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Abstract

This paper estimates the causal effect of retirement on health, health behavior, and healthcare utilization. Using Regression Discontinuity Design to exploit financial incentives in the German pension system for identification, I investigate a wide range of health behaviors (e.g. alcohol and tobacco consumption, physical activity, diet and sleep) as potential mechanisms. The results show a long-run improvement in health upon retirement. Relief from work-related stress and strain, increased sleep duration and more frequent physical exercise seem to be key mechanisms through which retirement affects health. Moreover, the improvement in health caused by retirement leads to a reduction in healthcare utilization.

Keywords: retirement, health, regression discontinuity design, health behavior, healthcare

JEL codes: I12, J14, J26

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1 Introduction

Since 2000, policymakers in several European countries have agreed upon reforms that increase the statutory retirement age. On the one hand, the demographic change in developed countries is expected to result in a larger share of elderly people. This has led to public concerns about the sustainability of pay-as-you-go pension systems. On the other hand, health and vitality of the elderly have greatly increased during the last decades of the 20th century. For example, the remaining life expectancy for a 60-year old male (female) in Germany has increased by 3.68 (2.87) years between 1989 and 2009 (FEDERAL STATISTICAL OFFICE, 2014). Although critics of the reform expressed concerns that workers in strenuous occupation might not be able to work until the (raised) official retirement age, the overall health effects of retirement are neglected in the political debate. This disregard can lead to the introduction of policies with adverse health effects (see e.g. De Grip et al., 2012). This paper estimates the causal effect of retirement on health and considers its implications for the healthcare system.

There are several conflicting ways that retirement might affect health. Retirement increases the amount of leisure time that an individual can invest in their health (e.g. physical exercise, sleep). Retirement might also reduce the amount of work-related stress and strain. Following these arguments, retirement positively affects health. On the other hand, retirees no longer have an incentive to invest in their health in order to maintain their income. As a consequence their health investment could decrease in retirement. In addition, work-related physical activity and social contacts on the job decrease as a result of the transition from work to retirement. Individuals who are very satisfied with their work might experience stress as a result of 'being forced' to retire. Finally, health might deteriorate due to the negative income effects of retirement.[1]

The direction of the overall health effect has implications for policies affecting the official retirement age and, as a consequence, the labor supply of elderly people. If retiring decreases health, an increase of the retirement age preserves the health of elderly employees. In contrast, if retirement has a positive effect on health, then an increase in the retirement age would lead to poorer health for individuals who have to keep on working instead of retiring. This could lead to increased healthcare spending, which might partially offset the savings of the pension funds.

[1] The average compensation level in Germany is around 50 percent net, i.e. the state pension benefits only amount to 50 percent of the last net wage income.

Previous studies on the causal effect of retirement on health are inconclusive. The strand of literature most relevant to this paper has focused on subjective (e.g. self-assessed health, well-being) and objective (e.g. limitations in Activities of Daily Living, diagnoses of specific diseases) measures of general health. Several studies report a significant increase in health after retirement (e.g. Charles, 2002, Johnston and Lee, 2009, Neuman, 2008, Coe and Lindeboom, 2008, Coe and Zamarro, 2011, Blake and Garrouste, 2012, De Grip et al., 2012, Latif, 2013, Insler, 2014), whereas other researchers (e.g. Dave et al., 2008, Behncke, 2012, Sahlgren, 2012) report significant negative effects on both objective and subjective health measures. Interestingly, these studies focus on the same countries, and therefore the contradictory findings cannot be explained by differences in the institutional setting or culture.[2]

Similarly, studies focusing on health-related outcomes come to conflicting conclusions. Rohwedder and Willis (2010), Mazzonna and Peracchi (2012), Bonsang et al. (2013) and Bingley and Martinello (2013) all find that retirement leads to a decrease in cognitive functions. Kuhn et al. (2010) report increased mortality upon retirement. Snyder and Evans (2006) conclude that employment past retirement age decreases mortality. However, Hernaes et al. (2013) find no significant effect of retirement on mortality, while Blake and Garrouste (2013) and Bloemen et al. (2013) even find that retirement leads to a decrease in mortality.

The inconclusive and conflicting evidence might stem from two different sources: endogeneity and effect heterogeneity. Workers experiencing a decline in health are more likely to retire (McGarry, 2004). If this reverse-causality is not resolved, the results can be negatively biased. Another possible explanation is effect heterogeneity. Due to different job characteristics and socio-demographic background, some individuals might experience a health-preserving effect upon retirement, whereas others experience no effect or a health-limiting effect. There is little research on heterogenous effects or potential mechanisms in this area.[3]

2 Behncke (2012) and Johnston and Lee (2009) use different datasets from the UK, whereas Charles (2002), Dave et al. (2008), Coe and Lindeboom (2008), Neuman (2008) and Insler (2014) use U.S. data from the Health and Retirement study. Coe and Zamarro (2011) and Sahlgren (2012) use European cross-country data from the Study of Health, Aging and Retirement in Europe (SHARE). Blake and Garrouste (2012) use French data. De Grip et al. (2012) use a sample of public sector workers from the Netherlands. Latif (2013) uses data from Canada.

[3] Goldman et al. (2008), Chung et al. (2009) and Godard (2013) investigate body mass as a potential mechanism. Lemola and Richter (2013) report an increase in sleep satisfaction around the retirement age in Germany, and Insler (2014) finds a decrease in smoking and an increase in physical activity upon retirement.

This paper uses Regression Discontinuity Design (RDD) to address the endogeneity of retirement. The RDD approach exploits that the probability of retiring increases discontinuously at the ages of 60, 63 and 65. These thresholds are induced by financial incentives in the German pension system. The first contribution of this paper is to provide further evidence on the effect of retirement on general health. In addition, focusing on multiple discontinuities increases the external validity of the findings.

The German institutional setting offers another important advantage over studies focusing on the US. In the US individuals become eligible for the Medicare insurance program once they pass the age threshold of 65. Previous studies suggested that Medicare eligibility affects the retirement probability as well as healthcare utilization (e.g. Rust and Phelan, 1997; Card et al., 2008). Both findings taken together imply that US studies need to disentangle the effects of retirement from Medicare insurance effects. Studies using (among else) the threshold of age 65 as an instrument for retirement (e.g. Neuman, 2008, Insler 2014) run the risk of confounding their results with the effects of Medicare eligibility. This problem is sidestepped in this paper by focusing on the German setting. Germany has a universal healthcare system, in which almost all individuals are either insured via Statutory Health Insurance or Private Health Insurance.[4] Retirees continue to be enrolled in their healthcare plan; therefore the estimated effect of retirement is not confounded by changes in health insurance.

The most important contribution of this paper is to estimate the effect of retirement on health, health behavior, time use and healthcare utilization to present suggestive evidence for the potential mechanisms through which retirement affects health. Investigating all four aspects using the same data and the same methodology provides comprehensive evidence for the health effects of retirement, the important mechanisms and their consequences for policy design. The only previous study that investigates health effects as well as potential mechanisms is by Insler (2014). He proposes behavioral adjustments of retirees as one of the main mechanisms. Analyzing the effect

[4] The Statutory Health Insurance covers 85.1% of the population, most importantly employees with an income between 450 and 4,350 Euro per month, spouses and children without individual insurance, students up to the age of 30 and unemployed individuals. employees with an income between 450 and 4,350 Euro per month, spouses and children without individual insurance, students up to the age of 30 and unemployed individuals. Private Health Insurance covers 11.1% of the population, mostly employees above the earnings threshold and self-employed individuals. 3.8% of the population have other sources of coverage (mostly soldiers, judges and civil servants covered by the state) and 0.2% are uninsured (Federal Statistical Office, 2012).

of retirement on smoking and physical exercise, he finds that individuals invest more in their health upon retirement (e.g. quit smoking and exercise more frequently). This paper extends the investigation of health behavior as a mechanism by analyzing dietary habit, alcohol consumption, body weight, sleep and social activity in addition to smoking and physical exercise, and goes beyond by considering heterogeneous effects and changes in time use as further explanations for the health effects of retirement. Finally, I consider the implications for the healthcare system, which is highly relevant for policy design.

The results show that retirement has a significant and positive effect on all three measures of health (self-reported health, physical health and mental health). These effects are not transitory and can be confirmed even three years after retirement. The investigation of effect heterogeneity, health behavior and time use data suggests three important mechanisms through which retirement affects health: *(i)* relief from work-related stress and strain; *(ii)* an increase in sleep duration; and *(iii)* an increase in physical activity. Retirees exercise more frequently and spend more time on physical activities in the household (e.g. repairs and gardening). In addition, retirement leads to an increase in the frequency of alcohol consumption, and an increase in body mass.[5] Most importantly, retirement also reduces utilization of both inpatient and outpatient care.

The rest of the paper is structured as follows: Section 2 describes the institutional setting in Germany and provides an overview over the data. The identification strategy and the corresponding econometric models are explained in section 3. Section 4 gives the results and provides several robustness checks. Section 5 concludes.

2 Institutional setting and data

2.1 The state pension system in Germany

Old-age provisions in Germany consist of three elements – state pensions, employer-based pensions, and private pension insurance schemes. Although policymakers have introduced several reforms since 2001[6] that are aimed at increasing the share of private pension schemes, the state pension scheme is still the single most important source of old-age provisions. According to the

[5] While this finding seems to contradict the positive health effects, there are several possible explanations. For example, the increase in physical activity could lead to an increase in muscle mass, and therefore a higher body mass.
[6] The "Riester- Rente" (Riester pension) was introduced in 2001 and the "Rürup-Rente" (Rürup pension) was introduced in 2005.

Federal Ministry of Labor and Social Affairs (2012), 64 percent of the gross household income of retirees comes on average from state pensions paid by the German Statutory Pension Insurance Scheme (Deutsche Rentenversicherung, DRV). Employer-based pensions and private pension schemes amount to less than 20 percent of the household income. Moreover, 63 percent of all retirees rely on state pensions as their only source of income.

