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Heterogeneous effects of retirement on the biomedical risk factors for cardiovascular and metabolic diseases: New evidence based on the physical examination database in Shanghai, China

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ABSTRACT

Retirement has a heterogeneous impact depending on gender and occupation. This study aimed to analyze and evaluate the heterogeneity and potential mechanism of retirement on the biomedical risk factors for cardiovascular and metabolic diseases. Physical examination data from 2017 to 2020 were extracted from a hospital database in Shanghai. The fluctuation tendency of biomedical risk factor indicators for cardiovascular and metabolic diseases was evaluated by gender and occupation shortly after retirement using fuzzy regression discontinuity design and was analyzed for internal mechanism. Retirement had a significantly negative influence on body weight ($\beta = -3.943$), body mass index ($\beta = -2.152$), and diastolic blood pressure ($\beta = -5.180$) in women working in public institutions or state-owned enterprises, but a positive influence on their blood glucose level ($\beta = 0.696$). Retirement had a significantly positive effect on high-density lipoprotein in men ($\beta = 0.138$), particularly those employed in private enterprises ($\beta = 0.339$). The internal influencing mechanism of retirement showed that the health attention effect after retirement among women in government or public institutions on diastolic blood pressure reduction was better than that before retirement. The body weight, body mass index, and diastolic blood pressure of women in public institutions or state-owned enterprises were reduced at retirement; however, they were exposed to higher risks of elevated blood glucose level. Conversely, high-density lipoprotein level, which is protective against cardiovascular disease, was increased in men at retirement. Retirement has a heterogeneous effect on cardiovascular and metabolic health among people of different genders or occupational experiences. Retirees with low health awareness should be targeted for behavioral interventions and monitored conscientiously by health providers during retirement adaptation.

1. Introduction

As the global aging trend intensifies, more people are reaching the retirement stage. By the end of 2019, there were 253.88 million people aged over 60 years in China, accounting for 18.1% of the total population (National Bureau of Statistics, 2019). The formulation of retirement policy and allocation of endowment resources have become crucial for China's social development. Retirement has a significant impact on retirees' consumption behaviors, time distributions, social relationships, and physical and mental health (Eibich, 2015; Bertoni et al., 2018; Z and W, 2020). Of the various welfare dimensions for older adults, health is a significant field affecting life quality and economic well-being. Exploring the causal relationship between retirement and health status

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Abbreviations

AIC	Akaike information criterion
ATE	Average Treatment Effect
BMI	Body mass index
DBP	Diastolic blood pressure
HDL	High-density lipoprotein
LDL	Low-density lipoprotein
RD	Regression discontinuity
RDD	Regression discontinuity design
SBP	Systolic blood pressure

can help formulate and optimize national retirement policies and resources.

However, the conclusions of current research on the effects of retirement on health are inconsistent because of the dual properties of health determined by the influence of exogenous shocks and long-term investment and depreciation (W et al., 2012; Yogo, 2016). Although retirees have less enthusiasm to invest in health to increase their income, there will be an increase in the passive consumption of health services due to the decline in health status. Therefore, the trade-off between the marginal cost of health investment and the marginal benefit of health consumption also influences the net effect of retirement. Although studies in Australia (Atalay & Barrett, 2014) and the Netherlands (Bloemen et al., 2017) found that retirement improved subjective (self-rated health) and objective health statuses (chronic diseases) and reduced mortality rates, some studies showed a negative impact (Behncke, 2012; Dave, 2008; Kuhn et al., 2020). For example, Godard (Godard, 2016) estimated that retirement led to a 12% increase in the probability of obesity in men aged 50–69 years within 2–4 years, especially among manual workers. Fitzpatrick and Moore (Fitzpatrick & Moore, 2018) found that the mortality rate of individuals aged 62 years significantly increased by 1.5% in the United States, using the regression discontinuity design (RDD) method.

Furthermore, despite the increased interest in the literature regarding the effect of retirement on health, evidence concerning underlying mechanisms remains inconclusive. Existing studies explain the mechanism from two aspects. First, changes in health behaviors and social activities after retirement become important channels affecting health. Eibich (Eibich, 2015) found that relief from work-related stress and strain, increased sleep duration, and more frequent physical exercise after retirement seemed to be key mechanisms influencing health. Second, retirement may impact the health status of retirees by affecting their cognitive functions (Bertoni et al., 2018). Celidoni et al. (Celidoni et al., 2017) found that retirement had a long-term negative effect on the cognitive function of retirees. Further, some studies suggested that retirement had a significantly positive effect on women's physical and mental health (L and L, 2017), and a significant promotive effect on men's mental health (D & He, 2016). However, most of these studies were based on self-assessment health indicators, and biochemical indicators were rarely used. While neglecting the comprehensive management of various chronic diseases, such as cardiovascular and metabolic diseases, in retired populations, which is crucial for China with its large elderly population. Furthermore, methods selected for the analysis of the impact of retirement on health have some limitations; for example, some econometric models did not completely control for unobservable influencing factors, with omission biases of important variables (Dave, 2008). Furthermore, the RDD can only estimate the local effect; thus, it can only identify the short-term effects of retirement on mortality (Fitzpatrick & Moore, 2018).

In addition, "male-female, health-survival paradox", which refers men are more likely to die than women at any given age, but women have poorer health at older ages, is not fully understood (Archer et al., 2018). The perspective of gender difference has always been an important dimension in the study of health in old age. It is believed that the differences in socioeconomic status and health resources between men and women lead to the health differences between the sexes (Nathanson, 1967; Verbrugge, 1976). This is consistent with previous research conclusions that socioeconomic status (education level, professional status and income level) is the most decisive factor affecting personal health status and life expectancy (Link and Phelan, 1995; Williams, 1990; Winkleby et al., 1992). The retirement policy design of different genders and different occupational experiences in China provides research feasibility for studying gender and occupational heterogeneity in health of the elderly population.

In China, both urban and rural residents enjoy old-age insurance benefits; however, China's endowment insurance system (corresponding to the retirement system) mainly covers urban workers, whereas rural social endowment insurance coverage is limited (W and Z, 2011). In rural areas, no strict retirement concept exists, residents mainly decide when to quit the labor market based on personal health and economic characteristics. By the national policy, the legal retirement ages for male employees in both public institutions, state-owned enterprises and private enterprises are 60, while the retirement ages for female employees in public institutions/state-owned enterprises and private enterprises are different, at 50 and 55, respectively.[2] However, health status is an important variable determining whether or not to retire (Disney et al., 2006; McGarry, 2004), and retirement can affect an individual's health status (Celidoni et al., 2017; L and L, 2017; D & He, 2016). Therefore, a causal relationship exists between the explanatory and the explained variables, which is called reverse causality. In addition, there are some unobservable variables such as individual behavior and health endowment that affect both health and retirement, thereby causing the problem of missing variable error. The above two cases will result in correlation between explanatory variables and error terms, and often lead to bias in the estimated coefficients (Hil et al., 2021).

