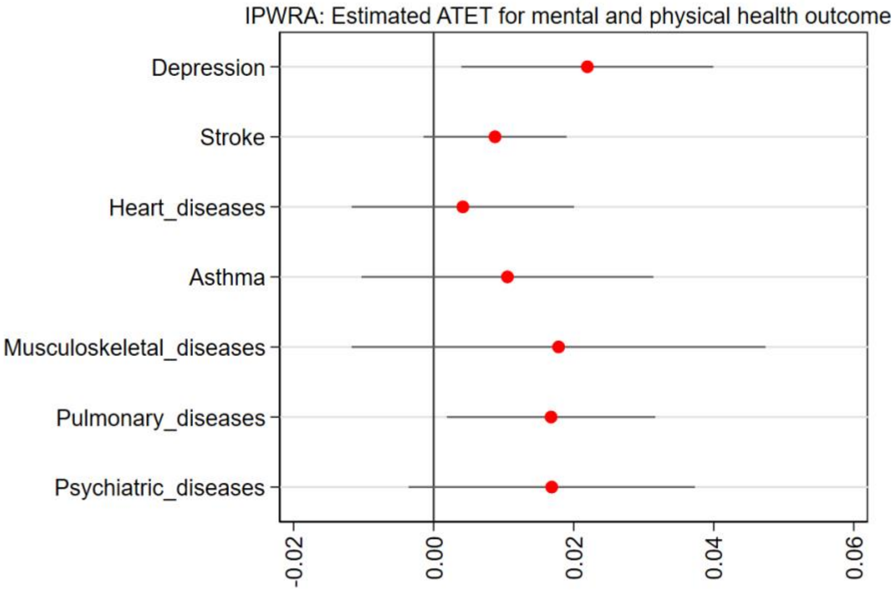


Table 4. IPWRA: Estimated ATET for mental and physical health outcomes by sub-samples.

Outcome variables	**Women:** ATET	**Men:** ATET	**Blue-collar:** ATET	**White-collar:** ATET
Depression (CES-D)	**0.025****	0.017	**0.030****	0.014
	(0.014)	(0.011)	**(0.016)**	(0.011)
Stroke	0.012	0.004	**0.015***	0.006
	(0.007)	(0.007)	**(0.009)**	(0.007)
Angina or heart attack	0.002	0.006	0.010	-0.002
	(0.008)	(0.014)	(0.016)	(0.009)
Asthma	0.011	0.018	0.017	0.003
	(0.015)	(0.014)	(0.017)	(0.014)
Osteoporosis or arthritis	0.007	0.012	0.030	0.003
	(0.021)	(0.022)	(0.026)	(0.019)
Pulmonary diseases	0.009	**0.026****	0.021	0.013
	(0.010)	**(0.012)**	(0.015)	(0.009)
Psychiatric diseases	**0.035****	-0.004	0.009	0.016
	(0.016)	(0.014)	(0.017)	(0.013)
Region and Time FE	*Yes*	*Yes*	*Yes*	*Yes*
Individual characteristics	*Yes*	*Yes*	*Yes*	*Yes*
Observations	3,254	3,356	2,333	4,264

Note: Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. This table reports results of the two-stage estimation of the inverse probability weighting regression adjustment (IPWRA) specification. In particular, this table reports results of the second-stage linear model on the effect of retirement on physical and mental health (outcome model). All models include incrementally pseudo-region and time fixed effects and the full battery individual-level observed characteristics. In this table, we are performing 7 x 5 = 35 hypothesis test, and therefore, we need to make adjustment for multiples comparisons. P-values adjusted for multiple hypothesis tests using the Bonferroni-Holm (Holm, 1979) method.