Eligibility for state pensions depends on the number of contribution years. Contribution times are accumulated either by paying an insurance premium, or through recognition of non-income periods, e.g. periods of unemployment, maternity leave or education. The insurance premium is relative to the monthly gross wage up to a contribution cap (18.9% up to an income of 5,800 Euros per month). The premium is equally split between employers and employees, i.e. the maximum premium for an employee in 2013 was 548 Euros per month. Soldiers, judges, civil servants, employees with an income less than 400 Euros per month, and the self-employed in certain occupations are not insured by the state pension system.[7] The amount of the pension paid is calculated according to the pension formula: $pension = EP \times AF \times cPV$, where EP are the amassed earnings points[8], AF is the age factor and cPV the current pension value (DRV, 2014a). The age factor depends on the age at which the pension is claimed. The base factor is 1.0 for the official retirement age, and it is decreased by 0.003 (0.3%) for each month of early retirement and increased by 0.005 (0.5%) for each month of delayed retirement. The current pension value specifies the monetary value of one earnings point. It is adjusted yearly according to the development of wages in the previous year, the current premium rate and a sustainability factor.[9] Since July 1, 2013, the current pension value is 28.14 Euros for West Germany and 25.74 Euros for East Germany. The nominal pension level states the ratio of the benchmark pension to average income.[10] It can be interpreted as the share of the last income that an (average) employee would receive upon retirement. In 2012 it is reported as 46 percent gross and 50 percent net (DRV, 2013b) The average monthly pension paid by the DRV in 2013 was 855 Euros (DRV, 2014b).

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[7] Self-employed craftsmen, artists, publicists, and self-employed in educational, nursing or naval professions are mandatory insured in the DRV.

[8] These are calculated as the gross income relative to the mean income, i.e. an employee earning exactly the mean income gains 1 earnings point.

9 The sustainability factor depends on the ratio between retirees receiving a pension and employees paying contributions.

[10] The benchmark pension is the amount a retiree would receive if she had 45 contribution years and earned average income in all years.

The DRV offers 6 different pension plans (DRV, 2013c). These pension plans are targeted towards different segments of the population, hence the eligibility criteria vary. Table 1 below lists the eligibility criteria, early and official retirement ages. In addition, the number of retirees on this plan in 2012 and the average pension value in 2012 for each pension plan are given to indicate the relative importance of the schemes (DRV, 2013b). Since the early 2000s most schemes underwent major reforms. However, these reforms were implemented with a lag of several years, and the retirement ages are only increased in small steps (e.g. the official retirement age for the standard old-age pension is increased by one month per birth year for individuals born after 1947). These reforms introduce only little exogenous variation and affect retirees from 2012 onwards. Therefore it is not possible to exploit these reforms for identification, and the analyses presented in this paper focuses on pre-reform retirement ages.

As can be inferred from Table 1, there are three major age thresholds in the German pension system – age 60 for the pension for women, the pension due to unemployment and partial retirement and the pension for severely disabled people[11], age 63 for the pension for long-term insured and age 65 for the standard old-age pension and the pension for especially long-term insured. Table 1 also demonstrates that the thresholds at age 60 and 65 are relatively more important than the threshold at age 63, since most retirees receive their pension under a plan with retirement age 60 or 65, respectively. For the empirical analysis I will exploit these thresholds in a Regression Discontinuity Design. However, I exclude the pension for severely disabled people from the analysis since the behavioral response of disabled people might differ from non-disabled retirees.

[11] This should not be confused with Disability Insurance. The pension for severely disabled people is considered as a regular old-age pension, which offers disabled individuals the possibility of early retirement.

Table 1: Overview over the German state pensions

Type of pension	Min. # of contribution years	Additional eligibility criteria	Retirement age: Early	Retirement age: Official	No. of retirees on December 31,2012	Average pension value in Euros West/East Germany
Old-age pension	5	-	-	65	8,223,520	512/839
Pension for long-term insured	35	-	63[2]	65	1,496,096	1072/1052
Pension for especially long-term insured	45	-	-	-	12,531	1420/1113
Pension for women	15	- female, born before 1952 and 10 contribution years after the age of 40	60	65	3,826,132	686/761
Pension due to unemployment or partial retirement	15	a.) partially retired since 24 months, and 8 contribution years within the last 10 years; or b.) currently unemployed and has been unemployed for 52 weeks after the age of 58 years and 6 months, and 8 contribution years within the last 10 years	60	65	2,398,004	1166/1035
Pension for severely disabled people	35	a.) degree of disability of 50[3] or more; or b.) born before 1951 and fully work disabled[4]	60	63	1,729,360	1050/886

[1]: Individuals born between 1948 and 1954with partial retirement agreement signed before 2007 can retire early at age 62.

[2]: The degree of disability is measured on a scale between 20 and 100 in increments of 10. The individual degree of disability is diagnosed by physicians and depends on the severity of the limitations imposed by the disability. For example, the loss of a whole hand or blindness on one eye with a simultaneous limitation of the other eye to 50 per cent or less is associated with a degree of disability of 50 (see Appendix to §2 of the Healthcare Provision Act (VersMedV).

[3]: Individuals are classified as fully work disabled if they are not able to work for more than 3 hours per day. This is comparable to the Disability Insurance scheme in most countries.

Source: German Statutory Pension Insurance Scheme, 2013b, 2013c.

2.2 Data

The data in this analysis is from the German Socio-Economic Panel Study (SOEP). SOEP is a representative panel study of private households in Germany. Starting in 1984, individuals are surveyed annually. The study expanded to include residents of former East Germany in 1990. All respondents answer about 150 questions per year on a range of topics, e.g. on labor market participation, education, family status, attitudes and perceptions, as well as health and health behavior. Moreover, the head of the household fills in a household questionnaire. Since 2000 the study interviews more than 20,000 individuals across more than 10,000 households. For further details, see Wagner, Frick and Schupp (2007).

The SOEP includes several measures of individual health. The standard 5-categorical Self-Assessed Health (SAH) and the 11-categorical health satisfaction measure are surveyed annually since 1994. In addition, since 2002, the continuous quasi-objective SF12 measure and the objective grip strength measure are included in every second year. Information on several dimensions of health behavior is available for different years.

2.2.1 Dependent variables

Health measures

For the empirical analysis I use both the SAH measure as well as the SF12 measure. For the SAH, respondents are asked how they would describe their current health status on a 5-point scale. The answers range from "bad" and "poor" to "satisfactory", "good" and "very good". For the analysis, I dichotomize the variable. The outcome "satisfactory health" is defined as "1" for the best three categories (i.e. the subjective health status is at least satisfactory) and "0" for the worst two categories.[12] As shown in Table 2 below, 81 percent of individuals in the sample report their health to be at least satisfactory (Column 2). The difference between retirees and non-retirees (Column 7 and 8) is about 6 percentage points and highly significant.

The SF12 consists of two measures for physical health *(pcs)* and mental health *(mcs)*. For these measures, respondents answer 12 questions that relate to different dimensions of health, e.g. vi-

[12] The dichotomization of the ordinal SAH measure offers an easier interpretation of the marginal effects. However, to ensure that the conclusions are robust to the choice of the cut-off, I estimate all models using the full 5-point scale. Neither the direction nor the significance of the effect changes.

tality, bodily pain, or emotional functioning. These questions are then aggregated into 8 subscales, and a specific algorithm[13] generates the two dimensions physical and mental health. In the standard SOEP version, both measures take on continuous values between 0 and 100, with a mean of 50 and a standard deviation of 10. The advantages of these two measures are, first, that they are less subjective than the SAH measure, i.e. they eliminate reporting bias (Ziebarth, 2010, Frick and Ziebarth, 2013). Second, they are based on a broad definition of health. Typical objective measures (such as grip strength or diagnoses of specific diseases) are based on very narrow definitions of health, for example they lack a mental health dimension. In contrast, the SF12 combines different dimensions of health (e.g. pain, vitality, functioning) into two comprehensive indices. As can be inferred from Table 2, retirees have on average worse physical health, but a higher mental health score.

Health behavior, time use and healthcare utilization

The SOEP offers various measures of health behavior in different years. In this analysis, I use data on smoking, alcohol consumption, diet and exercise, body weight, sleep and social support.[14] Smoking status is captured by a dummy variable, which takes on the value "1" if an individual smokes.[15] Alcohol consumption is captured by two dummy variables. In the SOEP, individuals are asked how often they drink beer, wine and sparkling wine, spirits and mixed drinks. If a respondent states that s/he never drinks any kind of alcohol, *no alcohol consumption* takes on the value "1". In contrast, if a respondent drinks any kind of alcohol on a regular basis, *regular alcohol consumption* is assigned the value "1" (Ziebarth and Grabka, 2009). Data on alcohol consumption is available for three years.

Concerning their diet, respondents are asked whether they follow a health-conscious diet. The variable *health-conscious diet* takes on the value "1" if respondents answer "very much" or "much" and "0" if they answer "a little" or "not at all". Individuals are also asked how often they participate in sports or exercise. If they exercise at least once a week, the variable *regular physi-*

[13] A detailed description of the algorithm is given by Andersen et al. (2007).
[14] Strictly speaking, social support is not a health behavior. However, since it is potentially an important mechanism and (at least partially) a result of individual choices, I include it in this section of the analysis.
[15] While more detailed information on the quantity of tobacco is available, it also involves a larger measurement error. In earlier waves the question conflated cigarettes, cigars and pipes, although the health consequences are likely to differ. Moreover, I would expect that changes on the extensive margin have a larger impact on health than changes on the intensive margin.

cal activity is assigned a “1”, otherwise the value is “0”. This measure does not take into account physical activity on the job. The body mass index is calculated from self-reported height and weight. Respondents also answer how long they typically sleep on a regular week day. Lastly, I use the reported number of close friends as a proxy for social contacts. If a person experiences a negative health shock, a high number of close friends implies that there are more people to potentially draw support from. The sample sizes for each outcome are shown in Table 2. About 21 percent of the sample drink alcohol on a regular basis, whereas 11 percent abstain completely from consumption. About 56 percent follow a health-conscious diet, and a third exercises at least once a week. Average sleep duration on weekdays is 7 hours, and the average individual is overweight with a BMI of 26.8.