The growing retiree population and its negative impacts on chronic diseases and medical burden in China warrant attention (W and Z, 2011), as the management of chronic diseases among retirees, especially cardiovascular and metabolic diseases, which are the main threats to the health of Chinese people, is crucial (Zhou et al., 2019). Moreover, directly related risk factors to these changes might have long-term consequences on cardiovascular and metabolic health, and on disability, longevity, and health care costs. Therefore, by using the fuzzy RDD to overcome endogeneity in the regression model, and utilizing accurate physical examination index variables, we enlarged the explorations on biomedical indicators and aimed to identify the impact of retirement on physical examination indicators in different retiree groups. We further explored the heterogeneity and mechanism of the impact of retirement on biomedical risk factors for cardiovascular and metabolic diseases. The findings may provide more explicit evidence for policymakers to formulate retirement policies and optimize the allocation of resources to improve the cardiovascular and metabolic health of retirees in China and similar countries and regions.

[2] According to the actual situation in China, occupations are roughly divided into two types according to the ownership. The first type is owned by the state, including state-owned enterprises and public institutions; the other type is a private enterprise (including foreign enterprises).

2. Materials and methods

2.1. Data and sample

Data extracted from the physical examination database[3] of a medical examination center in Shanghai from 2017 to 2020 included sociodemographic variables (identity number [ID], sex, age, workplace, retirement status, and physical examination times in this institution) and physical examination outcome indicators, including height, weight, body mass index (BMI), blood glucose, hypertension (systolic blood pressure [SBP] and diastolic blood pressure [DBP]), total cholesterol (CHO), triglyceride (TG), high-density lipoprotein (HDL), and low-density lipoprotein (LDL).

To explore the heterogeneous effects of retirement on cardiovascular and metabolic diseases, we selected risk factors of cardiovascular and metabolic diseases based on the following criteria: 1) sufficient evidence suggested an association with cardiovascular and metabolic diseases; 2) exposure data were available in study population. A total of nine factors were included: high blood glucose, high weight, high BMI, high SBP, high DBP, high CHO, high TG, high LDL and low HDL.

We obtained data from a total of 52,612 participants from the physical examination center, including 21,934 males and 30,678 females.[4] Before empirical tests, 1845 participants with missing variables, such as physical examination indicators, age, workplace, and retirement status, were excluded. To control for the age effect, we chose samples that were aged around the time of statutory retirement (Zhou et al., 2019). The remaining data were grouped according to the ownership nature of the employers and gender. For women working in public institutions or state-owned enterprises, participants between 45 and 65 years old were retained. For women working in private enterprises, we retained participants between the ages of 40 and 60. For all males, samples between 50 and 70 years old were reserved. Therefore, only those 10 years before and after the statutory retirement age were included. Finally, 8298 women and 5496 men were included. The participants provided their consent for the use of these data before their physical examinations. This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Tongji University. Under the guidance of the Ethics Committee, we fully guarantee the privacy and information security of participants.

To overcome within-sample errors and more accurately identify heterogeneous impact of retirement on health outcomes in the regression analysis, participants were divided into five sub-groups according to retirement age, including all male participants, men in private enterprises (Men 1), men in public institutions or state-owned enterprises (Men 2), women in private enterprises (Women 1), and women in public institutions or state-owned enterprises (Women 2).[5]

2.2. Study design

Since not all people retire exactly when they reach the statutory retirement age, and some people retire early or work after retirement, fuzzy breakpoint regression (FRDD) is used in the study. Referring to relevant studies on FRDD (L et al., 2016; Imbens & Lemieux, 2008), took assignment variable (the age of physical examination minus the legal retirement age) as the instrumental variable and used the two-stage least squares method (2SLS) to estimate. The first stage estimated the impact of assignment variable on retirement, and the second stage estimated the average treatment effect of retirement on physical examination indicators. The model was built as follows:

$$Retire_{gi} = \alpha_0 + \alpha_1 D_{gi} + \alpha_2 \left(age_{gi} - s_g\right) + \vartheta_{gi} \tag{1}$$

$$Physical\ indicators_{gi} = \beta_0 + \beta_1 \widehat{Retire}_{gi} + \beta_2 \left(age_{gi} - s_g\right) + \mu_{gi} \tag{2}$$

In the empirical model, s_g is the legal retirement age, s_1 is the retirement age for men ($s_1 = 60$), s_2 is the workers' retirement age for women in private enterprises ($s_2 = 50$), s_3 is the retirement age of the women working in public institutions or state-owned enterprises ($s_3 = 55$). $Physical\ indicators_{gi}$ represents the physical examination index (including height, weight, BMI, blood glucose, SBP, DBP, CHO, TG, HDL, and LDL) of the individual i in the group g; $Retire_{gi}$ represents the retirement status of the individual i in the group g; age_{gi} represents the age of the individual i in the group g; and $age_{gi} - s_g$ is the assignment variable of regression discontinuity design.D_{gi} is a dummy variable, reflecting the relationship between individual age and breakpoint. When $(age_{gi} - s_g) > 0$, $D_{gi} = 1$ and the individual is considered to be in the experimental group; when $(age_{gi} - s_g) < 0$, $D_{gi} = 0$, the individual is regarded considered to be in the control group. Although people were to retire at the legal retirement age, in practice, the age at which they retired was generally delayed up to one year after the mandatory retirement age (Imbens & Lemieux, 2008). Therefore, the individual of legal retirement age was excluded (Z and Y, 2015). Formula (1) represents the first stage regression, which is the regression analysis of the endogenous explanatory variable $\mathrm{Retire_{gi}}$ on the instrumental variable, $\mathrm{D_{gi}}$, to obtain the fitting value $\widehat{\mathrm{Retire}}_{\mathrm{gi}}$. Formula (2) represents the second-stage regression, that is, the explained variables $Physical\ indicators_{gi}$ are used to perform regression on the fitted values $\widehat{Retire}_{gi}$. In the estimation, β_1 is the local average treatment effect of retirement on physical examination indicators, ϑ_{gi} and μ_{gi} are the residual terms. According to the inference method of RDD, consistent estimators can still be obtained by regression without adding additional control variables (Lemieux, 2010). Therefore, the only dummy variable, year, was controlled for in the RDD benchmark regression model.

