



Article

The causal effect of retirement on stress in older adults in China: A regression discontinuity study

Simiao Chen^{a,*}, Pascal Geldsetzer^{a,b}, Till Bärnighausen^{a,c,d}

^a Heidelberg Institute of Global Health (HIGH), Faculty of Medicine and University Hospital, Heidelberg University, Heidelberg, Germany

^b Division of Primary Care and Population Health, Department of Medicine, Stanford University School of Medicine, Stanford University, Stanford, CA, USA

^c Africa Health Research Institute, Somkhele, KwaZulu-Natal, South Africa

^d Department of Global Health and Population, Harvard T.H. Chan School of Public Health, Boston, MA, USA



ARTICLE INFO

Keywords:

Retirement
Regression discontinuity design
Stress
China

ABSTRACT

Population aging in middle-income countries, including China, has resulted in strong economic incentives to increase the retirement age. These economic incentives should be weighed up against the effects of later retirement on physical and mental health and wellbeing. We aimed to determine the causal effect of retirement on perceived stress, an important measure of mental well-being. We used data from the China Health and Nutrition Survey in 2015 and adopted a non-parametric regression discontinuity design (RDD) to measure the causal effect of retirement on stress. Stress was assessed using the Perceived Stress Scale (PSS)-14. On average, the effect of retirement on stress was close to the null value and insignificant. In subgroup analyses, we found that retirement reduces stress in men but raises stress in women. Though these gender-specific effects were not statistically significant, their magnitudes were large. Thus, the average null result in the entire population appears to hide opposite gender-specific effects. More research is needed to confirm this finding in studies with larger sample sizes and understand the gender-specific pathways leading from retirement to stress.

Introduction

Population aging is a formidable challenge for many societies around the world. China is among the most rapidly aging societies in the world (Bloom et al., 2018a), where the population aged 65 and above is currently more than 10% and will continue to rise and reach approximately one third in 2050. This dynamic is leading to a shrinking workforce and a looming pension crisis. As people's healthy life expectancy is increasing (Hay et al., 2017), one approach considered by many countries (e.g., China, Japan, Germany, Austria, and the UK (Bloom, Kirby, Sevilla, & Stawasz, 2018b)) to mitigate some of the negative impacts of population aging is to raise the retirement age, thus increasing the labor force and decreasing the number of pension recipients. While there are many political and economic deliberations in setting an appropriate retirement age, a key consideration should be the effects of retirement on people's health and wellbeing.

Stress is an important measure of wellbeing. The experience of a perceived threat to one's mental, physical, emotional and spiritual wellbeing and the inability to cope with the perceived threat can trigger physiological mechanisms (e.g., increased heart rate and raised blood

pressure) that affect the entire body (Seaward, 2017). Chronic stress that lingers for prolonged periods of time is a form of human suffering and inadequate functioning because the body is perpetually aroused for danger and stress-related hormones remain at a high level (Seaward, 2017). As a result, stress is thought to have important negative consequences on physical and mental health. Studies have suggested that stress is a risk factor for chronic disease, such as diabetes and cardiovascular diseases (Kelly & Ismail, 2015; Kivimäki & Steptoe, 2018), as well as suicide (Miller, 1979). Studies have also found that retirement-related stress is associated with increased mortality (Adams & Lefebvre, 1981; Haynes, McMichael, & Tyroler, 1978) and that stress reduction can improve immune function (Davidson et al., 2003; Witek-Janusek et al., 2008). Stress may also lead to poor sleep (Ong et al., 2013) and induce unhealthy behaviors, such as smoking, excessive drinking, eating unhealthy foods, and opioid use (Schaie & Carstensen, 2006).

Retirement may affect stress through several pathways. According to role theory, retirement triggers role loss (Adams, Prescher, Beehr, & Lepisto, 2002). Retirement may increase stress if the occupational role is important to one's identity, while it may reduce stress if it relieves role strain and work overload (Adams et al., 2002; Elwell & Maltbie-

* Corresponding author. Heidelberg Institute of Global Health (HIGH), Faculty of Medicine and University Hospital, Heidelberg University, Im Neuenheimer Feld 130.3, 69120, Heidelberg, Germany.