For the data on time use respondents state how many hours on a typical weekday they spend on the respective activities. For this paper I focus on *repairs and gardening, leisure time activities, running errands, household chores, education* and *childcare*. *Repairs and gardening* include “repairs in and around the house, car, garden work etc.”, i.e. activities that require a physical effort and concentration and could potentially enhance an individuals’ health. Similarly, *running errands* and *household chores* require an effort and can be regarded as evidence of an active lifestyle. *Leisure time activities* are more ambiguous, as they include both physical activities (e.g. sports) and sedentary activities (e.g. reading). While time spend on *education* and learning can have a positive effect on health, retirees have less incentives to invest into their education and skills. Finally, time spend on *childcare* can be regarded as an intergenerational time transfer from grandparents to their middle-aged children. This can also enhance (mental) health of the grandparents.

I also investigate the effects of retirement on healthcare utilization to provide further evidence for policy makers.[16] For this analysis I use two measures of healthcare utilization – *(i)* whether an individual was hospitalized in the past year or not, and *(ii)* the number of doctor visits within

[16] While, *a priori*, the causal direction between health and healthcare utilization is not clear, a positive effect on health and a negative effect on healthcare utilization would indicate that individuals need less healthcare due to the positive health shock, since it is highly unlikely that less healthcare leads to better health. The same argument holds for a negative health shock and a positive effect on healthcare. On the other hand, if the effects on health and healthcare have the same sign, the causation is likely to run from healthcare to health, since it is unlikely that worse health leads to lower healthcare utilization and vice versa.

the past three months. Only 11 percent of the sample was admitted to a hospital within the past year, whereas the mean number of doctor visits is 3.5, albeit with variation between 0 and 99.

2.2.2 Definition of retirement and covariates

Before analyzing the effect of retirement, it is necessary to define the treatment. There are several definitions used in the literature (see for example Coe and Zamarro, 2011 and Insler, 2014). In general, retirement implies that an individual exits the labor market. This encompasses also individuals who are technically unemployed, but are not actively searching for a job. On the other hand, some retirees might exit their main occupation, but continue to work in another occupation, e.g. to generate additional income, meet other people or engage in meaningful work. In this paper I use self-reported retirement status as the treatment variable. I assume that retirement affects health mainly through behavioral adjustments, and that the behavioral adjustment occurs if an individual regards herself as retired.[17]

Control variables

I also include additional control variables as a robustness check and to investigate heterogeneous effects, e.g. gender, marital status, log of household income, education, retirement status of the partner and the existence of grandchildren. Education is measured by two dummy variables for individuals who completed vocational training, and individuals who obtained a university degree, respectively. The dummy variable for marital status is "1" if the individual is married and cohabiting and "0" otherwise. Monthly household income is adjusted to the price level of the year 2000 and equivalized according to the OECD formula.[18] The retirement status of the partner is obtained by matching the self-reported retirement status of spouses to each other.

[17] Since the questions on retirement status, pension income and employment status are asked independently, it is possible to check the concurrence of these indicators. For example, the definition of retirement could be based on the receipt of pension benefits. This definition would exclude individuals living off unemployment benefits or savings and not actively looking for work. On the other hand, some pension plans allow recipients to continue working while claiming benefits (e.g. the standard old-age pension). In the sample 92.7% of the self-reported retirees stated to receive an old-age pension. Only 1.5% of the individuals receiving pension benefits do not report themselves to be retired. This indicates that using a definition of retirement based on pensions is not likely to alter the results, since both definitions coincide for most observations. Similarly, only 2.8% of the self-reported retirees stated to work either full- or part-time, while 94.7% report their employment status as "Not working".

[18] The household income is weighted by the number of persons in the household. Children under the age of 14 are assigned a weight of 0.3, and each additional adult receives a weight of 0.5.

Occupational strain

I also check for effect heterogeneity with respect to occupational strain. The data on occupational strain is provided by Kroll (2011). Using data from the Employment Survey of the FEDERAL INSTITUTE FOR VOCATIONAL EDUCATION AND TRAINING (BIBB/BAuA-Erwerbstätigenbefragung), separate scales for physical and mental strain are constructed for the International Standard Classification of Occupations (ISCO88). The scales range from "1" (low strain) to "10" (high strain). Occupations with maximum physical strain (10) include (e.g.) miners, construction workers and firemen, whereas statisticians and accountants experience only minimum physical strain (1). Similarly, nurses and stewards are classified as having maximum mental strain, whereas construction workers have very low mental strain. These scales are matched to the SOEP data via the 4 digit ISCO88 codes. Using the original scales I generate three dummy variables: *High physical strain* is "1" if the average physical occupational strain of an individual (prior to retirement) is above the 75th percentile of the distribution of physical strain. Similarly, *high mental strain* is defined as "1" if the mental occupational strain of an individual is above the 75th percentile of the distribution of mental strain. *High overall strain* is defined as "1" if the combined average strain exceeds the 75th percentile.

2.2.3 Sample selection

For the main analysis ("working sample") I keep all observations within the 50 to 75 age range. Respondents who report a disability are dropped from the sample, since their behavioral response to retirement is likely to differ from non-disabled retirees. Individuals who return to the labor market (i.e. for which a switch from "retired" to "not retired" is observed) are excluded from the analysis. This sample includes civil servants and self-employed. While the pension system for civil servants is markedly different, the age thresholds are similar to those for employees. For some self-employed occupations pension insurance in the DRV is mandatory, while all other self-employed can opt-in. Therefore, it is likely that the age thresholds are also (partly) relevant for self-employed individuals. Finally, the sample also includes individuals who were not employed prior to retirement. Retirement still marks a transition for these individuals, since they finally exit the labor market. Moreover, this group is relatively large and excluding it would result in a large loss of statistical power.

For a robustness check based on eligibility for a state pension, I construct a second sample ("eligibility sample"). Linked register data on pension eligibility is not available, therefore I calculate a proxy for the individual eligibility age using self-reported information on employment history, gender, birth cohort, number and year of birth of children, and education. In this sample, I exclude individuals with a disability, civil servants and individuals, who were not part- or full-time employed prior to retirement.

Table 2 shows summary statistics for the working sample. Columns 2 to 6 provide the mean, standard deviation, minimum, maximum and number of observations for the whole sample. Columns 7 and 8 show the means for the treatment and control group (i.e. retirees and non-retirees), respectively. Column 9 provides the t-statistic for a test for the equality of means between treatment and control group.

Table 2: Summary Statistics

Variable	Mean	SD	Min	Max	N	Mean non-retirees	Mean retirees	t-statistic
A. Health measures								
Satisfactory health (3/5 of SAH categories)	0.817	0.387	0	1	99,409	0.842	0.785	22.694
Physical health (SF12)	47.330	9.152	10.526	76.421	38,545	49.294	44.878	48.083
Mental health (SF12)	51.795	9.531	3.533	78.264	38,545	51.122	52.635	-15.485
B. Covariates								
Age	60.659	7.036	50	75	99,409	55.805	66.696	-376.017
Male	0.472	0.499	0	1	99,409	0.473	0.472	0.387
Married and cohabiting	0.773	0.419	0	1	99,409	0.808	0.729	29.377
Log of household income (equivalized)	7.382	0.537	3.912	11.125	64,231	7.454	7.292	39.193
University degree	0.238	0.426	0	1	99,409	0.271	0.197	27.608
No formal degree	0.182	0.386	0	1	99,409	0.154	0.217	-25.108
Social activites with friends once a week	0.131	0.337	0	1	99,409	0.121	0.142	-9.665
Participation in communities once a week	0.071	0.257	0	1	99,409	0.065	0.079	-8.729
Partner is retired	0.449	0.497	0	1	76,434	0.226	0.755	-170.227
Existence of grandchildren	0.399	0.490	0	1	99,409	0.281	0.545	-86.730
Average overall strain	5.199	2.685	1	10	63,001	5.193	5.218	-0.980
Average physical strain	5.186	2.689	1	10	63,001	5.163	5.258	-3.803
Average mental strain	5.325	2.683	1	10	63,001	5.355	5.234	4.812
C. Health behavior								
Smoking	0.256	0.437	0	1	37,953	0.316	0.181	30.854
Regular alcohol consumption	0.213	0.409	0	1	18,869	0.208	0.218	-1.580
No alcohol consumption	0.115	0.319	0	1	18,869	0.100	0.135	-7.436
Health-conscious diet	0.562	0.496	0	1	32,955	0.524	0.607	-15.182
Regular leisure-time physical activiy	0.337	0.473	0	1	45,408	0.353	0.317	8.109
Sleep duration on week days	7.028	1.194	1	16	35,862	6.862	7.221	-28.334
Body Mass Index (BMI)	26.803	4.285	13.281	75.276	39,587	26.592	27.066	-11.001
Number of close friends	4.461	4.235	0	99	20,741	4.444	4.482	-0.642
D. Time use								
Time use: Repairs and gardening	1.177	1.295	0	13	95,122	0.927	1.485	-65.400
Time use: Leisure time activities	2.549	2.146	0	20	96,729	1.988	3.242	-91.449
Time use: Running errands	1.186	0.820	0	12	96,968	1.048	1.358	-59.213
Time use: Household chores	2.039	1.693	0	20	96,741	1.816	2.313	-45.902
Time use: Education	0.144	0.533	0	12	90,930	0.184	0.095	25.953
Time use: Childcare	0.252	1.018	0	24	90,756	0.264	0.238	3.959
E. Healthcare utilization								
Hospital stay in the past year	0.119	0.324	0	1	99,163	0.097	0.147	-23.719
Doctor visits in the past three months	3.508	4.007	0	99	72,819	3.338	3.687	-11.738

Source: SOEP v29, own calculations. Notes: Column 1 and 2 give the overall mean and standard deviation of the variable. Column 3 to 5 provide the overall minimum, maximum and the number of observations. Column 6 gives the mean for retirees (treatment group). The means for non-retirees (control group) are given in column 7. Column 8 gives the t-statistic for the equality of means of both groups. Household income is measured in Euros per month and adjusted to the price level of the year 2000. The equivalence income is then calculated using the standard OECD formula. Social activities with friends include time spent helping friends. Participation in communities includes voluntary work, local politics and religious communities. Average strain is derived from the occupational demand scales provided by Kroll (2011) by taking the average of the strain values associated with the jobs held prior to retirement.