2.3. Statistical analysis

The breakpoint validity check and continuity test were conducted to confirm the applicability of fuzzy RDD using two steps. First, in this study, to prevent measurement error in the assignment variable, the variable was calculated as the age of physical examination (the year of physical examination minus the year of birth on ID card) minus statutory retirement age. Second, endogenous grouping problem should be prevented; hence, individuals should not be able to manipulate the assignment variables to enable entry into either the treatment or control groups (Dinardo & Lee, 2011; Lemieux, 2010). Theoretically, it was impossible to manipulate the age of "retirement," and thus alter the distribution on both sides of the breakpoint. Further, the samples on both sides of the breakpoint were tested for smoothness, and McCrary's test (Mccrary, 2008) was used to draw kernel density curves of assignment variables (Fig. S1). The curves did not show obvious jumps, and the confidence intervals mostly overlapped, thereby indicating no significant difference in the density functions on both sides of the breakpoint. Since the bandwidth used in McCrary's test was not the optimal value calculated by the CCT method (Calonico et al., 2012), the g-statistic was further constructed for sample non-random test (Bugni & Canay, 2021) based on the optimal bandwidth set by CCT and with no limit on the number of samples. Furthermore, the g-statistic did not

[3] In China, the labor law encourages employers to provide free annual physical examination services to employees, including on-duty and retired persons (workers and retirees have the same probability of having a consultation). In addition to the on-boarding physical examination and individual industries, employees voluntarily participate in the physical examination, and the special physical examination center undertakes the physical examination work.

[4] The reason for the difference in the number is that females pay more attention to physical examination than males; thus, the women outnumbered men in the same period.Data source: https://baijiahao.baidu.com/s?id=1696705999850597049&wfr=spider&for=pc.

[5] We combined the two male groups to obtain the average impact of retirement on health status. However, different employer groups of the females have different legal retirement ages. Therefore, female groups were not integrated.

involve kernel density and local polynomial problems; compared with McCrary's test, it was asymptotically effective under weaker conditions. The test results of g-statistics (Table S1) shows that the null hypothesis is rejected, and there is no human intervention in the sample distribution ($p > 0.10$). Therefore, the breakpoints used in this study met the above two assumptions, and the jump at the breakpoint can be regarded as a causal effect of retirement on health outcomes.

In addition, if there was a jump in the conditional density function of individuals' characteristic variable at the breakpoint, the treatment effect cannot be attributed to the retirement policy. Therefore, the validity of regression discontinuity (RD) estimation must meet the continuity hypothesis, wherein the individual characteristic variable should be continuous at the breakpoint (Z and W, 2020). If there was a sample selection problem, retirement should have a significant impact on individuals' characteristic variables. The 2SLS second-stage regression results of retirement effects on height and the number of physical examinations under the framework of regression discontinuity design showed no significant impact of retirement on individual characteristic variables (Table S2), thus satisfying the continuity hypothesis.

Based on the assumption that all the valid estimation assumptions for RDD were satisfied, the heterogeneity effect of retirement on health indicators was estimated for different genders and occupational types using 2SLS. Furthermore, we changed the bandwidth and added control variables to test the robustness, and finally added a cross-multiplication term to test the path of the retirement effect. All analyses were performed using STATA 16 (Stata Corp., College Station, TX, USA).

3. Results

3.1. Basic characteristics

Most participants were women, with an average age of 55.3 years. Approximately 88.3% of the participants worked in public institutions or state-owned enterprises, and 15.9% had retired. The mean values of cardiovascular and metabolic diseases-related indicators were all within normal ranges (Table 1) (Revision Committee of the Chinese Guidelines for the Prevention and Treatment of Hypertension, 2019; L and W, 2021; W et al., 2019).

3.2. Regression results of retirement on physical examination indicators

The RD model was used to obtain consistent estimators without controlling for other variables (Lemieux, 2010), except the instrumental variable (assignment variable) and year, as a dummy variable. Based on the polynomial order selection of the assignment variables and with reference to the Akaike information criterion (AIC), the assignment variable selection was a first-order polynomial controlled for in this study's benchmark regression analysis.

Regression results of columns (1)–(3) in Table 2 show that retirement among women working in private enterprises had no significant impact on physical examination indicators. However, retirement had a significantly negative effect on men's body weight and BMI, and a significantly positive effect on their HDL. In addition, retirement had a significantly negative impact on body weight, BMI, and DBP, and a significantly positive impact on blood glucose for women in state-owned enterprises or public institutions. Columns (4) and (5) show that for men, retirement had a significantly negative effect on TG and a significantly positive effect on HDL especially for those in private enterprises. Furthermore, retirement had a significantly negative impact on body weight for men in state-owned enterprises or public institutions.

Table 1
Basic characteristics of respondents ($N = 8298$).

Characteristics	Mean	SD	Min value	Max value
Sex (Male = 0, Female = 1)	0.602	0.490	0	1
Age (years)	55.247	7.127	40	70
Working in state-owned enterprises or public institutions (No = 0, Yes = 1)	0.883	0.322	0	1
Physical examination times in this institution	3.310	0.463	3	4
Retired or not (No = 0, Yes = 1)	0.159	0.365	0	1
Height	166.623	7.588	151.500	184.500
Weight	64.782	10.936	44.800	93.500
BMI[a]	23.241	2.929	17.300	31.500
Blood glucose	5.578	1.058	4.400	10.900
SBP[a]	129.853	18.170	94	179
DBP[a]	77.656	11.467	53	107
CHO[a]	5.134	0.907	3.150	7.690
TG[a]	1.478	0.918	0.410	5.540
HDL[a]	1.367	0.330	0.770	2.290
LDL[a]	3.146	0.796	1.380	5.270

[a] BMI, body mass index; CHO, total cholesterol; DBP, diastolic blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SBP, systolic blood pressure; SD, standard deviation; TG, triglyceride.

3.3. Robustness test

3.3.1. Influence of retirement on physical examination index under different bandwidths

To test the influence of retirement on physical examination indicators related to cardiovascular and metabolic diseases under different bandwidths, columns (1), (3), (5), (7), and (9) in Table 3 are the RD estimation results of sample intervals limited to bandwidths of 8 years before and after the legal retirement age. Columns (2), (4), (6), (8), and (10) in Table 3 are the RD estimation when the sample interval was restricted to the bandwidth of 12 years before and after the statutory retirement age. As shown in Table 3, compared with the bandwidth model of 10 years before and after the breakpoint of statutory retirement age in Table 2, retirement still had no significant impact on physical examination indicators for women working in private enterprises after adjusting bandwidths. However, for women working in state-owned enterprises or public institutions, the significance of retirement on blood glucose, body weight, BMI, and DBP did not change. For all men group or private enterprises male group, there was little change in the level of significance of the retirement effect on HDL. In addition, retirement had no significant effect on the regression coefficients of other physical examination indices, or the significance was not sensitive to bandwidth.