Table 5: Second-stage of the IPWRA (outcome model): control group

RA: Outcomes model for Control group (employed)	**Depression**	**Stroke**	**Pulmonary diseases**	**Psychiatric diseases**
Female	0.031*** (0.009)	-0.006 (0.006)	-0.016** (0.007)	0.014 (0.012)
Age	-0.014 (0.017)	-0.009 (0.012)	0.020 (0.014)	-0.003 (0.015)
Squared Age	0.001 (0.001)	0.001 (0.001)	-0.00 1 (0.001)	-0.001 (0.001)
Married or Cohabiting	-0.034*** (0.012)	0.010* (0.005)	0.011 (0.008)	-0.012 (0.013)
Children lives in household	-0.016 (0.009)	-0.001 (0.006)	-0.002 (0.009)	0.015 (0.013)
Country of birth in UK	0.013 (0.021)	0.006 (0.018)	-0.000 (0.018)	-0.099*** (0.016)
Never went or not yet finished	-0.032 (.032)	-0.027** (0.010)	-0.048*** (0.013)	-0.128*** (0.028)
Went to school until 14 or below	0.017 (0.043)	0.015 (0.026)	0.096*** (0.035)	-0.070** (0.032)
O level	0.010 (0.012)	-0.008 (0.006)	0.047*** (0.007)	-0.033** (0.016)
A level	0.015 (0.016)	0.007 (0.011)	0.015 (0.010)	-0.106*** (0.018)
Higher education below degree	-0.007 (0.014)	-0.001 (0.010)	0.007 (0.008)	-0.013 (0.021)
South East	-0.004 (0.017)	-0.012 (0.012)	0.012 (0.011)	-0.037 (0.024)
London	0.068** (0.029)	-0.021* (0.012)	0.085*** (0.011)	-0.047 (0.032)
East England	0.005 (0.017)	-0.025** (0.011)	0.053*** (0.022)	-0.002 (0.025)
West Midlands	0.018 (0.019)	-0.018 (0.013)	0.003 (0.010)	0.004 (0.028)
East Midlands	0.029 (0.020)	-0.026** (0.012)	0.051*** (0.017)	-0.025 (0.026)
Yorkshire and The Humber	0.028 (0.023)	-0.015 (0.013)	0.001 (0.011)	-0.060** (0.026)
North West	0.020 (0.020)	-0.030** (0.012)	0.021 (0.013)	-0.005 (0.029)
North East	-0.013 (0.021)	0.015 (0.020)	0.031 (0.022)	-0.087*** (0.029)
Wave 2004/05	0.014 (0.022)	-0.031* (0.016)	-0.009 (0.018)	-0.068*** (0.026)
Wave 2006/07	-0.001 (0.021)	-0.028* (0.015)	-0.011 (0.017)	-0.052** (0.024)
Wave 2008/09	0.010 (0.021)	-0.016 (0.016)	-0.006 (0.016)	-0.027 (0.026)
Wave 2010/11	0.023 (0.022)	-0.011 (0.016)	-0.006 (0.016)	-0.027 (0.025)
Wave 2012/13	-0.014 (0.020)	-0.022 (0.015)	-0.001 (0.017)	-0.018 (0.026)
Wave 2014/15	-0.016 (0.020)	-0.029** (0.014)	-0.010 (0.018)	0.001 (0.028)
Wave 2016/17	-	-	-	-
1st Quintile Population Density (Least dense)	0.014 (0.059)	-0.007 (0.010)	0.014 (0.018)	-0.064 (0.046)
2nd Quintile Population Density	-0.005 (0.021)	0.017 (0.010)	0.020 (0.014)	-0.018 (0.025)
3rd Quintile Population Density	0.019 (0.021)	0.009 (0.009)	0.043*** (0.015)	-0.025 (0.023)
4th Quintile Population Density	-0.014 (0.020)	0.001 (0.008)	0.016 (0.012)	-0.015 (0.023)
5th Quintile Population Density (Most dense)	-0.008 (0021)	0.005 (0.010)	0.071*** (0.013)	-0.031 (0.022)
1st Quintile Index of Multiple Deprivation Score 2004 (Least deprived)	-0.002 (0.019)	0.003 (0.008)	0.005 (0.020)	0 .001 (0.022)
2nd Quintile Index of Multiple Deprivation Score 2004	0.022 (0.020)	0.008 (0.009)	0.021 (0.020)	0.027 (0.022)
3rd Quintile Index of Multiple Deprivation Score 2004	-0.013 (0.019)	0.034*** (0.010)	0.004 (0.019)	0.028 (0.020)
4th Quintile Index of Multiple Deprivation Score 2004 (Most deprived)	0.008 (0.019)	0.010 (0.007)	-0.001 (0.018)	0 .089*** (0.022)

Current smoker	-0.003 (0.015)	0.004 (0.008)	0.034** (0.016)	-0.045*** (0.015)
Drinks over the limit	-0.033*** (0.009)	-0.009 (0.005)	-0.012* (0.007)	-0.001 (0.011)
Never engages vigorous or moderate act more than once a week	0.084 (0.028)	0.005 (0.013)	0.049** (0.024)	-0.004 (0.025)
Whether taking medication - excluding contraceptives only	-0.007 (0.011)	0.014 (0.005)	0.032*** (0.008)	0.056*** (0.012)
Has private health insurance, whether in your own name or through	-0.017 (0.011)	-0.001 (0.006)	0.001 (0.009)	-0.005 (0.015)
Fair or poor self-assessed health (HES)	0.132*** (0.021)	0.015 (0.011)	0.010 (0.013)	0.127*** (0.023)
Has limiting long-standing illness (HES)	-0.002 (0.010)	-0.006 (0.005)	0.004 (0.009)	0.026** (0.012)
Chances of being alive at age 75 answer in wave 1 (26-50%)	-0.052 (0.028)	-0.003 (0.020)	-0.039 (0.027)	-0.112*** (0.042)
Chances of being alive at age 75 answer in wave 1 (51-76%)	-0.050 (0.027)	-0.022 (0.019)	-0.039 (0.027)	-0.084 ** (0.042)
Chances of being alive at age 75 answer in wave 1 (76-100%)	-0.054 (0.027)	-0.016 (0.020)	-0.044 (0.027)	-0.086** (0.042)
Constant	0.609 (0.566)	0.330 (0.396)	-0.686 (0.462)	0.515 (0.518)
Number of observations	6,610	6,610	6,610	6,610