3 Econometric models

3.1 Endogeneity

Apart from the need to distinguish the effect of retirement on health from the effect of aging, it is also necessary to resolve the endogeneity problem of retirement status. The literature identifies three sources of endogeneity – omitted variable bias (OVB), justification bias, and reverse causality. Omitted variable bias might be induced through differences in unobserved individual characteristics, which influence both health and the retirement decision, e.g. the genetic makeup or subjective life expectancy. In order to control for unobserved, time-invariant individual heterogeneity, all models are estimated as individual fixed-effects panel data models.

If non-working (i.e. retired or unemployed) respondents perceive continued employment as the norm for healthy persons of their age, they might underreport their health status in order to justify their deviation from the norm. This "justification bias" would downward-bias the results. It is difficult to address this issue in the absence of objective health measures. However, with regard to the average retirement age in Germany (63.5 in 2011) it seems questionable whether individuals at age 60 would feel the need to justify their retirement status. In addition, the direction of the bias also implies that the results can be interpreted as a lower bound.

Reverse causality poses a more severe problem. As noted earlier, several studies show that health affects the retirement decision. Moreover, unexpected health shocks have a larger impact than a steady decline in health. This means that comparisons of pre-retirement health to post-retirement health cannot claim a causal interpretation. In order to allow for a causal interpretation of the analysis, I use Regression Discontinuity Design.

3.2 Regression Discontinuity Design

General idea

The RDD approach exploits institutional rules by which the treatment is assigned. It requires an assignment variable that (partly) determines whether individuals are treated or not. Individuals above a certain threshold receive the treatment, whereas individuals just below the threshold are not treated. Then, a discontinuity in the outcome variable at the value of the threshold of the assignment variable can be interpreted as a causal effect of the treatment under some mild assumptions (Lee and Lemieux, 2010).

This paper uses age as an assignment for retirement. While in Germany individuals are not forced into retirement,[19] the statutory pension schemes provide strong incentives to retire at certain ages, i.e. there are thresholds for early and full retirement, and individuals are not eligible for any pension before the early retirement age.[20] However, this implies that treatment is not completely determined by age; instead, the probability to retire increases rapidly at the thresholds for early and full retirement. This implies that the analysis is based on a fuzzy regression discontinuity design. The estimated treatment effect is a Local Average Treatment Effect (LATE), i.e. the effect on the compliers affected by the instrument. In this case, the estimated effect should be interpreted as the effect on individuals retiring once they exceed the specified age threshold, which is used as a discontinuity.

Setup

First, I check for a discontinuity in retirement status by age. Figure 1 shows the share of retirees at every age between 50 and 75 in the dataset. The dots indicate bins of 3 months.

Figure 1: Probability of retirement by age

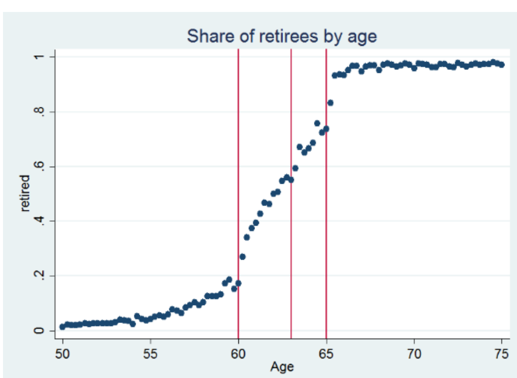
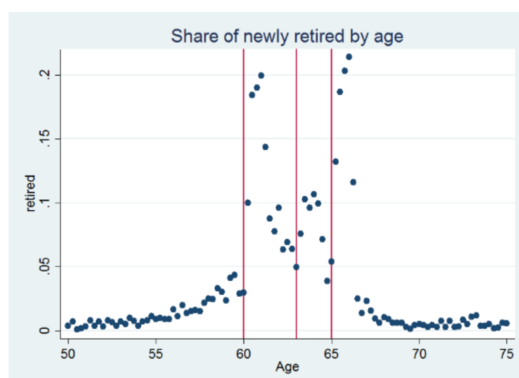


Figure 2: Probability of retiring by age



Source: SOEP v29, own calculations.

[19] Working contracts or collective agreements may contain stipulations that an individual has to retire at the official retirement age.

[20] There are also incentives to postpone retirement, i.e. if an individual continues to work beyond the official retirement age s/he receives a premium for every month of eligibility.

Although there are already a few retirees before the age of 60, the probability of being in retirement increases rapidly between 60 and 65. While less than 20 percent are retired before the age of 60,[21] more than 80 percent are retired after the age of 65. The share of retirees increases to nearly 100 percent at age 66. At age 60 (earliest retirement age) the probability increases sharply by about 10 to 15 percentage point. This discontinuity becomes even more evident when one considers the increase from age 60 to age 60.5 – within these 6 months 20 percent of the individuals in the sample transition into retirement, i.e. the share of retirees approximately doubles. The increase at age 63 (middle red line) seems to follow the linear trend between age 60 and 65, i.e. there is not much evidence for a discontinuity at age 63. At age 65 (official retirement age) I observe a similar pattern as for age 60 – a sharp increase of about 20 percent within 6 months of crossing the age threshold. At both thresholds the increase in the retirement probability within 3 months is considerably smaller than the total change within 6 months. This implies that individuals retiring at these ages often delay their retirement by a few months. A possible explanation could be that the German pension system requires that retirees claim their benefits at least three months prior to the intended retirement date; hence these individuals could be late in claiming their benefits, or further clarification of their accounts were necessary which necessitated the observed delay. Figure 2 shows the increment in the share of retirees by age. While the probability to retire is quite high at each point between 60 and 65, the jumps at age 60 and age 65 stand out. Given that the lowest threshold for early retirement is at age 60 (see Table 1) and the threshold for official retirement is 65 for most individuals, this result should be expected from the institutional setting. For the main specification I exploit all three discontinuities described above, i.e. the treatment effect is estimated for individuals retiring at age 60, 63 or 65. Since this covers the majority of all retirees, the estimated effect should have a high external validity. However, since the complier groups are likely to differ between these thresholds, I also present separate estimates for each discontinuity.

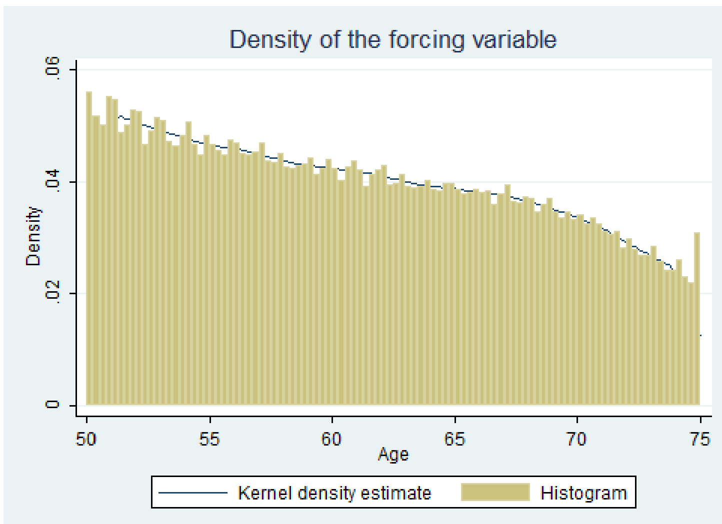
Assumptions

There are two main assumptions needed for the validity of RDD. First, I have to assume that the outcome is a smooth function of the assignment variable. Since aging is a gradual process, it

[21] Since retirement is self-reported, these individuals could have exited the labor market via unemployment or disability insurance. These observations are kept in the sample, because the main interest of this analysis is the behavioral responses of retirees upon exit of the labor market.

appears reasonable to assume that the health-age profile of an individual is smooth. Of course, this further requires that this smooth function is appropriately modeled. Otherwise nonlinearities in the health-age profile could be mistaken as discontinuities, as demonstrated by Angrist and Pischke (2009). Second, I need to assume that the assignment variable cannot be precisely controlled near the threshold, i.e. individuals cannot manipulate their age. This assumption holds by construction, since individuals cannot manipulate their age.[22] A common check for this assumption is to investigate the density of the forcing variable (i.e. age). The histogram and the kernel density estimate of age are shown in Figure 3 below. The binwidth corresponds to three months. Apart from a seasonal pattern, the density of age appears to be very smooth.

Figure 3: Density of age



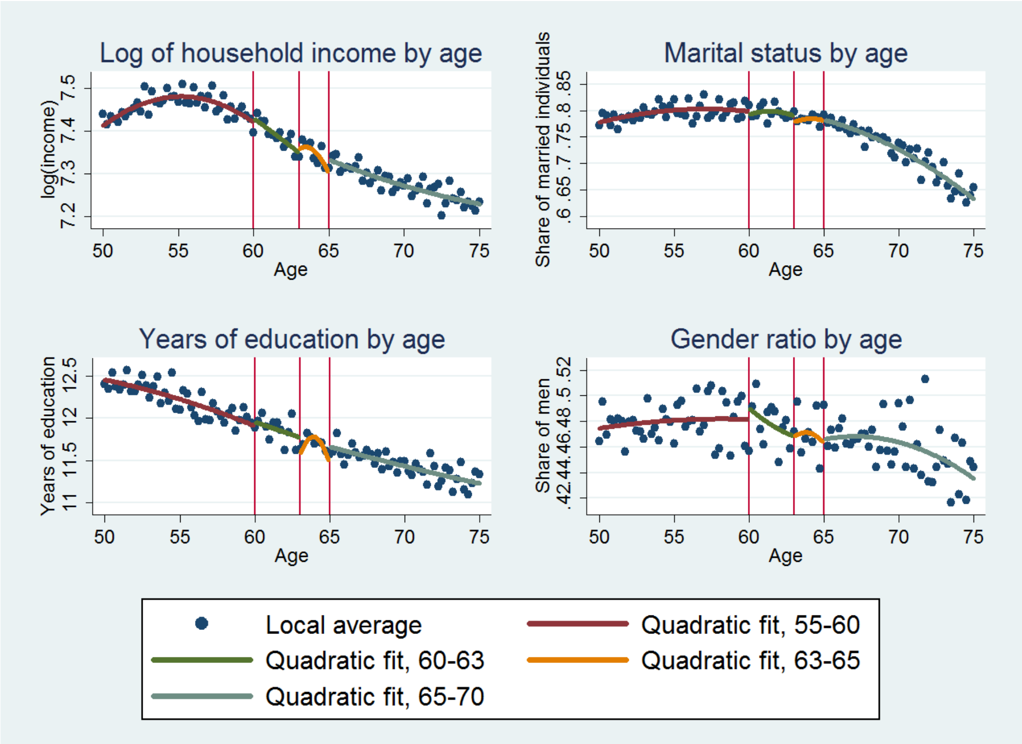
Source: SOEP v29, own calculation

I also check for discontinuities in predetermined variables. If there would be discontinuities in another, predetermined variable, this would cast doubt on the identification strategy since the results could be driven by an unobserved confounder. Figure 4 below shows the log of household income, the probability of being married and cohabiting, years of education and the share of males in the sample by age. The corresponding graphs can be interpreted as placebo tests. For example, income is clearly affected by retirement (through replacement rates below 100 percent), therefore I would expect to see a discontinuity. For marital status the case is less clear – since it

[22] The age of an individual is not self-reported but rather calculated from their date of birth. Given that the SOEP is a long-term panel study and that inconsistencies in the data are cleared every year, it appears highly unlikely that individuals would systematically lie about their age. Still, this cannot be excluded in principle.

is not predetermined it could be a potential outcome of retirement.[23] Years of education[24] and the share of male respondents are predetermined variables, which should not be affected by retirement. The dots in Figure 4 indicate local averages over bins of width 0.25 (3 months). The lines are fitted as quadratic trends.