3.3.2. Examination of physical examination indicators after retirement and after adding the control variables

Several factors affect health. According to available data, indicators related to cardiovascular and metabolic diseases in the physical examination database were selected as control variables. Then, we added the physical examination times at the institution into the RD benchmark regression model, to test for the influence of changes in retirement on health indicators after adding control variables. The regression results in Table 4 show that there is no substantial difference between this finding and the basic regression results after adding control variables.

3.3.3. Effect of retirement mechanism on physical examination index

The physical examination times at the institution was considered a proxy variable for the degree of health attention, and an interaction term between retirement and the physical examination times at the institution was added to the RD benchmark regression model to preliminarily explore the influencing mechanism of retirement on cardiovascular and metabolic health outcomes. From column (3) in Table 5, the interaction coefficient between retirement of women and the times of physical examinations shows that the influence of health attention degree on BMI reduction after retirement was weakened ($\beta = -0.123$) compared to that before retirement. However, the results of the interaction term between retirement and physical examinations times in women employed by

Table 2
Effects of retirement on health indicators.

Legal retirement age (year)	Men[a]	Women 1[a]	Women 2[a]	Men 1[a]	Men 2[a]
	(1)	(2)	(3)	(4)	(5)
Dependent variable: Blood glucose					
Retired or not (No = 0, Yes = 1) (IV = D)	−0.402 (0.231)	2.001 (2.444)	0.696*** (0.166)	−0.538 (0.384)	−0.376 (0.265)
Assignment variable	0.040*** (0.008)	−0.013 (0.029)	0.006 (0.005)	0.040* (0.016)	0.039*** (0.009)
Constant term	5.945*** (0.055)	5.249*** (0.105)	5.320*** (0.037)	5.883*** (0.224)	5.946*** (0.057)
Dependent variable: Weight					
Retired or not (No = 0, Yes = 1) (IV = D)	−3.433* (1.654)	−45.607 (42.690)	−3.943* (1.653)	−2.013 (3.601)	−3.694* (1.840)
Assignment variable	−0.041 (0.057)	0.532 (0.512)	0.123* (0.054)	−0.048 (0.147)	−0.037 (0.062)
Constant term	73.128*** (0.416)	59.049*** (1.288)	60.079*** (0.373)	72.574*** (1.578)	73.179*** (0.435)
Dependent variable: BMI[b]					
Retired or not (No = 0, Yes = 1) (IV = D)	−0.966* (0.489)	−11.387 (13.649)	−2.152*** (0.571)	−1.041 (1.089)	−0.948 (0.542)
Assignment variable	0.018 (0.017)	0.179 (0.165)	0.104*** (0.019)	0.032 (0.044)	0.017 (0.018)
Constant term	24.342*** (0.121)	21.996*** (0.456)	22.978*** (0.129)	24.687*** (0.533)	24.325*** (0.125)
Dependent variable: CHO[b]					
Retired or not (No = 0, Yes = 1) (IV = D)	0.047 (0.156)	−4.053 (4.455)	−0.103 (0.182)	0.357 (0.334)	−0.008 (0.174)
Assignment variable	−0.008 (0.005)	0.086 (0.054)	0.041*** (0.006)	−0.014 (0.013)	−0.007 (0.006)
Constant term	4.952*** (0.039)	5.011*** (0.165)	5.378*** (0.040)	4.990*** (0.181)	4.954*** (0.040)
Dependent variable: TG[b]					
Retired or not (No = 0, Yes = 1) (IV = D)	−0.287 (0.189)	−2.952 (3.356)	0.217 (0.159)	−0.943* (0.388)	−0.155 (0.212)
Assignment variable	0.001 (0.006)	0.056 (0.040)	0.024*** (0.005)	0.045** (0.016)	−0.006 (0.007)
Constant term	1.741*** (0.047)	1.133*** (0.107)	1.313*** (0.033)	1.955*** (0.199)	1.725*** (0.049)
Dependent variable: HDL[b]					
Retired or not (No = 0, Yes = 1) (IV = D)	0.138** (0.049)	1.322 (1.672)	−0.090 (0.063)	0.339** (0.105)	0.099 (0.055)
Assignment variable	−0.002 (0.002)	−0.018 (0.020)	−0.001 (0.002)	−0.014** (0.005)	−0.001 (0.002)
Constant term	1.210*** (0.012)	1.532*** (0.055)	1.505*** (0.015)	1.178*** (0.051)	1.214*** (0.013)
Dependent variable: LDL[b]					
Retired or not (No = 0, Yes = 1) (IV = D)	0.035 (0.140)	−3.302 (3.884)	−0.181 (0.165)	0.413 (0.296)	−0.035 (0.157)
Assignment variable	−0.008 (0.005)	0.066 (0.047)	0.032*** (0.005)	−0.018 (0.012)	−0.007 (0.005)
Constant term	3.103*** (0.036)	3.029*** (0.140)	3.367*** (0.037)	3.044*** (0.142)	3.111*** (0.037)
Dependent variable: SBP[b]					
Retired or not (No = 0, Yes = 1) (IV = D)	1.990 (3.090)	−20.627 (65.838)	−0.108 (3.305)	4.263 (6.174)	1.563 (3.471)
Assignment variable	0.824*** (0.104)	1.072 (0.812)	0.839*** (0.108)	0.85^{3}** (0.251)	0.819*** (0.114)
Constant term	138.482*** (0.804)	123.471*** (2.628)	130.631*** (0.764)	135.588*** (3.249)	138.674*** (0.836)
Dependent variable: DBP[b]					
Retired or not (No = 0, Yes = 1) (IV = D)	−3.403 (1.964)	−115.696 (76.069)	−5.180* (2.153)	−1.383 (4.262)	−3.756 (2.186)
Assignment variable	0.154* (0.066)	1.771* (0.901)	0.356*** (0.071)	0.234 (0.167)	0.142* (0.073)
Constant term	82.750*** (0.493)	72.334*** (2.009)	75.777*** (0.493)	82.052*** (2.339)	82.826*** (0.509)
Control the year dummy variable	Yes	Yes	Yes	Yes	Yes
Observation	5496	946	7352	671	4825

The numbers in brackets are robust standard deviations, *, **nd *** are significant at the level of 5%, 1%, and 0.1%, respectively.

[a] Men 1 refers to the male respondents in private enterprises; Men 2 are those in public institutions or state-owned enterprises; Women 1 are from private enterprises; and Women 2 are the respondents in public institutions or state-owned enterprises; Ages 60, 60, 60, 50, and 55 years are the statutory retirement ages for the corresponding groups, respectively.

[b] BMI, body mass index; CHO, total cholesterol; DBP, diastolic blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SBP, systolic blood pressure; SD, standard deviation; TG, triglyceride.

state-owned enterprises or public institutions showed that the degree of health attention had a more positive effect on the reduction of DBP after retirement than the influence before retirement ($\beta = 0.522$). The interaction term of retirement and physical examination times had no significant effect on other physical examination indicators.