Note: Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 6. Second-stage of the IPWRA (outcome model): treatment group

RA: Outcomes model results for Treatment group (retirement)	**Depression**	**Stroke**	**Pulmonary diseases**	**Psychiatric diseases**
Female	**0.043**** (0.017)	0.003 (0.010)	-0.026** (0.013)	**0.060***** **(0.018)**
Age	-0.046 (0.029)	-0.008 (0.015)	**0.046***** **(0.015)**	-0.009 (0.022)
Squared Age	0.003 (0.001)	0.001 (0.001)	**-0.001***** **(0.001)**	0.001 (0.001)
Married or Cohabiting	**-0.054***** (0.018)	0.003 (0.010)	-0.005 (0.014)	-0.020 (0.020)
Children lives in household	0.001 (0.021)	-0.007 (0.010)	-0.013 (0.016)	-0.013 (0.024)
Country of birth in UK	0.004 (0.038)	-0.020 (0.013)	-0.013 (0.027)	-0.164** (0.030)
Never went or not yet finished	**0.098***** **(0.027)**	-0.033* (0.017)	-0.050** (0.022)	-0.164*** (0.037)
Went to school until 14 or below	0.029 (0.060)	0.056 (0.050)	0.060 (0.053)	-0.060 (0.050)
O level	0.011 (0.019)	-0.006 (0.010)	0.039** (0.016)	-0.038 (0.025)
A level	-0.003 (0.025)	0.020 (0.018)	0.035* (0.022)	-0.101 (0.020)
Higher education below degree	0.017 (0.023)	-0.006 (0.012)	**0.032*** **(0.018)**	-0.012 (0.030)
South East	-0.022 (0.027)	-0.019 0.017	0.028 (0.022)	-0.022 (0.035)
London	0.074 (0.047)	0.003 (0.024)	0.050 (0.031)	-0.077 (0.043)
East England	0.028 (0.030)	-0.013 (0.018)	**0.069*** **(0.024)**	-0.043 (0.035)
West Midlands	0.014 (0.032)	0.001 (0.021)	0.035 (0.024)	-0.025* (0.039)
East Midlands	0.023 (0.034)	0.007 (0.022)	0.021 (0.023)	-0.034 (0.041)
Yorkshire and The Humber	-0.013 (0.031)	-0.029 (0.018)	0.030 (0.023)	-0.041 (0.038)
North West	-0.023 (0.032)	-0.009 (0.021)	0.035 (0.024)	0.007 (0.043)
North East	-0.036 (0.039)	-0.045 (0.036)	**0.083***** **(0.040)**	-0.112 (0.043)
Wave 2004/05	-0.031 (0.035)	-0.012 (0.019)	-0.003 (0.028)	-0.040** (0.034)

Wave 2006/07	-0.016 (0.036)	0.004 (0.021)	-0.009 (0.028)	-0.064 (0.036)
Wave 2008/09	-0.024 (0.034)	-0.005 (0.018)	-0.002 (0.028)	**-0.038*** **(0.034)**
Wave 2010/11	-0.023 (0.033)	-0.001 (0.019)	0.010 (0.028)	-0.020 (0.034)
Wave 2012/13	-0.035 (0.031)	0.007 (0.021)	0.004 (0.027)	0.032 (0.035)
Wave 2014/15	-0.022 (0.034)	0.006 (0.022)	0.024 (0.029)	-0.005 (0.036)
Wave 2016/17	-	-	-	-
1st Quintile Population Density (Least dense)	0.065 (0.124)	-0.004 (0.017)	**-0.081**** **(0.035)**	0.099 (0.111)
2nd Quintile Population Density	0.017 (0.037)	**0.040*** **(0 015)**	0.026 (0.029)	0.025 (0.037)
3rd Quintile Population Density	0.006 (0.035)	**0.033*** **(0.015)**	0.002 (0.026)	-0.016 (0.034)
4th Quintile Population Density	0.005 (0.035)	0.017 (0.016)	-0.008 (0.025)	0 .033 (0.035)
5th Quintile Population Density (Most dense)	0.003 (0.035)	**0.034**** **(0.016)**	0.008 (0.027)	0.014 (0.033)
1st Quintile Index of Multiple Deprivation Score 2004 (Least deprived)	**-0.070**** **(0.042)**	-0.025 (0021)	-0.008 (0.033)	**-0.068*** **(0.041)**
2nd Quintile Index of Multiple Deprivation Score 2004	**-0.071*** **(0.042)**	-0.016 (0.022)	-0.019 (0.032)	-0.065 (0.041)
3rd Quintile Index of Multiple Deprivation Score 2004	0.052 (0.042)	0.010 (0.023)	-0.005 (0.032)	0.038 (0.041)
4th Quintile Index of Multiple Deprivation Score 2004 (Most deprived)	**0.074*** **(0.042)**	-0.024 (0.021)	-0.014 (0.032)	0.029 (0.042)
Current smoker	0.029 (0.029)	0.005 (0.015)	0.031 (0.025)	-0.005 (0.029)
Drinks over the limit	-0.030** (0.015)	-0.011 (0.009)	-0.017 (0.013)	0.023 (0.019)
Never engages vigorous or moderate act more than once a week	**0.052***** **(0.046)**	0.032 (0.024)	0.043 (0.034)	0.029 (0.038)
Whether taking medication - excluding contraceptives only	0.018 (0.017)	**0.021**** **(0.009)**	0.031** (0.013)	0.050** (0.019)
Has private health insurance, whether in your own name or through	-0.027 (0.022)	-0.003 (0.012)	-0.006 (0.018)	0.001 (0.027)
Fair or poor self-assessed health (HES)	0.108*** (0.033)	0.005 (0.015)	-0.010 (0.019)	0.136*** (0.035)
Has limiting long-standing illness (HES)	-0.021 (0.017)	0.002 (0.009)	-0.009 (0.014)	0.052*** (0.019)
Chances of being alive at age 75 answer in wave 1 (26-50%)	-0.012 (0.050)	-0.012 (0.026)	0.038 (0.036)	-0.108** (0.055)
Chances of being alive at age 75 answer in wave 1 (51-76%)	-0.054 (0.049)	-0.015 (0.025)	-0.002 (0.034)	-0.104* (0.054)
Chances of being alive at age 75 answer in wave 1 (76-100%)	-0.049 (0.048)	-0.002 (0.029)	-0.012 (0.033)	-0.101* (0.053)
Constant	1.94** (0.986)	0.264 (0.512)	-1.52*** (0.533)	0.861 (0.779)
Number of observations	6,610	6,610	6,610	6,610