Figure 4: Marital status and household income by age



Source: SOEP v29, own calculation. The dots mark local averages over bins of width 0.25 (3 months). The colored lines show a quadratic fit to the original data for the respective age range.

There appears to be a small discontinuity in income at age 63. There are no visible discontinuities for marital status. While the fitted trends show a discontinuity in years of education at age 63, this is more likely to be an artifact of "overfitting" the data – the local average indicate an almost perfectly linear decline with age. There is strong variation in the gender ratio across bins without an indication of a discontinuity at the given age thresholds. All in all, the validity of RDD is not threatened by the covariates. Nevertheless I provide estimates with and without covariates as a robustness check in section 4.

[23] Stancanelli (2014) finds that retirement increases divorce rates.

[24] Years of education is generated from information on schooling and tertiary education. While there is variation within individuals in the sample, it is very small and therefore negligible.

Choice of the bandwidth

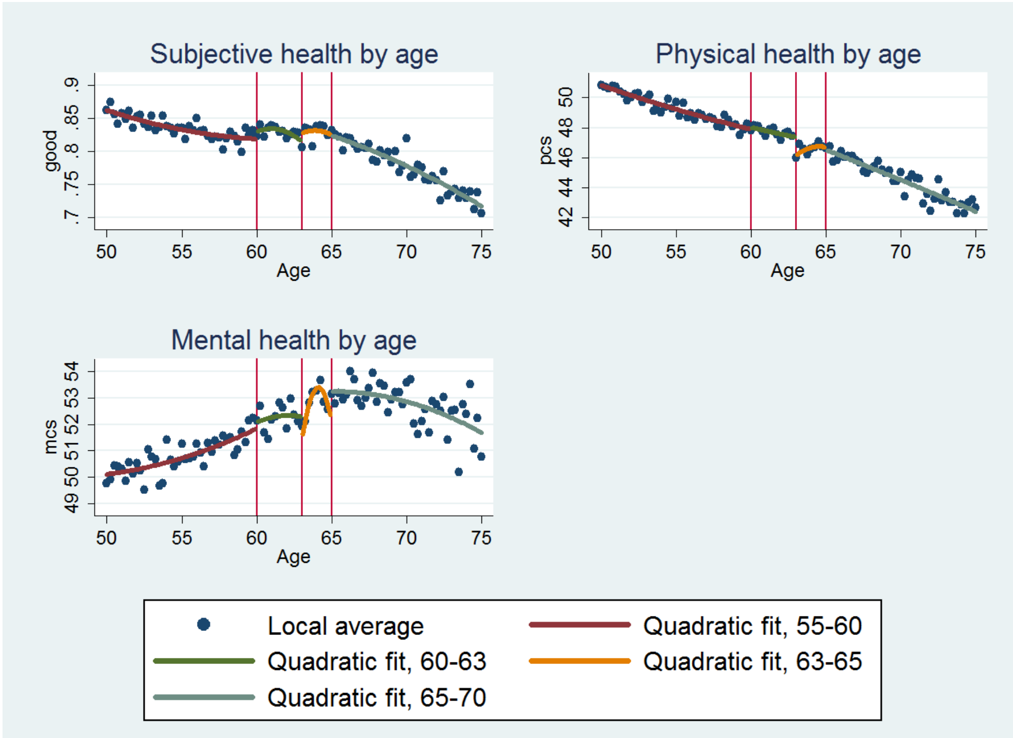
A crucial decision in RDD is the choice of the bandwidth. The bandwidth determines which observations should be used in the estimation by setting a maximum distance from the discontinuity. Observations outside this range are simply discarded. Adopting a small bandwidth will minimize bias, however the variance might be very large due to the small number of observations (Lee and Lemieux, 2010). In contrast, a larger bandwidth will lead to a smaller variance, but the bias is potentially large. In line with Moreau and Stancanelli (2013) and Stancanelli and van Soest (2012) I use a bandwidth of 10 years for the main specification, which leads to an estimation sample of age 50 to 75 (10 years before the first discontinuity at age 60 and 10 years after the last discontinuity at age 65). As a robustness check I provide estimates using a bandwidth of 5 years, i.e. an estimation sample of age 55 to 70.[25]

Graphical evidence

Before I estimate the treatment effect, I investigate the outcome variables graphically in order to detect possible discontinuities. Figure 5 below shows the health-age profile for all three outcomes. As before, the dots mark local averages over intervals of width 0.25 (or three months), while the colored lines are fitted to the original data. According to the graph, physical health decreases almost linearly with age. Satisfactory health also decreases with age, however there seems to be a small increase between age 60 and 65, after which it decreases again. The relationship between mental health and age is highly nonlinear. The mental health summary score increases with age until approximately 70, and then decreases slightly. From the graphical inspection it appears that there are positive discontinuities in satisfactory and mental health at age 60, and a negative discontinuity in physical health at age 63. This could indicate *(i)* that the effect of retirement differs across health measures, and *(ii)* that there is important heterogeneity in the treatment effect. Overall, the discontinuities seem to be rather small, especially given the high variance of the data. However, one has to take into account that crossing the age threshold only increases the treatment probability by about 15 percent. Therefore the discontinuity has to be weighted by the increase in the treatment probability to obtain an estimate of the local average treatment effect.

[25] This bandwidth is close to the optimal bandwidth following Imbens and Kalyamaran (2009).

Figure 5: Health outcomes by age



Source: SOEP v29, own calculation. The dots mark local averages over bins of width 0.25 (3 months). The colored lines show a linear fit to the original data for the respective age range. Satisfactory health is a binary variable for the three best categories of the Self-Assessed Health (SAH) measure. The summary scores for physical and mental health are derived from the SF12.

Estimation

The fuzzy RDD is estimated as a Two-Stage Least Squares model with individual fixed effects. For the main specification with three discontinuities at age 60, 63 and 65 I estimate the following model:

$$\begin{aligned} r_{it} = {} & \beta_0 + \beta_1 age_{it} + \beta_2 age_{it} * age60_{it} + \beta_3 age_{it} * age63_{it} + \beta_4 age_{it} * age65_{it} \\ & + \beta_5 age60_{it} + \beta_6 age63_{it} + \beta_7 age65_{it} + \theta x_{it} + c_i + \delta_t + u_{it} \end{aligned}$$

$$\begin{aligned} health_{it} = {} & \gamma_0 + \gamma_1 age_{it} + \gamma_2 age_{it} * age60_{it} + \gamma_3 age_{it} * age63_{it} + \gamma_4 age_{it} * age65_{it} \\ & + \pi \hat{r}_{it} + \xi x_{it} + \alpha_i + \varsigma_t + \varepsilon_{it} \end{aligned}$$

Here, $age60_{it}$ is a binary variable that is "1" if individual *i* in year *t* is at the right-hand side of the discontinuity at age 60 (i.e. $60 < age < 63$), and "0" if she is on the left-hand side. The variables $age63_{it}$ and $age65_{it}$ are defined accordingly. r_{it} is the treatment dummy and $\hat{r}_{it}$ denotes the predicted values from the first stage. π is then the treatment effect of retirement. c_i and α_i are individual-fixed effects, x_{it} is a vector of individual characteristics with the corresponding coefficient vectors θ and ξ, and δ_t and ς_t denote a set of (separate) month- and year-fixed effects.[26] u_{it} and ε_{it} are the idiosyncratic errors for the first and second stage respectively. In this model the health-age profile is modeled via a piecewise-linear trend, i.e. I allow for the possibility that age follows a different trend above each threshold.[27] I test the choice of the age polynomial by estimating the model for all three health outcomes and three different bandwidths (5, 7 and ten years) using a piecewise linear, quadratic and cubic age trend. For each specification I calculate the Akaike Information Criterion (AIC), which trades off model fit and complexity. The results indicate that for almost all specifications the linear trend should be preferred, i.e. the gain in model fit does not compensate for the higher complexity of the model. Nevertheless, in a robustness check I estimate the model using a piecewise quadratic age trend.

4 Results

4.1 Results from OLS

In a first step I estimate the correlation between retirement and health using simple Ordinary Least Squares and Fixed-effects models. The results from these models cannot be interpreted as causal effects, since they do not address the reverse causality. However, since I would suspect a negative bias from reverse causality (negative health shocks force an individual to retire), the results from the FE models could be regarded as a lower bound of the true effect.[28] Table 3 below shows the estimated correlation of retirement and the three health measures. Here, the age trend is modeled by a third-order polynomial and the models include separate month- and year-

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[26] I also include interactions between month- and year-dummies as additional control variables in some specifications.