E-mail address: simiao.chen@uni-heidelberg.de (S. Chen).

<https://doi.org/10.1016/j.ssmph.2019.100462>

Received 15 May 2019; Received in revised form 28 July 2019; Accepted 29 July 2019

2352-8273/© 2019 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Crannell, 1981; Kim & Moen, 2002; Wang & Shultz, 2010). Continuity theory emphasizes general human tendencies to maintain consistency in life patterns over time and conceptualizes retirement as a stressful disruption people need to cope with (Atchley & Robinson, 1982; Richardson & Kilty, 1991; Wang & Shi, 2014). Components of this disruption include changes in income and work-related social networks. Previous studies found that financial and social mechanisms link retirement to stress (Kim & Moen, 2002; Van Solinge & Henkens, 2008). For example, retirement may increase stress because it shrinks work-related social networks (Van Tilburg, 2003). People with larger and more diverse networks are able to access more resources and can thus cope better with stressful life events (Cattell, 2001).

The effects of retirement on stress are likely different for men and women for a number of reasons. First, stress physiology and behavioral strategies for problem solving differ between men and women (Seaward, 2017). Second, there are important underlying gender differences in mortality and morbidity (Case & Paxson, 2005), which can be explained by both biological and behavioral factors (Schünemann, Strulik, & Trimborn, 2017). These factors may also modify the effects of retirement on health-related outcomes. For example, retirement has been found to have positive effects on cognitive functioning for men but negative effects for women (Lei & Liu, 2018). Third, women and men face different retirement ages in many countries (e.g., in China men retire at age 60 while women retire at age 50 or 55), which could explain gender-specific effects. At a relatively young age, retirement could mainly lead to role loss and consequently cause stress (Adams et al., 2002). At a relatively old age, retirement could mainly reduce work-related stress. Insights into potential gender heterogeneity of retirement effects may help policy makers design differentiated policies for men and women. As a result, the overall effectiveness of such policies could increase, improving the wellbeing of older populations.

While previous studies have shown associations between retirement and stress (Villamil, Huppert, & Melzer, 2006), these associations are unlikely to describe causal relationships (Jokela et al., 2010; Lindeboom, Portrait, & Van den Berg, 2002; Mein, Martikainen, Hemingway, Stansfeld, & Marmot, 2003; Oksanen et al., 2011; Vo et al., 2015; Westerlund et al., 2009). For example, workers experiencing stress are more likely to retire (McGarry, 2004), raising concerns about reverse causality. In addition, even the causally strongest of the previous studies that have estimated the relationship between retirement and stress – which have employed longitudinal designs with individual-level fixed effects – cannot rule out confounding, because they may have omitted important variables that changed over time.

Our study also fits into the broader literature on the causal effects of retirement on mental health. The previous research has provided mixed evidence. While some research found that retirement is beneficial for mental health or has no effect on mental health (Deng & He, 2016; Eibich, 2015; Johnston & Lee, 2009; Lei & Liu, 2018; Picchio & van Ours, 2018), some studies found that retirement is detrimental to mental health (Heller-Sahlgren, 2017; Li, 2017). Likely reasons for these inconsistent findings include different social contexts and methodologies, disparate measurements of the same mental health outcome, and different outcomes. It is plausible that retirement can significantly affect one mental health outcome but may have limited impact on another one. Common mental health outcomes that have been studied thus far include depression (Coe & Zamarro, 2011; Deng & He, 2016; Leinonen, Lahelma, & Martikainen, 2013; Li, 2017; Oksanen et al., 2011), and cognitive ability (Coe & Zamarro, 2011; Lei & Liu, 2018; Vercambre, Okereke, Kawachi, Grodstein, & Kang, 2016). Very few studies have explored the causal effect of retirement on stress, and the existing studies suffer from poor stress measurement (e.g., only use a single question to measure stress (Bertoni & Brunello, 2017)). To our knowledge, no study thus far has examined the causal effect of retirement on stress using a validated stress scale. In this study, we use such a scale for outcome assessment, the Perceived Stress Scale (PSS)-14.