Note: Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 7. KPSM-DD estimates for mental and physical health outcomes: short-term impacts.

Outcome variables	**All population**	**Living in a severely hit region**	**Blue-collar worker**	**Male**	**Male living in a severely hit region**	**Blue-collar male worker living in a severely hit region**	**Female**	**Female living in a severely hit region**	**Blue-collar female worker living in a severely hit region**
Depression	**-0.039****	**-0.086****	-0.009	**-0.077*****	**-0.142*****	-0.044	-0.023	-0.033	0.084
(CES-D)	**(0.022)**	**(0.038)**	(0.039)	**(0.026)**	**(0.041)**	(0.075)	(0.035)	(0.062)	(0.238)
Stroke	-0.012	-0.017	-0.005	0.016	0.037	0.090	**-0.047*****	**-0.084*****	**-0.431*****
	(0.010)	(0.020)	(0.017)	(0.012)	(0.026)	(0.044)	**(0.014)**	**(0.029)**	**(0.108)**
Angina or heart	**-0.033***	-0.014	0.066	-0.002	0.063	0.068	**-0.046****	-0.053	0.091
attack	**(0.019)**	(0.035)	(0.037)	(0.031)	(0.059)	(0.100)	**(0.021)**	(0.036)	(0.175)
Asthma	0.052	0.023	0.021	0.025	0.034	-0.026	0.073	0.022	-0.003
	(0.024)	(0.041)	(0.044)	(0.031)	(0.053)	(0.086)	(0.037)	(0.061)	(0.220)
Osteoporosis or	-0.011	0.094	0.018	0.031	0.056	0.019	-0.007	-0.073	-0.249
arthritis	(0.034)	(0.060)	(0.059)	(0.044)	(0.079)	(0.157)	(0.051)	(0.087)	(0.243)
Pulmonary	0.017	0.001	0.073	0.012	0.026	0.096	0.025	0.012	-0.020
diseases	(0.016)	(0.029)	(0.035)	(0.024)	(0.040)	(0.086)	(0.022)	(0.040)	(0.163)
Psychiatric	0.020	0.023	0.022	-0.014	0.002	-0.034	0.052	0.134	-0.062
diseases	(0.023)	(0.040)	(0.036)	(0.027)	(0.045)	(0.053)	(0.036)	(0.060)	(0.818)
Region and Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,403	1,573	1,487	2,203	758	302	1,688	751	112

Note: Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Severely hit region takes value 1 if the individual lives in a region with unemployment rate higher or equal to the mean during the studied period. P-values adjusted for multiple hypothesis tests using the Bonferroni-Holm (Holm, 1979) method. Kernel-based Propensity Score Matching to generate weights of the treated group using probit model.

Table 8. KPSM-DD estimates for mental and physical health outcomes: long-term impacts.