[27] All parametric models are estimated via the STATA module xtivreg2 (see Baum et al., 2010). The parametric models have the disadvantage that observations on one side of the discontinuity have the same influence on the estimator, regardless of their distance to the discontinuity. In a nonparametric model observations are weighted so that observations close to the cutoff have a higher weight than observations far away from the cutoff. However, given the typically high unexplained variance in the SF12 health measures, the number of observations is too small to gain conclusive evidence from nonparametric estimation in this case. Nevertheless, for satisfactory health the number of observations is much higher. Here, the effects estimated by local linear regression confirm the parametric results.

[28] This only holds under the assumption that omitted variable bias only stems from time-constant individual characteristics, which are addressed in the FE model. Otherwise the OVB could lead to bias in both directions, hence the direction of the overall bias is unclear.

fixed effects. For each outcome the first specification (left column) gives the result from OLS estimation and the second specification (right column) provides the FE estimates without further control variables.

Table 3: Estimates from OLS regression

Outcome	*Satisfactory health*				*Physical health*				*Mental health*			
Specification	**1**		**2**		**1**		**2**		**1**		**2**	
retired	-0.043	***	0.029	***	-2.52	***	-0.024		-0.044		0.841	***
	0.007		*0.006*		*0.216*		*0.182*		*0.217*		*0.206*	
Individual fixed effects	no		yes		no		yes		no		yes	
Control variables	no		no		no		no		no		no	
R²	0.032		0.015		0.076		0.050		0.016		0.010	
N	99,403		97,429		38,545		32,906		38,545		32,906	

Source: SOEP v29, own calculations. Notes: Standard errors are given in italics. All models include controls for a cubic age-trend as well as month- and year-fixed effects. Model 1 is estimated by OLS, model 2 incudes individual-fixed effects. The sample is limited to individuals between 50 and 75. Significance is coded as follows: * = 0.1, ** = 0.05, *** = 0.01.

The results show that the correlations estimated via OLS are large and negative for satisfactory and physical health, i.e. retirees have on average worse physical health and a lower probability to rate their current health as at least satisfactory than non-retirees of the same age. The correlation of retirement and mental health is insignificant in the OLS specification. However, once I account for time-invariant unobserved heterogeneity (e.g. genetic makeup) in the Fixed-Effects specifications, the correlations are insignificant (physical health) or even positive (subjective and mental health).

4.2 Results from Regression Discontinuity design

First stage results

Table 4 shows the estimated effects for all three outcomes and discontinuities. All specifications include a piecewise linear age trend, individual- and separate month- and year-fixed effects. The first specification (Columns 1, 3 and 5) gives the effect for pure RDD, i.e. without further control variables. The second specification (Columns 2, 4 and 6) includes additional controls for marital status, education as well as month-year interaction effects. First, the Kleibergen-Paap Wald F-statistics for weak instruments are well above the rule-of-thumb value of 10 and suggest that the discontinuities are jointly significant as predictors of retirement status. The point estimates (omitted for space limitations) indicate that conditional on age, the retirement probability increases by about 12 percentage points if an individual is slightly above the threshold at age 60. Interestingly, for individuals above the threshold at age 63 the retirement probability decreases by about 1.5 percentage points. This mirrors the findings in Figure 1, and suggests that although the discontinuities are jointly significant as predictors of retirement, the threshold at age 63 may be insignificant. Finally, crossing the threshold at age 65 increases the retirement probability by about 16 percentage points.

Table 4: Multiple Regression Discontinuity estimates at age 60, 63 and 65

	Satisfactory health				*Physical health*				*Mental health*			
Specification	*1*		*2*		*1*		*2*		*1*		*2*	
retired	0.145	***	0.144	***	2.849	**	2.960	***	5.117	***	5.096	***
	0.032		*0.032*		*1.123*		*1.118*		*1.278*		*1.278*	
Change in standard deviations	*0.375*		*0.372*		*0.311*		*0.323*		*0.537*		*0.535*	
N	*97,429*		*97,429*		*32,906*		*32,906*		*32,906*		*32,906*	
Kleibergen-Paap Wald F	*407.248*		*414.647*		*121.297*		*122.760*		*121.297*		*122.760*	
Additional controls	no		yes		no		yes		no		yes	

Source: SOEP v29, own calculations. Notes: Standard errors are given in italics. All standard errors are clustered on the individual-level. All models include a piecewise linear age trend, individual-fixed effects and separate dummy variables for month and year of the interview. Specification 2 includes control variables for marital status, education and month-year interaction effects. The sample includes all observations from age 50 to 75. Significance is coded as follows: * = 0.1, ** = 0.05, *** = 0.01.

Second stage results

The estimated treatment effects in Table 4 show that retirement has a strong positive impact on all three health measures. The effect mental health is especially large, resulting in a change of about half a standard deviation. The effects on physical health and satisfactory health are smaller (about 0.3 standard deviations). All in all, the results indicate that there is a positive causal effect of retirement on health. Moreover, the results suggest that the effect on mental health is more profound than on physical health. These findings are in line with, for example, the findings of Blake and Garrouste (2012) for French retirees and Johnston and Lee (2009) for the UK.

The estimated effects cover individuals retiring either at the early and official retirement age for both men and women. Hence, the findings presented above should be valid for the majority of retirees in Germany. However, this joint estimation might also conceal important heterogeneity across complier groups. Therefore I estimate the model using only one discontinuity and the corresponding sub-sample. In particular, I estimate the effect *(a)* for women retiring at age 60 (with the sample including all women aged 50 to 70); *(b)* for men with labor market experience of 35 years or more at age 63[29] (sample aged 53 to 73); and *(c)* for men at age 65 (sample aged 55 to 75). The results are given in Table 5. Panel A shows the effects for all three health outcomes on women at age 60. The effects on satisfactory and mental health are small and insignificant, whereas the effect on physical health is smaller than in table 4, but marginally significant. This indicates that the estimated effects in Table 4 are not identified by women retiring at age 60, with the exception of physical health. Panel B gives the effects on men with at least 35 years of labor market experience. Here, the results indicate a strong and highly significant effect on satisfactory health, which exceeds the estimated effect in Table 4. Similarly, the effect on physical health is very strong but insignificant, whereas the effect on mental health is negative and insignificant. However, it is important to note that the Wald F-statistic is relatively small for all three outcomes, and only the value for satisfactory health exceeds the rule-of-thumb threshold of 10. Finally, Panel C gives the result for men retiring at age 65. Here, the results show an improvement in satisfactory health that is about the same magnitude as the joint effect in Table 4. Similarly, the effect on mental health is positive and highly significant, whereas the effect on physical health is small and insignificant. All in all, this suggests that the overall effects reported in Table 4 are mostly identified by men, which might be due to the higher labor market participation compared to women.

[29] Men under age 63 are included if the difference to age 63 plus their labor market experience exceeds 35 years, i.e. they are still able to accumulate the required contribution years.

Table 5: Single Regression Discontinuity estimates

	Satisfactory health				*Physical health*				*Mental health*			
Specification	*1*		*2*		*1*		*2*		*1*		*2*	
A. Women at age 60												
retired	0.015		0.020		1.507	**	1.449	*	-0.630		-0.657	
	0.029		*0.029*		*0.758*		*0.767*		*0.868*		*0.872*	
N	*43,951*		*43,951*		*14,516*		*14,516*		*14,516*		*14,516*	
Kleibergen-Paap Wald F	*793.422*		*781.695*		*792.328*		*779.910*		*792.328*		*779.910*	
B. Men with 35 years of employment at age 63												
retired	0.418	**	0.418	**	6.677		4.212		-85.093		-89.188	
	0.167		*0.168*		*16.933*		*17.342*		*75.763*		*83.817*	
N	*31,786*		*31,786*		*10,249*		*10,249*		*10,249*		*10,249*	
Kleibergen-Paap Wald F	*24.230*		*24.079*		*1.382*		*1.229*		*1.382*		*1.229*	
C. Men at age 65												
retired	0.150	***	0.147	***	0.043		0.140		7.487	***	7.374	***
	0.027		*0.027*		*0.881*		*0.876*		*0.991*		*0.986*	
N	*34,242*		*34,242*		*11,650*		*11,650*		*11,650*		*11,650*	
Kleibergen-Paap Wald F	*1,542.393*		*1,539.053*		*0.296*		*0.295*		*705.782*		*697.969*	
Additional controls	*no*		*yes*		*no*		*yes*		*no*		*yes*	

Source: SOEP v29, own calculations. Notes: Standard errors are given in italics. All standard errors are clustered on the individual-level. All models include a piecewise linear age trend, individual-fixed effects and separate dummy variables for month and year of the interview. Specification 2 includes control variables for marital status, education and month-year interaction effects. The bandwidth for each sample is 10 years. Significance is coded as follows: * = 0.1, ** = 0.05, *** = 0.01.

I also estimate the models using two-year leads of health as outcomes in order to investigate the long-run effects of retirement. The results in Table 6 suggest that after two years the effects on self-reported health and mental health are still large and significant. Therefore, I conclude that retirement has positive long-run effect on self-rated and mental health, while there might be a small, transitory effect on physical health. Before I explore heterogeneity and potential mechanisms of the treatment effects, I present some additional robustness checks for the main results.

Table 6: Long-term effects - Multiple Regression Discontinuity estimates

	Satisfactory health in two years				*Physical health in two years*		*Mental health in two years*			
Specification	*1*		*2*		*1*	*2*	*1*		*2*	
retired	0.181	***	0.183	***	0.279	0.235	5.389	***	5.471	***
	0.038		*0.038*		*1.038*	*1.038*	*1.263*		*1.264*	
Change in standard deviations	*0.468*		*0.473*		*0.030*	*0.026*	*0.565*		*0.574*	
N	*65,709*		*65,709*		*26,290*	*26,290*	*26,290*		*26,290*	
Kleibergen-Paap Wald F	*246.291*		*249.402*		*104.372*	*104.980*	*104.372*		*104.980*	
Additional controls	no		yes		no	yes	no		yes	

Source: SOEP v29, own calculations. Notes: Standard errors are given in italics. All standard errors are clustered on the individual-level. All models include a piecewise linear age trend, individual-fixed effects and separate dummy variables for month and year of the interview. Specification 2 includes control variables for marital status and education. The sample includes all observations from age 50 to 75. Significance is coded as follows: * = 0.1, ** = 0.05, *** = 0.01.