4. Discussion

This study utilized physical examination data and RDD to explore the short-term cardiovascular and metabolic health fluctuations of different groups after retirement. Shortly after retirement, the body weight, BMI, and DBP of women in state-owned enterprises or public institutions showed a declining trend, while the blood glucose level showed otherwise. For retired men, HDL showed an increasing trend, shortly after retirement, and it mainly affected men in private enterprises. However, retirement had no significant effect on the physical examination indices among women in private enterprises and men employed by state-owned enterprises or public institutions. The mechanism analysis results showed that compared with the effect of health attention before retirement on DBP, health attention after retirement had a more positive effect on DBP reduction.

Consistent with the findings of a previous study (L et al., 2016), retirement has a positive impact on the cardiovascular and metabolic health level of women in state-owned enterprises or public institutions. It also proved that there was a significantly positive impact on the HDL of men in private enterprises. To further analyze its internal mechanisms, first, state-owned enterprises or public institutions retirees have higher pension compared to enterprise staff, which is not much lower than the in-service salary. Meanwhile, this group population have more free time, which may encourage access to more income through other

Table 3
Test of health index changes of retirement effect under different bandwidths.

Legal retirement age (year)	Men[a]		Women 1[a]		Women 2[a]		Men 1[a]		Men 2[a]	
	[52, 68] (1)	[48,72] (2)	(J & Z, 2013; Imbens & Angrist, 1994) (3)	[38, 62] (4)	[47, 63] (5)	[43, 67] (6)	[52, 68] (7)	[48,72] (8)	[52, 68] (9)	[48,72] (10)
Dependent variable: Blood glucose										
Retired or not (IV = D)	−0.515 (0.285)	−0.249 (0.204)	0.009 (1.771)	2.265 (1.576)	0.813*** (0.218)	0.622*** (0.130)	−0.439 (0.450)	−0.298 (0.390)	−0.525 (0.331)	−0.244 (0.229)
Dependent variable: Weight										
Retired or not (IV = D)	−4.093* (2.068)	−2.501 (1.454)	−24.560 (28.392)	−13.590 (21.548)	−4.859* (2.214)	−3.652** (1.297)	−0.135 (4.085)	−3.075 (3.380)	−4.933* (2.344)	−2.390 (1.600)
Dependent variable: BMI[b]										
Retired or not (IV = D)	−1.498* (0.616)	−0.701 (0.429)	−3.128 (9.341)	−2.756 (7.353)	−2.299** (0.760)	−1.945*** (0.446)	−1.087 (1.252)	−1.438 (1.018)	−1.600* (0.695)	−0.558 (0.470)
Dependent variable: CHO[b]										
Retired or not (IV = D)	0.244 (0.196)	−0.070 (0.137)	−4.191 (3.407)	−1.719 (2.468)	−0.108 (0.242)	−0.029 (0.143)	0.245 (0.387)	0.149 (0.304)	0.245 (0.222)	−0.104 (0.151)
Dependent variable: TG[b]										
Retired or not (IV = D)	−0.473* (0.233)	−0.221 (0.167)	−2.731 (2.533)	−0.374 (1.675)	0.114 (0.211)	0.305* (0.123)	−0.691 (0.447)	−0.992** (0.351)	−0.423 (0.265)	−0.071 (0.186)
Dependent variable: HDL[b]										
Retired or not (IV = D)	0.199** (0.062)	0.108* (0.043)	0.532 (1.168)	0.996 (1.007)	−0.092 (0.085)	−0.105* (0.050)	0.253* (0.117)	0.327** (0.094)	0.190** (0.071)	0.067 (0.047)
Dependent variable: LDL[b]										
Retired or not (IV = D)	0.286 (0.176)	0.091 (0.123)	−3.003 (2.919)	−1.906 (2.261)	−0.175 (0.219)	−0.123 (0.129)	0.205 (0.336)	0.281 (0.267)	0.299 (0.200)	−0.154 (0.137)
Dependent variable: SBP[b]										
Retired or not (IV = D)	2.885 (3.887)	4.316 (2.714)	−5.986 (49.341)	11.821 (38.787)	−4.636 (4.423)	−0.387 (2.593)	6.225 (7.094)	6.118 (5.643)	2.246 (4.442)	3.932 (3.019)
Dependent variable: DBP[b]										
Retired or not (IV = D)	−1.585 (2.448)	−3.217 (1.725)	−77.506 (44.782)	−59.701 (37.581)	−5.997* (2.878)	−5.253** (1.694)	0.549 (4.978)	−0.724 (3.904)	−2.004 (2.763)	−3.672 (1.902)
Year dummy variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observation	4498	6526	737	1164	5537	9047	546	800	3952	5726

The numbers in brackets are robust standard deviations, *, ** and *** are significant at the level of 5%, 1%, and 0.1%, respectively.

[a] Men 1 refers to the male respondents in private enterprises; Men 2 are those in public institutions or state-owned enterprises; Women 1 are from private enterprises; and Women 2 are the respondents in public institutions or state-owned enterprises; Ages 60, 60, 60, 50, and 55 years are the statutory retirement ages for the corresponding groups, respectively.

[b] BMI, body mass index; CHO, total cholesterol; DBP, diastolic blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SBP, systolic blood pressure; SD, standard deviation; TG, triglyceride.

means (Z and Y, 2015). In addition, people working in state-owned enterprises or public institutions usually have higher education and health awareness levels than individuals working in private enterprises (J et al., 2019). Therefore, it is more likely for them to invest in health due to more accessible funds, time, and better health awareness level (L and L, 2017). Second, the frequency of physical exercise increases significantly after retirement for both men and women (L et al., 2016). Increasing exercise frequency may be one of the mechanisms of positive physical health after retirement (Eibich, 2015; Kaempfen and Maurer, 2016). Retirees prefer more physical exercise to compensate for the loss of work-related physical activities (Eibich, 2015). Furthermore, it is noteworthy that women focus more on weight management than men (J & Z, 2013), which leads to a more significant impact on body weight and BMI (Godard, 2016). Third, individuals enjoy putting in more energy and more health investments on their health after retirement, which may increase adherence to the annual physical examinations, and thus, a more positive influence on biomedical indicators, which was also confirmed in the mechanism analysis. Fourth, after retirement, the relief from work-related stress and fatigue symptoms may lead to better health status (Mazzonna and Peracchi, 2012; Westerlund et al., 2010). Finally, other possible mechanisms, such as changes in diet and sleep patterns, may also improve the short-term health of retirees (Eibich, 2015; Goldman et al., 2008).