Outcome variables	**All population**	**Living in a severely hit region**	**Blue-collar worker**	**Male**	**Male living in a severely hit region**	**Blue-collar male worker living in a severely hit region**	**Female**	**Female living in a severely hit region**	**Blue-collar female worker living in a severely hit region**
Depression	-0.013	-0.032	-0.007	-0.026	-0.060	-0.030	-0.003	-0.044	0.189
(CES-D)	(0.017)	(0.031)	(0.030)	(0.020)	(0.037)	(0.079)	(0.026)	(0.050)	(0.132)
Stroke	0.005	-0.006	0.003	0.020	0.018	0.070	-0.013	-0.031	-0.245**
	(0.004)	(0.017)	(0.015)	(0.011)	(0.025)	(0.049)	(0.011)	(0.023)	(0.102)
Angina or heart	-0.017	-0.009	0.031	-0.002	-0.008	0.016	-0.025	-0.049	0.071
attack	(0.015)	(0.028)	(0.028)	(0.024)	(0.048)	(0.083)	(0.016)	(0.033)	(0.093)
Asthma	0.020	-0.023	-0.007	-0.014	-0.021	-0.034	0.020	-0.046	-0.012
	(0.019)	(0.034)	(0.032)	(0.024)	(0.045)	(0.072)	(0.029)	(0.050)	(0.126)
Osteoporosis or	-0.018	-0.029	-0.063	0.032	0.162	-0.019	-0.028	-0.015	-0.384**
arthritis	(0.027)	(0.056)	(0.047)	(0.039)	(0.079)	(0.032)	(0.040)	(0.076)	(0.063)
Pulmonary	0.023	0.038	0.040	0.014	0.025	0.065	0.021	0.011	-0.477***
diseases	(0.014)	(0.024)	(0.026)	(0.019)	(0.036)	(0.075)	(0.018)	(0.037)	(0.096)
Psychiatric	0.004	-0.084	-0.025	-0.031	-0.008	0.051	-0.067	-0.091	-0.020
diseases	(0.019)	(0.096)	(0.022)	(0.028)	(0.015)	(0.024)	(0.009)	(0.018)	(0.084)
Region and Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,899	2,112	1,999	3,014	1,072	424	2,882	1,016	400

Note: Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Severely hit region takes value 1 if the individual lives in a region with unemployment rate higher or equal to the mean during the studied period. P-values adjusted for multiple hypothesis tests using the Bonferroni-Holm (Holm, 1979) method. Kernel-based Propensity Score Matching to generate weights of the treated group using probit model

Table 9. Robustness checks: effects of retirement on further health outcomes and biomarkers.

Outcome variables	**Full sample:** ATET	**Women:** ATET	**Men:** ATET	**All population:** KPSM-DD	**Female living in a severely hit region** KPSM-DD	**Male living in a severely hit region** KPSM-DD
Poor self-assessed health	0.015***	0.011*	0.020**	-0.006	0.010	0.037
	(0.005)	(0.006)	(0.008)	(0.008)	(0.018)	(0.023)
Life satisfaction –close to ideal	0.001	-0.003	0.008	-0.003	0.048	0.008
	(0.008)	(0.012)	(0.011)	(0.015)	(0.044)	(0.027)
Loneliness –lack of companionship	0.006	0.007	0.005	0.004	0.078	-0.024
	(0.014)	(0.021)	(0.019)	(0.027)	(0.075)	(0.068)
Difficulties with mobility	0.041***	0.019	0.062***	-0.047**	-0.138**	0.130
	(0.013)	(0.020)	(0.017)	(0.024)	(0.065)	(0.035)
BMI (obese)	-0.004	-0.031	0.022	0.046	-0.071	0.129
	(0.014)	(0.020)	(0.021)	(0.025)	(0.068)	(0.118)
High Waist circumference (>102	-0.005	-0.012	-0.004	-0.014	-0.039	-0.002
cm for men and >88 cm for women)	(0.015)	(0.021)	(0.023)	(0.028)	(0.072)	(0.072)
High systolic Blood Pressure	-0.017	-0.006	-0.017	0.013	-0.456	0.082
(>140mmHG)	(0.011)	(0.027)	(0.031)	(0.066)	(0.085)	(0.114)
High diastolic Blood Pressure	-0.009	0.012	-0.048***	-0.001	0.043	0.124
(>90mmHG)	(0.020)	(0.014)	(0.016)	(0.035)	(0.065)	(0.073)
High cholesterol level (>6.2mmol/l)	0.014	0.008	0.017	0.005	-0.006	-0.087
	(0.021)	(0.032)	(0.029)	(0.069)	(0.261)	(0.131)
High triglyceride level (>2.26	0.027	0.035	0.013	0.020	0.114	0.172
mmol/l)	(0.018)	(0.023)	(0.029)	(0.057)	(0.094)	(0.094)
High-sensitivity C-reactive protein	0.010	0.001	0.025	0.012	-0.096	-0.028
level (>3mg/l)	(0.019)	(0.026)	(0.027)	(0.054)	(0.100)	(0.131)
Region and Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,981	2,455	2,526	5,877	1,003	1,059

Note: Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. P-values adjusted for multiple hypothesis tests using the Bonferroni-Holm (Holm, 1979) method. Estimated average treatment effects on the treated (ATET) using an Inverse probability weighting regression adjustment estimator (Columns (1)-(3)), and kernel propensity score marching difference-in-difference (KPSM-DD) estimator for effects in short-term (Columns (4)-(6)) for mental and physical health outcomes by different subsamples.

APPENDIX

A. Exploring the main identifying assumptions

First, we check whether there is sufficient overlap in the observed characteristics by comparing the distributions of the propensity scores across individuals in treated and control groups. The corresponding plot (Figure A1) suggests the presence of suitable matches.[17] This appears to satisfy the common support assumption. Figure A2 presents the Kernel density plot which shows the estimated densities of the probability of getting the treatment for both retirees and employees. Visually, we can see a significant overlap in the distribution of the retirees and employees.