To address the knowledge gap regarding causal retirement effects

on stress, we used a rigorous quasi-experimental approach, the regression discontinuity design (RDD). This approach has been used to examine the causal effects of retirement on other outcomes (e.g., healthcare expenditure (Zhang, Salm, & van Soest, 2018), household consumption (Li, Shi, & Wu, 2015), and cognition (Lei & Liu, 2018)). RDD has also been used in epidemiology (Bor et al., 2014, 2017; Chen et al., 2019; Oldenburg et al., 2016, 2018; Patenaude, Chimbindi, Pillay, & Bärnighausen, 2018). With this study, we aim to determine the causal effect of retirement on perceived stress in older adults in China.

Methods

Data source and study population

We used data from the China Health and Nutrition Survey (CHNS),¹ which is a population-based longitudinal household survey that has, to date, collected individual-level information on health, socioeconomic status, and social and family networks in 10 waves, since 1989. The CHNS initially covered eight of China's thirty-four provinces; it added a ninth province in 1997, three mega cities in 2011, and three more provinces in 2015. These provinces vary widely in geography, economic development, public resources, and health indicators (Popkin, Du, Zhai, & Zhang, 2009). The survey used multi-stage random cluster sampling in each of the provinces. Counties in the nine provinces were stratified by income (low, middle, and high), and a weighted sampling scheme was used to randomly select four counties in each province. Villages and townships within the counties and urban and suburban neighborhoods within the cities were selected randomly. From 1989 to 1993, there were 190 primary sampling units; an additional province and its sampling units were added in 1997. Currently, the number of primary sampling units is 360. The response rate is 88% at the individual level and 90% at the household level (Popkin et al., 2009). For this study, we used the recently released 2015 wave of the CHNS, because it is the most recent wave available and includes for the first time data on stress. More detailed information on the CHNS design can be found elsewhere (Popkin et al., 2009).

Retirement definition

China's statutory retirement policy was officially launched in 1978 and has not changed since then. While China has proposed the “progressive delay retirement scheme” to postpone retirement ages in recent years, the policy is still under debate and will not be implemented widely until 2022. Currently, the statutory retirement age is 60 years for men, 55 years for female government employees, and 50 years for other female workers. This policy does not vary by province and is enforced strictly in the public sector. In the private sector, though employees do not have to retire, they become eligible for a pension at the statutory retirement age, which can motivate retirement (Lei & Liu, 2018; Li, Shi, & Wu, 2016).

We used the following three questions in the CHNS questionnaire to determine retirement: 1) “do you currently have a job?” (0 = Yes, 1 = No), 2) “why are you not employed?” (1 = currently searching for jobs, 2 = doing housework, 3 = disabled, 4 = student, 5 = retired, 6 = too young to work, 7 = other reasons, 8 = don't know), and 3) “when did you retire?” (open response). We defined people as retired if

¹ This research uses data from the China Health and Nutrition Survey (CHNS). We thank the National Institute of Nutrition and Food Safety (China Center for Disease Control and Prevention), Carolina Population Center (University of North Carolina at Chapel Hill), the US National Institutes of Health (Fogarty International Center, and R01-HD30880, DK056350 and R01-HD38700) for financial support for the CHNS data collection and analysis files from 1989 to 2006. We also thank the China-Japan Friendship Hospital and the Chinese Ministry of Health for support for the CHNS 2009 and later surveys.

they fulfilled the following three conditions: 1) self-reported that they had retired (as per questions 1 and 2 in the previous sentence); 2) had been working, had never quit the labor force before retirement, and had not worked after retirement (because we conceptualize “retirement” as a change from working to non-working status); and 3) were older than 40 years (because people who “retire” very early are likely to have stopped working for reasons other than normal age-related retirement).