Contrary to previous findings, we found that retirement had a significantly negative effect on blood glucose levels in women employed by state-owned enterprises or public institutions (Mosca et al., 2011; C, 2016). Women in state-owned enterprises or public institutions retire later than those in private enterprises, which often imply a menopausal status after retirement. Decreased estrogen level could lead to postmenopausal women having diabetes and abnormal lipid metabolism, which is also one of the factors causing increased incidence of elevated blood sugar and chronic diseases in postmenopausal women (Grogan et al., 1997). Additionally, dietary habits cannot be ruled out. Compared with men, women prefer to eat sweets (Grogan et al., 1997). After retirement, women have more time for leisure and enjoying food, thus leading to elevated blood sugar levels.

Moreover, for men, we found that shortly after retirement, HDL increased, and the finding was robust following multiple test p-value corrections and several sensitivity analyses, including different bandwidth choices; this is consistent with other research conclusions (Pedron et al., 2020). HDL levels are both genetically related and strongly associated with a healthy lifestyle. A healthy diet rich in unsaturated fatty acids, such as the right intake of fish oil preparations, can raise HDL cholesterol (Roussell and Kris-Etherton, 2007). In China's drinking culture, leaders often are unable to resist business banquets (especially for male leaders), and unable to avoid alcohol and greasy food consumption (Chung, 2011; Lin, 2020). Men are more likely to organize and participate in liquor meetings than women (Deng et al., 2020; Li et al., 2012). For men, meanwhile, retirement often means the end of social status and connections (Lei et al., 2010). After retirement, the frequency of participation in business banquets decreases, and the dietary style is healthier, which may result in the short-term increase of HDL in men after retirement. As a protective lipoprotein, HDL can preserve the vascular endothelia, thereby preventing atherosclerosis, reversing

Table 4
Retirement effects on health indicators after adding the control variables.

Legal retirement age (year)	Men[a]	Women 1[a]	Women 2[a]	Men 1[a]	Men 2[a]
	60 (1)	50 (2)	55 (3)	60 (4)	60 (5)
Dependent variable: Blood glucose					
Retired or not (IV = D)	−0.406 (0.232)	1.955 (2.500)	0.696*** (0.166)	−0.499 (0.402)	−0.378 (0.265)
Dependent variable: Weight					
Retired or not (IV = D)	−3.379* (1.661)	−47.366 (44.270)	−3.943* (1.653)	−2.616 (3.718)	−3.664* (1.840)
Dependent variable: BMI[b]					
Retired or not (IV = D)	−0.957* (0.491)	−12.051 (14.051)	−2.152*** (0.571)	−1.111 (1.123)	−0.942 (0.542)
Dependent variable: CHO[b]					
Retired or not (IV = D)	0.046 (0.156)	−4.196 (4.634)	−0.103 (0.182)	0.293 (0.346)	−0.008 (0.174)
Dependent variable: TG[b]					
Retired or not (IV = D)	−0.294 (0.190)	−3.103 (3.505)	0.217 (0.159)	−1.009* (0.408)	−0.157 (0.213)
Dependent variable: HDL[b]					
Retired or not (IV = D)	0.140** (0.049)	1.405 (1.716)	−0.090 (0.063)	0.346** (0.108)	0.100 (0.055)
Dependent variable: LDL[b]					
Retired or not (IV = D)	0.031 (0.141)	−3.450 (4.014)	−0.181 (0.165)	0.367 (0.307)	−0.037 (0.157)
Dependent variable: SBP[b]					
Retired or not (IV = D)	2.129 (3.099)	−22.084 (67.739)	−0.106 (3.305)	5.548 (6.406)	1.612 (3.470)
Dependent variable: DBP[b]					
Retired or not (IV = D)	−3.315 (1.972)	−119.445 (79.574)	−5.177* (2.151)	−0.336 (4.431)	−3.728 (2.188)
Year dummy variable	Yes	Yes	Yes	Yes	Yes
Control variable	Yes	Yes	Yes	Yes	Yes
Observation	5496	946	7352	671	4825

The numbers in brackets are robust standard deviations, *, ** and *** are significant at the level of 5%, 1%, and 0.1%, respectively.
[a] Men 1 refers to male respondents in private enterprises; Men 2 are those in public institutions or state-owned enterprises; Women 1 are from private enterprises; and Women 2 are respondents in public institutions or state-owned enterprises; Ages 60, 60, 60, 50, and 55 years are the statutory retirement ages for the corresponding groups, respectively.
[b] BMI, body mass index; CHO, total cholesterol; DBP, diastolic blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SBP, systolic blood pressure; SD, standard deviation; TG, triglyceride.

cholesterol levels, fighting oxidation, and promoting angiogenesis (O et al., 2020). Therefore, retirement increases HDL levels in men, and consequently helps prevent cardiovascular diseases.

However, when comparing post-retirement health outcomes between men and women, it should be considered that older women's participation in the labor market is more selective than those of older men. Studies have shown that women's participation in the labor market before retirement is lower than that of men, and it is more likely for working women to have higher levels of education (Brsch-Supan, Ferrari). However, this did not jeopardize the internal validity of the fuzzy RDD. The local average effect estimated by RDD should apply to a specific subgroup rather than for the whole group of women. Therefore, we grouped different occupational types, and the regression coefficients obtained in our study could serve as a lower limit for explaining the health effects of retirement for groups with different occupational

Table 5
Mechanism of retirement effects on physical examination results.

Explained variables:	Blood glucose[a]	Weight[a]	BMI[a]	DBP[a]	HDL[a]
	(1)[b]	(2)[b]	(3)[b]	(4)[b]	(5)[b]
Retired or not (No = 0, Yes = 1)(IV = D)	0.388 (0.221)	−2.898 (1.803)	−0.708 (0.620)	−11.312*** (2.575)	0.152 (0.127)
Retirement * Times of physical examination in this institution	0.026 (0.019)	−0.089 (0.170)	−0.123* (0.058)	0.522* (0.234)	0.025 (0.018)
Control the year dummy variable	Yes	Yes	Yes	Yes	Yes
Observation	7352	7352	7352	7352	671

[a] BMI, body mass index; DBP, diastolic blood pressure; HDL, high-density lipoprotein.
[b] Columns (1)–(4) are RD regression results of women working in state-owned enterprises or public institutions, and columns (5) are regression results of male working in private enterprises.

experience. Limited by the available data, we were unable to investigate the effect of education level, specific job content, and work intensity (such as work-related physical activity, job stress, and job satisfaction), which may lead to endogenous problems of individuals' career choices and heterogeneity of retirement effect on physical examination results.

It is also worth noting that the results of our study are based on RDD, which is used to estimate the intervention effect near a breakpoint (legal retirement age) rather than the Average Treatment Effect (ATE) across the whole domain (age of all samples covered), and the estimate is the Local Average Treatment Effect (LATE) (Imbens & Angrist, 1994). Thus, we examined the short-term impact of retirement shocks on health. Considering long-term effects, the aging trend of the population would result in an inevitable decline in the health status of individuals as they age.