[Figures A1-A3 around here]

Second, we assess whether the balance of covariates is achieved after matching. Table 2 reports a summary of the covariate balancing tests pre- and post-matching. The standardized mean difference for all covariates used in the IPWRA is reduced from 10.7% pre-matching to 1.9% post-matching. Matching leads to a bias reduction of about 90%. The p-values of the likelihood ratio tests indicate that the joint significance of covariates was always rejected post-matching. Yet, pre-matching the joint significance of the differences between the covariates is never rejected. The pseudo-R2 also dropped from 8.8% pre-matching to 0.3% post-matching. Overall, the low mean standardized bias, joint insignificance of the covariates and low pseudo-R2 are indicative of successfully balancing the distribution of covariates between retirees and employees through matching.

[Table 2 around here]

Finally, based on data for the years preceding the economic crisis, we explore the validity of the common trend assumption between treated and the control groups. This is investigated by comparing trends in health outcomes before the crisis across treatment and control groups (2004-2007). For the KPSM-DD estimator to be valid, there should be no significant differences in health outcomes trends prior to the Great Recession. Indeed, this assumption can be made more reasonable through careful selection of the comparison group, and appropriate adjustment for covariates (Stuart et al., 2014). In our case, the kernel propensity score matching is considered when choosing a subset of the treatment and comparison groups with similar pre-intervention levels or trends. Figure A4 shows that before the onset of the crisis in 2008/9, trends in the post-matching sample are overall very similar during the two waves prior to the GR (2004/5 and 2006/7).

[17] We have also conducted post-estimation balancing tests which indicate that our model significantly improved the level of balance, i.e. the weighted standardised differences are all close to 0 and the variance ratios are all close to 1. However, the full tables are too large to be included in the paper (but are all available upon request).

[Figure A4 around here]

Figure A1. Propensity Score Distribution and Common support for propensity score estimation.

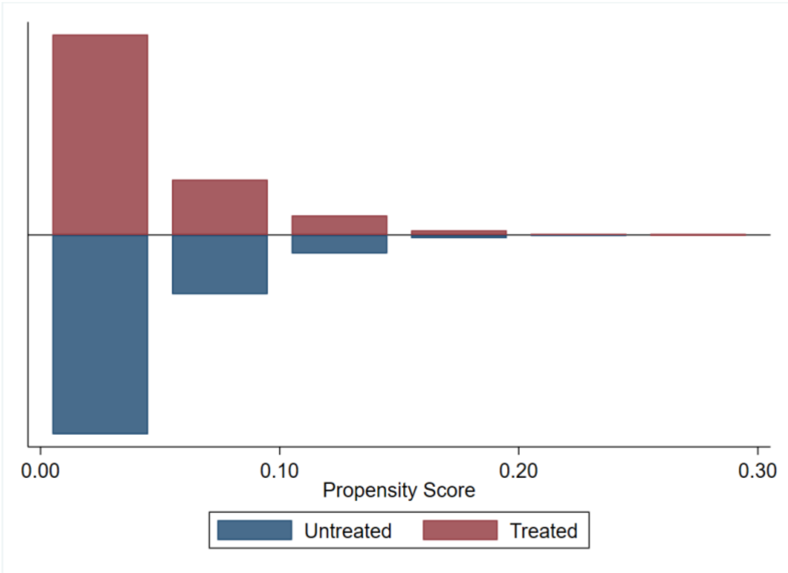


Figure A2. Kernel densities of the probability of getting the treatment-IPWRA.