4.3 Robustness

The robustness of the estimated effects with respect to the inclusion of covariates is shown in Table 4 above. Furthermore, I investigate the robustness to the choice of the bandwidth, the specification of the age trend and the specification of the assignment variable.[30]

Bandwidth choice

The bandwidth choice is crucial in RDD, since there is trade-off between bias and variance. Therefore, I estimate the model described in section 3.2 using a bandwidth of five years, i.e. the sample is restricted to observations between age 55 and age 70. The results are provided in Table A.1 in the appendix. The estimated effect on satisfactory health is only about half as large as the original effect, which suggests that the results for the larger bandwidth are upward-biased. Still, the effect is significant, and with about 0.2 standard deviations still quite large. The magnitude of the effect on physical health is not affected by the bandwidth choice, and it is still highly significant. The smaller bandwidth decreases the effect on mental health from 0.5 standard deviations to 0.15 standard deviations, which is no longer significant. This suggests the presence of an up-

[30] As noted before, I also investigate the robustness of the results for satisfactory health to a different variable specification. I estimate all models using the full five-point SAH measure. While the magnitude of the effects is not comparable, the direction and significance remain the same.

ward-bias in the original results, which is probably due to the highly nonlinear relationship between mental health and age.

Quadratic age trends

Similarly, in parametric models the validity of RDD depends on the correct specification of the trend in the assignment variable. If the chosen polynomial is too restrictive, nonlinearities in the assignment variable can be mistaken for discontinuities. On the other hand, a flexible higher-order polynomial reduces the statistical power of the model. Therefore, I estimate models using a piecewise quadratic age trend (i.e. a quadratic age trend interacted with all discontinuities). Table A.2 in the appendix presents the results. The estimated coefficient for satisfactory health is about half of the original estimate (0.2 standard deviations), but highly significant. The effect on physical health is about the same magnitude as in Table 4 (0.35 standard deviations) and significant in all specifications. The effect on mental health decreases to 0.2 standard deviations, and is no longer significant.

Specification of the assignment variable

One might argue that age is not the correct assignment variable, since the probability to retire depends on the individual eligibility age, and not on age itself. For example, for an employed man it should not matter whether he is above or below the age threshold of 60, since he is eligible neither for a pension for women, nor for a pension due to unemployment. In this framework, the assignment variable would be calculated as the difference between an individual’s age and the earliest age at which s/he is eligible for a state pension. I also run a RDD based on the time to eligibility as a robustness check using the “eligibility sample” described in section 2. All in all, the results (shown in Table A.3 in the appendix) confirm the finding of a positive effect of retirement on health. The effect on satisfactory health is positive and significant. The effect on physical health is large and negative, but very imprecisely estimated. In contrast, the effect on mental health is large (about 1.5 standard deviations) and highly significant.

In the next two sections I investigate heterogeneity and potential mechanisms of the treatment effect using RDD with age as the assignment variable and a bandwidth of 10 years.

4.4 Effect heterogeneity

I investigate whether the estimated effects differ according to gender, education, occupational demands or family characteristics. On the one hand, individuals retiring from strenuous jobs might experience different effects than individuals retiring from sedentary jobs, since retirement relieves them from work-related strain. Both gender and education are important determinants of occupational choice, hence occupational heterogeneity might also be reflected in heterogeneity with respect to these two characteristics. On the other hand, the above mentioned characteristics might influence the behavioral response of retiring individuals. For example, individuals in physically straining occupations might experience a reduction in overall physical activity upon retirement due to the loss of work-related activity. Higher educated individuals might invest more in their health due to the lower opportunity costs. Hence, heterogeneous treatment effect might also reflect the underlying mechanisms. I estimate the models separately for each subgroup by interacting all independent variables with the group dummies.[31] The results for all health outcomes are shown in Table 7.

The first row shows the treatment effect for the reference group (women, individuals with vocational training, from sedentary occupations, without a retired partner and without grandchildren, respectively). Each column gives the result for a separate regression. The effect for women is significant for satisfactory and mental health, while the estimated treatment effect is significantly larger for men for both outcomes. There is effect heterogeneity with respect to education, i.e. individuals with a university degree or without a formal tertiary degree experience a significantly smaller (or no) effect on satisfactory health. This is likely due to different occupations – individuals without a formal degree are more likely to work in menial labor, while academics

[31] This allows for the possibility of differential age-trends, while at the same time delivering standard errors for the group differences. However, I restrict the time-shocks to be the same across groups. The instruments (i.e. the dummies for the discontinuities) were also interacted with the group dummies to derive additional instruments. This is only valid if the group variables are assumed to be exogenous with respect to health for the according age range. In the case of gender and education, this assumption appears reasonable. In the case of occupational demand, it might be the case that individuals with a declining health status switch to less demanding occupations prior to retirement. However, given that employment perspectives are declining with age, this might not happen very often. Moreover, by calculating the average occupational strain for all years prior to retirement, the bias should be minimized. Lastly, retirement status of the partner cannot be expected to be exogenous. If an individual suffers a negative health shock and is forced to retire, it can be expected that the partner is also more likely to retire (e.g. in order to provide care and assistance (Marcus, 2013)). Therefore I additionally instrument the retirement status of the partner by a dummy variable indicating whether the partner is above the early retirement threshold at age 60 or not. This additional instrument is then interacted with the dummy variables for the three discontinuities. Furthermore, in this case I restrict the age-trend to be the same across groups, since the group variable is not exogenous.

have a higher job satisfaction and might therefore dislike retirement. There is little evidence for heterogeneity with respect to occupational demands. Individuals retiring from physically demanding jobs experience a large and positive effect on physical health, which suggests that their health improves as a consequence of relief from work-related strain. On the other hand, individuals retiring from physically or mentally straining occupations experience no significant mental health improvements. It should be noted that the Wald F-statistic is very small in this case, i.e. the instruments are weak (due to the small group size in the fully interacted model) and the effects are imprecisely estimated. While individuals whose partner is also retired experience a higher increase in physical health, which is significant on the ten percent level, they also benefit less with respect to their self-reported health status and their mental health. This could suggest that jointly retired couples follow a healthier lifestyle (e.g. they might be physically more active), but that the increase in the time spent together leads to more conflicts, which deteriorate their mental health. Lastly, the presence of grandchildren does not seem to play a role.

Table 7: Effect heterogeneity

	Satisfactory health				*Physical health*				*Mental health*			
	1	2	3	4	1	2	3	4	1	2	3	4
retired	0.210 ***	0.167 ***	0.168 ***	0.153 ***	3.382 **	2.568 **	1.421	2.808	6.561 ***	6.839 ***	6.750 ***	4.469 **
	0.042	*0.037*	*0.039*	*0.048*	*1.486*	*1.294*	*1.252*	*1.726*	*1.731*	*1.519*	*1.399*	*1.990*
retired x university degree	-0.129 *	-	-	-	-4.134 *	-	-	-	-0.310	-	-	-
	0.066				*2.429*				*2.808*			
retired x no degree	-0.176 *	-	-	-	4.079	-	-	-	-9.228 **	-	-	-
	0.102				*3.799*				*3.901*			
retired x high physical strain	-	-0.175	-	-	-	7.820 *	-	-	-	-9.220 **	-	-
		0.119				*4.392*				*4.185*		
retired x high psycho-logical strain	-	0.101	-	-	-	-2.813	-	-	-	-10.904 *	-	-
		0.167				*5.124*				*5.631*		
retired x high overall strain	-	-0.093	-	-	-	-0.166	-	-	-	-6.746 *	-	-
		0.108				*3.097*				*3.671*		
retired x partner retired	-	-	-0.079 ***	-	-	-	1.747 *	-	-	-	-3.039 ***	-
			0.025				*0.928*				*0.926*	
retired x grandchil-dren	-	-	-	-0.046	-	-	-	-0.568	-	-	-	0.448
				0.064				*2.230*				*2.553*
N	*97,429*	*97,429*	*74,764*	*97,429*	*32,906*	*32,906*	*25,476*	*32,906*	*32,906*	*32,906*	*25,476*	*32,906*
Kleibergen-Paap Wald F	*18.831*	*3.911*	*138.960*	*81.432*	*5.352*	*1.222*	*44.348*	*21.498*	*5.352*	*1.222*	*44.348*	*21.498*

Source: SOEP v29, own calculations. Notes: Standard errors are given in italics. All standard errors are clustered on the individual-level. Time-fixed effects include dummy variables for year and month of the interview. All models include a piecewise linear age trend. The age trend is interacted with the respective group variable to allow for differential age trends, except for specification 4. High strain is a dummy variable, which takes on the value of one for individual whose average occupational strain exceeded the 75th percentile of the sample. Significance is coded as follows: * = 0.1, ** = 0.05, *** = 0.01.

4.5 Mechanisms

Health behavior

The investigation of effect heterogeneity suggests that one mechanism of the effect of retirement is indeed the relief from occupational strain. However, behavioral adjustment might also contribute to the increase in health. Therefore I estimate the model using various measures of health behavior as outcome variables. In particular, I look at alcohol and tobacco consumption, diet and exercise, sleep and social contacts. The results are shown in Table 8 below.

The effect on smoking is small and insignificant, which appears reasonable given the addictive nature of tobacco. There is, however, some evidence for a change in alcohol consumption – retirement seems to increase the probability to consume alcohol regularly by about 12 percentage points. While this effect might seem quite large, the variable does not account for the quantity of alcohol consumed. Hence, if retirees consume small or moderate quantities of alcohol more regularly, this should not affect their health negatively. In addition, Ziebarth and Grabka (2009) document that (moderate) alcohol consumption is positively correlated with health. The results also suggest that there is a sizable increase in the probability to regularly participate in leisure-time physical activity. Since many forms of physical activity require a time investment, this is in line with the expectations derived from economic theory. I also find a significant increase in body mass of about 0.5 points of BMI. While both the finding of higher physical activity and increased body weight is in line with earlier studies (e.g. Godard, 2013), this appears to be counterintuitive, given the generally positive effect of retirement on health. The seeming contradiction can be resolved by considering that the Body Mass Index does not discriminate between healthy and unhealthy mass. The increase in physical activity could lead to an increase in muscle mass. Hence the BMI would increase, although the individual is healthier. The increase in BMI could also suggest that the increase in leisure-time physical activity is smaller in magnitude than the reduction in work-related physical activity, resulting in less physical activity and a consequent weight gain. This could imply that in the long-run the positive effect of retirement is outweighed by the negative effects of the additional body mass. However, given the earlier finding of long-lasting positive health effects, this explanation seems unlikely.