Although the use of RDD allowed us to estimate the causal effects of retirement, the unmeasured confounders and the issue of reverse causality were some limitations to our study. The following are the main limitations of the study. First, most of the effects of retirement were likely to be small, thus requiring larger sample sizes for further analysis.[6] This will allow for higher polynomial specifications and age-retirement interactions, without considering fitting degrees. Second, the effect of retirement on some physical examination indicators was not robust after the changes in bandwidths, which indicate that there may be a class I error. Since the individual health status could be affected by many factors, such as genetics, environment, and lifestyle, and our data ignored the regional factors that could account for the differences in the health behaviors and health status (Schipf et al., 2014), the data limitations cannot fully explain this uncertainty. However, some indicators did not completely fulfil the continuity hypothesis. Third, since the fuzzy RDD can only estimate the changes in the physical examination indices within a short period after retirement, the applicability of the research conclusions is limited. Finally, the sample does not include those who did not participate in the physical examination (such as migrant workers whose employers do not provide free physical examination benefits) and rural or suburban residents who did not undergo physical examination in tertiary hospitals. This study population underwent the physical examinations in a hospital. This suggests that our participants generally

[6] In terms of the data source, we procured the database in 2021 (the 2022 data were not available at that time); thus, the data were up to date at that time, and we would explore further if given the opportunity to update the data in the future.

paid more attention to health than the non-participating population in the physical examinations, which could introduce a selection bias and weaken the representativeness of our findings, since it could overestimate the positive effects of retirement and underestimate its negative effects.

5. Conclusions

This study provided new evidence on the impact of retirement on biomedical risk factors for chronic cardiovascular and metabolic diseases. It also contributes to research about the effect of retirement on health behaviors by using an analysis design that allows causal inference. Using a fuzzy RDD for causal inference, we found that retirement improved the health of the population in the short term, despite heterogeneity of occupation type and gender. Although there was a short-term increase in blood glucose after retirement among women in state-owned enterprises or public institutions, retirement was still a protective factor for body weight, BMI, DBP in women, for HDL in men, which might have a long-lasting positive effect on the incidence of cardiovascular and metabolic diseases. Retirees with low awareness of health should be regarded as high-risk groups and should represent potential targets for behavioral interventions. Health measures including interventions on lifestyle, leisure-time physical activity, behavioral and mental health during the retirement adaptation period should be seriously considered by health providers and retired individuals.

Author statement

All authors contributed to the study conception and design. Mingwang Cheng, Lin Jiang, Zhaoxin Wang, Wenya Yu and Yan Yang wrote the main manuscript text, Xiang Liu, Xiang Gao, Yipeng Lv and Liang Zhou prepared Table1–5, Jianwei Shi, Jiaoling Huang and Qiao Chu prepared supplementary materials. All authors reviewed the manuscript.

Ethical statement

This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Tongji University (ref: LL-2016-ZRKX-017). All participants provided verbal informed consent.

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Declaration of competing interest

The authors declare no conflict of interest.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2022.101333.

References

Archer, C. R., Recker, M., Duffy, E., et al. (2018). Intralocus sexual conflict can resolve the male-female health-survival paradox. *Nature Communications, 9*, 5048.
Atalay, K., & Barrett, G. F. (2014). The causal effect of retirement on health: New evidence from Australian pension reform. *Economics Letters, 125*(3), 392–395.
Behncke, S. (2012). Does retirement trigger ill health? *Health Economics, 21*(3), 282–300.
Bertoni, M., Brunello, G., & Mazzarella, G. (2018). Does postponing minimum retirement age improve healthy behaviors before retirement? Evidence from middle-aged Italian workers. *Journal of Health Economics, 58*, 215–227.
Bloemen, H., Hochguertel, S., & Zweerink, J. (2017). The causal effect of retirement on mortality: Evidence from targeted incentives to retire early. *Health Economics, 26*(12), e204–e218.
Brsch-Supan AH, Ferrari I. Old-age labor force participation in Germany: What explains the trend reversal among older men? And what the steady increase among women? Social Science Electronic Publishing.
Bugni, F. A., & Canay, I. A. (2021). Testing continuity of a density via g-order statistics in the regression discontinuity design. *Journal of Econometrics*.
C, F. (2016). The relationship between estrogen level and blood lipid, blood glucose and blood homocysteine in postmenopausal women. *Chinese Journal of Laboratory Diagnosis, 20*(5), 3.
Calonico, S., Cattaneo, M., & Titiunik, R. (2012). *Robust data-driven inference in the regression-discontinuity design*. Working Papers.
Celidoni, M., Dal Bianco, C., & Weber, G. (2017). Retirement and cognitive decline. A longitudinal analysis using SHARE data. *Journal of Health Economics, 56*, 113–125.
Chung, M. (2011). Eat, drink and may your business prosper. *Doing business business successfully in China*, 155–176.
Dave, R. (2008). Spasojevic. The effects of retirement on physical and mental health outcomes. *Southern Economic Journal*.
Deng, Y. L., Liu, X. F., He, Y., Han, Q. J., Wang, X. C., Tian, K. Q., et al. (2020). Status of drinking behavior of adult residents in Fangshan District of Beijing. *Occupation and Health, 36*(23), 3255–3258.
D, T., & He, X. (2016). Effects of retirement on health of elderly men: An empirical study based on breakpoint regression. *Population Research, 6*, 82–91.
Dinardo, J., & Lee, D. S. (2011). Program evaluation and research designs. *Handbook of Labor Economics, 4a*, 463–536.
Disney, R., Emmerson, C., & Wakefield, M. (2006). Ill health and retirement in britain: A panel data-based analysis. *Journal of Health Economics, 25*(4), 621–649.
Eibich, P. (2015). Understanding the effect of retirement on health: Mechanisms and heterogeneity. *Journal of Health Economics, 43*, 1–12.
Fitzpatrick, M. D., & Moore, T. J. (2018). The mortality effects of retirement: Evidence from Social Security eligibility at age 62. *Journal of Public Economics*.
Godard, M. (2016). Gaining weight through retirement? Results from the SHARE survey. *Journal of Health Economics, 45*, 27–46.
Goldman, D. P., Lakdawalla, D. N., & Zheng, Y. (Eds.). (2008). *Retirement and Weight*.
Grogan, S. C., Bell, R., & Conner, M. (1997). Eating sweet snacks: Gender differences in attitudes and behaviour. *Appetite, 28*(1), 19–31.
Hil, A. D., Johnson, S. G., Greco, L. M., O'Boyle, E. H., & Walter, S. L. (2021). Endogeneity: A review and agenda for the methodology-practice divide affecting micro and macro research. *Journal of Management, 47*(1), 105–143.
Imbens, G. W., & Angrist, J. D. (1994). Identification and estimation of local average treatment effects. *Econometrica, 62*(2), 467–475.
Imbens, G., & Lemieux, T. (2008). Special issue editors' introduction: The regression discontinuity design-theory and applications. *Journal of Econometrics, 142*(2), 611–614.
J, W., S, Y., & T, Q. (2019). Is the Government crowding out corporate Human resources: Evidence from the Quality of Chinese Enterprises' export products. *South China Journal of Economics, 6*, 111–134.
J, Q., & Z, K. (2013). Beauty economics. *China's Labor Market: Does body size matter?, 12*(3), 983–1006.
Kaempfen, F., & Maurer, J. (2016). Time to burn (calories)? The impact of retirement on physical activity among mature Americans. *Journal of Health Economics, 45*, 91–102. Jan.
Kuhn, A., Wuellrich, J. P., & Zweimüller, J. (2020). Fatal attraction? Access to early retirement and mortality. *Journal of Public Economics, 191*, Article 104087.
Lei, X. Y., Tan, L., & Zhao, Y. H. (2010). Does retirement affect health? *China Economics Quarterly, 9*(4), 1539–1558.
Lemieux, L. T. (2010). Regression discontinuity designs in economics. *Journal of Economic Literature, 48*(2), 281–355.
Lin, Y. H. (2020). A study on Chinese drinking culture and alcoholism. *Korean Association of Addiction Crime Review, 10*(1), 69–86.