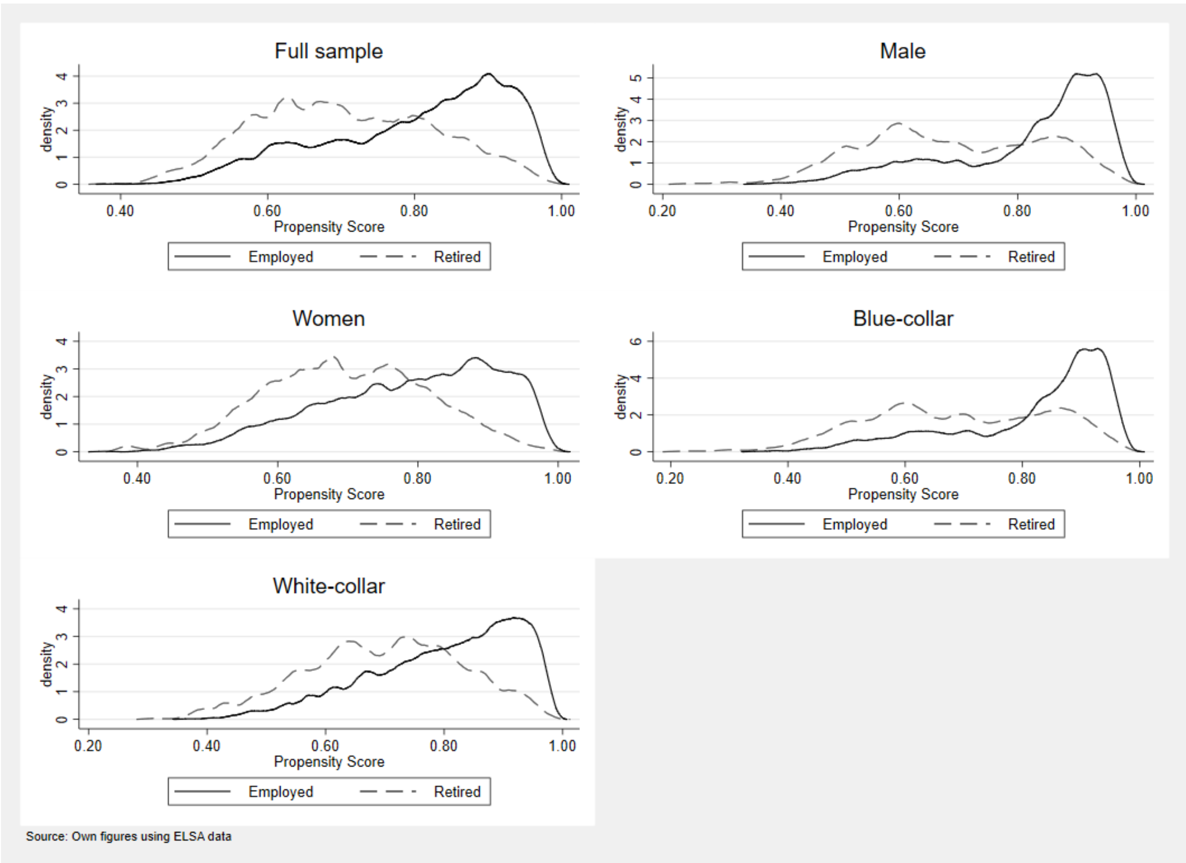


Table A3. Standardised percentage bias across covariates before and after matching.