The results also show that the sleep duration on a week day increases upon retirement, which is in line with the findings of Lemola and Richter (2013). The effect of about 0.8 hours (0.6 standard deviations) is very large, and seems to explain the increase in self-reported and mental health. There seems to be no effect on the number of close friends. All in all, the results point towards physical activity and sleep as the key mechanism through which retirement affects health. The estimated effects suggest that the lower opportunity costs of a healthy lifestyle for retirees indeed result in higher health investments.

Table 8: Health behavior - RD estimates

	Smoking	*Regular alcohol consumption*	*No alcohol consumption*	*Regular physical activity*	*Health-conscious diet*	*Sleep duration*	*BMI*	*Number of close friends*
retired	-0.007	0.210 *	-0.199 **	0.086 *	0.033	0.813 ***	0.585 **	1.377
	0.036	*0.121*	*0.092*	*0.046*	*0.089*	*0.240*	*0.271*	*0.859*
Change in standard deviations	*-0.016*	*0.513*	*-0.623*	*0.173*	*0.070*	*0.681*	*0.137*	*0.325*
N	*33,585*	*16,035*	*16,035*	*39,892*	*27,412*	*33,975*	*34,031*	*13,854*
Kleibergen-Paap Wald F	*114.178*	*21.155*	*21.155*	*197.914*	*82.339*	*58.759*	*122.833*	*67.757*

Source: SOEP v29, own calculations. Notes: Standard errors are given in italics. All standard errors are clustered on the individual-level. All models include a piecewise linear age trend, individual-fixed effects and separate dummy variables for month and year of the interview. Significance is coded as follows: * = 0.1, ** = 0.05, *** = 0.01.

Time use

To provide further evidence on the behavioral responses of individuals to retirement, I investigate changes in time use. The results are provided in Table 9. Retirement has a significant effect on all included activities. The effect is especially strong for leisure time activities (e.g. hobbies), which is not surprising. Retirees can allocate their time to leisure activities without trading off income, which is fixed. While this is likely to result in utility gains, the effect on health is much more ambiguous. Leisure-time activities can include both health investments (e.g. sports) and sedentary activities (e.g. reading), and therefore the effects of increased leisure time could be either health enhancing or deteriorating. Interestingly, retirement also increases time invested in repairs in and around the house and gardening, household chores and running errands. These activities all require a physical effort and concentration, and can therefore be expected to enhance health by providing physical activity over and above the increase in sports and exercise. Similarly, providing childcare is likely to result in retirees pursuing an active lifestyle. Time investment in education decreases as a result of retirement, as retirees have no longer monetary incentives to invest into their education and skills. In summary, the time use data confirms that retirees invest their time into an active lifestyle, and the increase in physical activity is likely to cause the health improvements upon retirement reported in this paper.

Table 9:Time use and healthcare - RD estimates

	Repairs and gardening		*Leisure time activities*		*Running errands*		*Household chores*		*Education*		*Childcare*		*Hospital stay*		*Number of doctor visits*	
retired	1.097	***	1.021	***	0.410	***	0.334	***	-0.076	*	0.218	**	-0.073	**	-1.429	***
	0.103		*0.180*		*0.067*		*0.104*		*0.040*		*0.087*		*0.031*		*0.383*	
Change in standard deviations	*0.847*		*0.476*		*0.500*		*0.197*		*-0.143*		*0.214*		*-0.225*		*-0.357*	
N	*93,044*		*94,698*		*94,936*		*94,718*		*88,752*		*88,575*		*97,178*		*70,033*	
Kleibergen-Paap Wald F	*389.014*		*397.692*		*397.136*		*391.650*		*360.429*		*362.411*		*407.002*		*331.124*	

Source: SOEP v29, own calculations. Notes: Standard errors are given in italics. Time use is measured in hours and refers to a typical weekday. All standard errors are clustered on the individual-level. All models include a piecewise linear age trend, individual-fixed effects and separate dummy variables for month and year of the interview. Significance is coded as follows: * = 0.1, ** = 0.05, *** = 0.01.

Healthcare utilization

Lastly, I explore whether the higher health investments of retirees affect their healthcare utilization. The last two columns of Table 9 show the estimated treatment effects. Retirement leads to a decrease in both the probability to be hospitalized and the number of doctor visits. The effect on outpatient care is especially sizable. This further confirms the finding of a positive effect of retirement on health, since one would expect to find an increase in healthcare utilization if health deteriorates as a consequence of retirement. This emphasizes the need for policymakers to consider the health effects of retirement when considering pension reforms, since sizable effects on healthcare spending could occur.

5 Conclusion

This paper estimates the causal effect of retirement on health, health behavior and healthcare utilization using a Regression Discontinuity Design with multiple discontinuities that are caused by incentives in the German pension systems. The results indicate that retirement has a positive effect on health. The probability to report a health status of satisfactory or better increases by about 15 percentage points, while physical and mental health improve by 0.3 to 0.6 standard deviations. These RDD results are robust to the inclusion of control variables, the choice of the bandwidth, the age trend and an alternative specification. Most importantly, these effects are not transitory. Even 3 years after retirement the significant health improvements can be confirmed.

Furthermore, there is significant heterogeneity across socio-economic groups. In general, males benefit more from retirement than females. Lower educated individuals benefit less with respect to self-reported and mental health, which is likely due to their selection into menial occupations. Academics also benefit less from an improvement of their self-reported health. The investigation of health behavior shows that retirement leads to an increase in alcohol consumption, physical activity, sleep duration and weight.

Overall, the findings of this paper suggest three important mechanisms through which retirement affects health. First, retirement relieves employees from work-related stress and strain. Employees from physically straining occupations benefit especially from a recovery of their physical health, whereas the majority of workers experience an improvement in self-rated and mental health. Second, retirees increase their sleep duration on weekdays. Given that non-retirees sleep on average less than 7 hours per workday, an increase by 45 minutes per day is likely to enhance their self-reported and mental health. Third, and finally, retirees use their additional leisure-time to pursue a more active lifestyle by investing more time into daily activities requiring a physical effort, and by more frequently exercising.

Most importantly, the findings of this paper imply that the positive health effects of retirement lead to reductions in healthcare costs. Therefore, increasing the official retirement age as a cost containment measure in the pension system is likely to increase costs in the healthcare systems, since older employees face higher opportunity costs to maintain their health status through health investments. This underlines the importance for policymakers to consider the externalities of retirement policies for population health.

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Appendix

Table A.1: Robustness check I: Bandwidth of five years

	Satisfactory health				*Physical health*				*Mental health*	
Specification	*1*		*2*		*1*		*2*		*1*	*2*
retired	0.071	*	0.068	*	2.916	**	3.001	**	1.444	1.324
	0.040		*0.040*		*1.320*		*1.318*		*1.493*	*1.492*
Change in standard deviations	*0.183*		*0.176*		*0.319*		*0.328*		*0.152*	*0.139*
N	*59,079*		*59,079*		*19,267*		*19,267*		*19,267*	*19,267*
Kleibergen-Paap Wald F	*214.736*		*216.482*		*71.901*		*72.331*		*71.901*	*72.331*
Additional controls	no		yes		no		yes		no	yes

Source: SOEP v29, own calculations. Notes: Standard errors are given in italics. All standard errors are clustered on the individual-level. All models include a piece-wise linear age trend, individual-fixed effects and separate dummy variables for month and year of the interview. Specification 2 includes control variables for marital status, education and month-year interaction effects. The sample includes all observations from age 55 to 70. Significance is coded as follows: * = 0.1, ** = 0.05, *** = 0.01.

Table A.2: Robustness check II: Quadratic age trends

	Satisfactory health				*Physical health*				*Mental health*	
Specification	*1*		*2*		*1*		*2*		*1*	*2*
retired	0.080	**	0.081	**	3.217	***	3.239	***	1.922	1.913
	0.032		*0.032*		*1.188*		*1.185*		*1.312*	*1.312*
Change in standard deviations	*0.207*		*0.209*		*0.352*		*0.354*		*0.202*	*0.201*
N	*97,429*		*97,429*		*32,906*		*32,906*		*32,906*	*32,906*
Kleibergen-Paap Wald F	*300.039*		*302.399*		*84.054*		*84.672*		*84.054*	*84.672*
Additional controls	no		yes		no		yes		no	yes

Source: SOEP v29, own calculations. Notes: Standard errors are given in italics. All standard errors are clustered on the individual-level. All models include a piece-wise quadratic age trend, individual-fixed effects and separate dummy variables for month and year of the interview. Specification 2 includes control variables for marital status, education and month-year interaction effects.The sample includes all observations from age 50 to 75. Significance is coded as follows: * = 0.1, ** = 0.05, *** = 0.01.

Table A.3: Robustness check III: RD design on eligibility

	Satisfactory health				*Physical health*		*Mental health*			
Specification	*1*		*2*		*1*	*2*	*1*		*2*	
retired	0.172	*	0.184	*	-5.668	-5.325	12.856	**	12.568	***
	0.093		*0.094*		*4.227*	*4.137*	*5.104*		*5.016*	
Change in standard deviations	*0.444*		*0.475*		*-0.619*	*-0.582*	*1.349*		*1.319*	
N	*23,193*		*23,193*		*6,672*	*6,672*	*6,672*		*6,672*	
Kleibergen-Paap Wald F	*126.934*		*123.106*		*31.603*	*31.685*	*31.603*		*31.685*	
Additional controls	no		yes		no	yes	no		yes	

Source: SOEP v29, own calculations. Notes: Standard errors are given in italics. All standard errors are clustered on the individual-level. All models include a piece-wise linear trend for time to eligibility, a quadratic age trend, individual-fixed effects and separate dummy variables for month and year of the interview. Specification 2 includes control variables for marital status, education and month-year interaction effects.The bandwidth chosen for time to eligibility is five years. Significance is coded as follows: * = 0.1, ** = 0.05, *** = 0.01.