Link, B. G., & Phelan, J. (1995). Social conditions as fundamental causes of disease. *Journal of Health and Social Behavior, 1*(35), 80–94.
Li, Y. C., Zhang, M., Jiang, Y., Deng, Q., Zhao, Y. J., Huang, Z. J., et al. (2012). Drinking behaviors and patterns among floating population aged 18-59 years old in China. *Chinese Journal of Epidemiology, 11*, 1186–1191, 2014.
L, S., & L, X. (2017). Effects of retirement on physical and mental health of Chinese elderly population. *Population Research, 5*, 74–88.
L, Z., & W, N. (2021). Research progress of dyslipidemia and atherosclerotic pan-vascular disease. *Chinese Journal of the Frontiers of Medical Science (Electronic Version), 11*, 145–150.
L, S., Z, S., & H, A. (2016). Compulsory education law and the rate of return on urban education in China: Based on breakpoint regression design. *Economic Research Journal, 2*, 154–167.
Mazzonna, F., & Peracchi, F. (2012). Ageing, cognitive abilities and retirement. *SSRN Electronic Journal, 56*(4), 691–710.
Mccrary, J. (2008). Manipulation of the running variable in the regression discontinuity design: A density test. *Journal of Econometrics, 142*(2), 698–714.
McGarry, K. (2004). Health and retirement: Do changes in health affect retirement expectations? *Journal of Human Resources, 39*(3), 624–648.
Mosca, L., Benjamin, E. J., Berra, K., Bezanson, J. L., Dolor, R. J., Lloyd-Jones, D. M., et al. (2011). Effectiveness-based guidelines for the prevention of cardiovascular disease in women–2011 update: A guideline from the American heart association. *Journal of the American College of Cardiology, 57*(12), 1404–1423.
Nathanson, C. A. (1967). Illness and the feminine role: A theoretical review. *Social Science & Medicine, 9*(2), 57–62.
National Bureau of Statistics. (2019). *Statistical bulletin of the people's Republic of China on national economic and social development 2019*.
O, L., P, Y., & O, Z. (2020). Effects of high density lipoprotein function change on cardiovascular diseases and perioperative cardiovascular protection. *Chinese Journal of Arteriosclerosis*, (10), 856–860.
Pedron, S., Maier, W., Peters, A., Linkohr, B., Meisinger, C., Rathmann, W., et al. (2020). The effect of retirement on biomedical and behavioral risk factors for cardiovascular and metabolic disease. *Economics and Human Biology, 38*, Article 100893.
Revision Committee of the Chinese Guidelines for the Prevention and Treatment of Hypertension. (2019). Chinese guidelines for the prevention and treatment of hypertension 2018 revised edition. *Prevention and Treatment of Cardio-Cerebral-Vascular Disease, 19*(1), 1–44.
Roussell, M. A., & Kris-Etherton, P. (2007). Effects of lifestyle interventions on high-density lipoprotein cholesterol levels. *Journal of Clinical Lipidology, 1*, 65–73.
Schipf, S., Ittermann, T., Tamayo, T., Holle, R., Schunk, M., Maier, W., et al. (2014). Regional differences in the incidence of self-reported type 2 diabetes in Germany: Results from five population-based studies in Germany (DIAB-CORE consortium). *Journal of Epidemiology & Community Health, 68*(11), 1088–1095.
Verbrugge, L. M. (1976). Females and illness: Recent trends in sex differences in the United States. *Journal of Health and Social Behavior, 17*(4), 387–403.
Westerlund, H., Vahtera, J., Ferrie, J. E., Singh-Manoux, A., Pentti, J., Melchior, M., et al. (2010). Effect of retirement on major chronic conditions and fatigue: French GAZEL occupational cohort study. *BMJ, 341*, c6149.
W, J., G, Q., & W, W. (2012). An economic study on "aging health". *Economic Research Journal, 1*, 134–150.
Williams, D. R. (1990). Socioeconomic differentials in health: A review and redirection. *Social Psychology Quarterly, 53*(2), 81–99.
Winkleby, M. A., Jatulis, D. E., Frank, E., et al. (1992). Socioeconomic status and health: How education, income, and occupation contribute to risk factors for cardiovascular disease. *American Journal of Public Health, 82*(6), 816–820.
W, Y., W, C., Z, S., Z, P., & H, L. (2019). Chinese guidelines for the surgical treatment of obesity and type 2 diabetes (2019 edition). *Chinese Journal of Practical Surgery, 4*, 301–306.
W, Y., & Z, S. (2011). Fairness analysis of China's social endowment Insurance System. *Taxation and Economy, 4*, 56–61.
Yogo, M. (2016). Portfolio choice in retirement: Health risk and the demand for annuities, housing, and risky assets. *Journal of Monetary Economics, 80*, 17–34.
Zhou, M., Wang, H., Zeng, X., Yin, P., Zhu, J., Chen, W., et al. (2019). Mortality, morbidity, and risk factors in China and its provinces, 1990-2017: A systematic analysis for the global burden of disease study 2017. *Lancet, 394*(10204), 1145–1158.
Z, C., & W, X. (2020). The effect of retirement on residents' health: A study based on breakpoint regression method. *Research on Economics and Management, 9*, 112–128.
Z, H., & Y, K. (2015). Retirement and urban household consumption: Empirical evidence based on breakpoint regression design. *Economic Research Journal, 1*, 124–139.