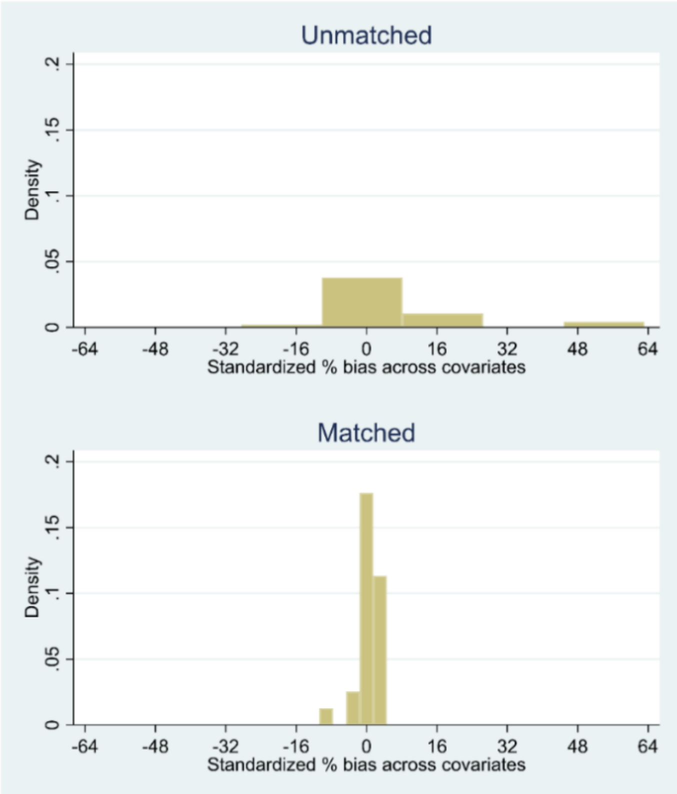
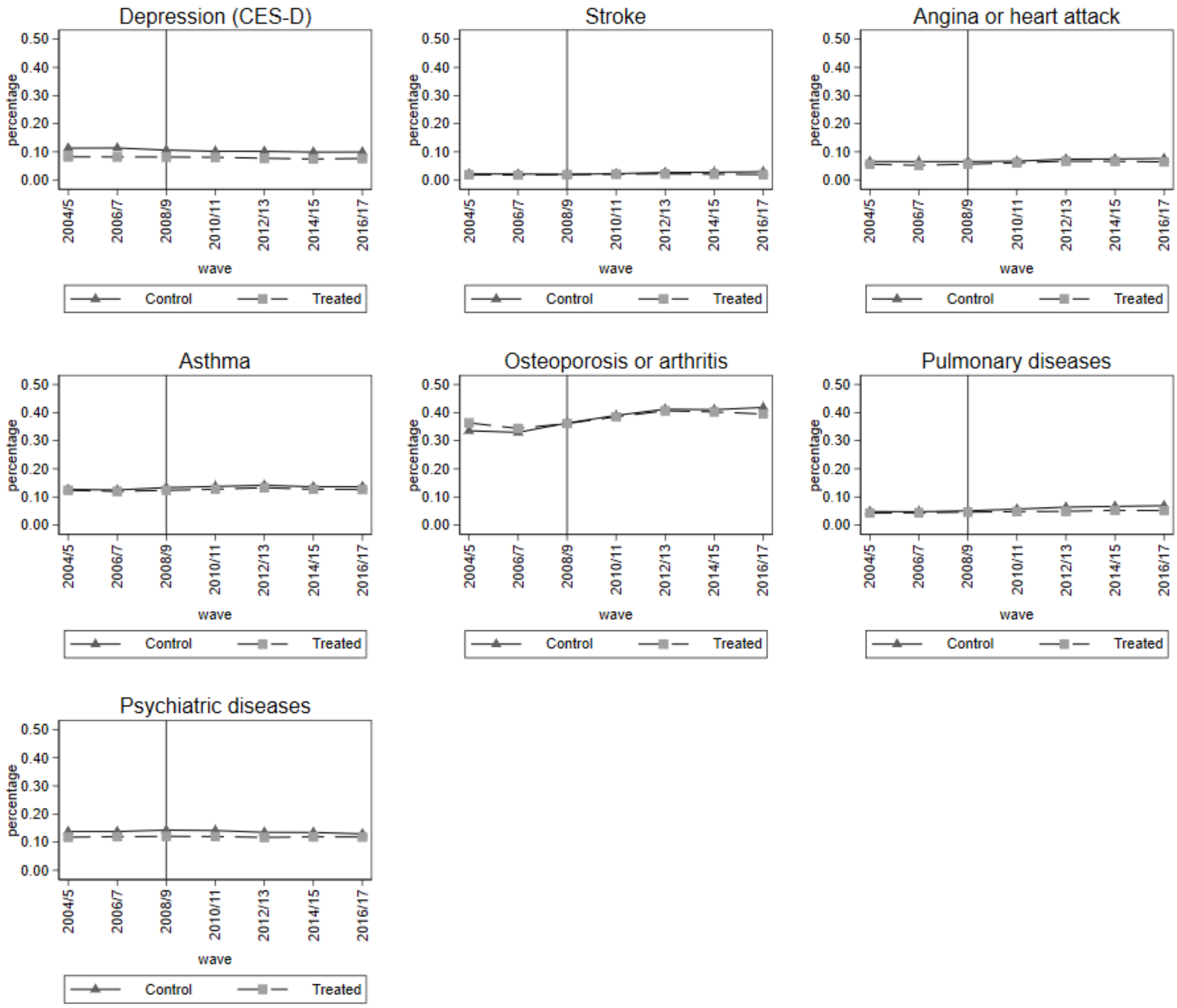
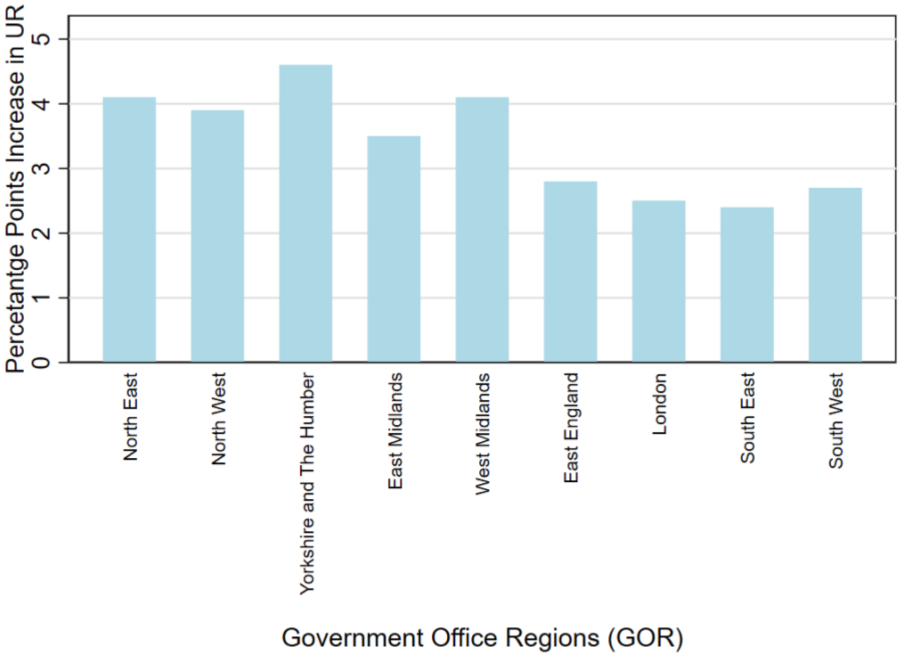


Figure A4. Trends of health outcomes in treated and control groups (post-matching).



Source: Own figures based on the ELSA data from 2004 to 2017.

Figure A5. Percentage point increases in unemployment rates during the period of study.



Note: These were calculated as the difference between the maximum and the minimum value (before the economic crisis) of the unemployment rate in our sample for each regional unit. Source: Office for National Statistics (ONS).