Sample selection criteria

We applied the following selection criteria to this dataset: 1) we eliminated duplicate records, 2) we kept those individuals who retired after age 40 and who had never quit the labor force before retirement, and 3) we removed people who answered don't know or had missing data on stress outcomes. The final sample consisted of 5990 individuals, of whom 3159 were men and 2831 were women.

Outcome variables

The CHNS used the PSS-14 to assess the degree to which people perceived their lives as stressful (Cohen, Kamarck, & Mermelstein, 1983). PSS-14 is a well-established scale (Cohen et al., 1983) and has been validated in China (Leung, Lam, & Chan, 2010). Specifically, PSS-14 includes 14 questions such as “did you feel nervous and stressed in the past month?” and “did you feel upset if unexpected events happened in the past month?” to measure stress (the PSS-14 questionnaire is shown in **S1 Questionnaire**). All of the questions are measured on a scale with the ordered categories of 0 = “never”, 1 = “almost never”, 2 = “sometimes”, 3 = “fairly often”, and 4 = “very often”. We then calculated the total perceived stress score according to the standard PSS-14 methodology (Cohen et al., 1983). We obtained the total scores by reversing the scores on the seven positive items (i.e., items 4, 5, 6, 7, 9, 10, and 13) – e.g., 0 = 4, 1 = 3, 2 = 2, etc. –, and then summing across all 14 items.

The regression discontinuity design

RDD is a good analytical design for our study because an arbitrary threshold (the statutory retirement age) in a continuous assignment variable (age) increases the probability of exposure (retirement). RDD estimates the causal effect of retirement without active randomization by exploiting that people with an age just above and just below the statutory retirement age threshold are likely exchangeable with each other, except for the probability of being retired. We were thus able to estimate the causal effect of retirement on stress by comparing individuals just above and just below the statutory retirement threshold in their stress levels.

To do so, we adopted a so-called fuzzy RDD. Like an instrumental variable estimation, fuzzy RDD generates the complier average causal effect of retirement on stress, i.e., the effect of retirement itself on those who retire according to the age threshold in China's statutory retirement policy. In fact, fuzzy RDD can be thought of as an instrumental variable estimation, where the instrument is an indicator variable identifying whether an individual is younger or older than the statutory retirement age. Fuzzy RDD estimates the causal effect of retirement on stress under the following assumptions (Bärnighausen et al., 2017; Imbens & Lemieux, 2008). First, in order to yield valid causal effects, the probability of retirement must be discontinuous at the thresholds. Fig. 2 shows significant jumps in the probabilities of being retired at the statutory retirement age thresholds. We see a clear discontinuity at age 50 for female employees who retire at age 50 according to the formal retirement rule. Though the statutory retirement age for female civil servants is 55, we did not see a clear discontinuity in retirement probability for women at age 55 (Fig. 2). Because female civil servants are a relatively small group (Zhang et al., 2018), and we have little information on the type of occupation due to missing data, we used age

50 as the threshold of RDD for all women. This proxy is consistent with another study on the effect of retirement on healthcare utilization in China (Zhang et al., 2018).

Second, fuzzy RDD assumes that the potential outcomes would be continuous without retirement (Moscoe, Bor, & Bärnighausen, 2015). We used visual assessment of a histogram of age around the retirement threshold to test for manipulation of the assignment variable, which could lead to a violation of this continuity assumption, i.e., some respondents reporting a false age in order to change their eligibility status for retirement. In general, such manipulation was only a minor concern in our study because the CHNS was not used to decide on eligibility for retirement. Indeed, there is no visual evidence of such manipulation (Fig. 3). We also used a formal statistical test of manipulation, the McCrary test (Fig. S2) (McCrary, 2008). In addition, we tested whether observed covariates were continuous near the threshold following Lee, Moretti and Butler (Lee, Moretti, & Butler, 2004) and Imbens and Lemieux (Imbens & Lemieux, 2008) by using observed covariates as outcomes and age as assignment variable (Table S1). We show the details of these tests in the results section.

Statistical analysis

Following Lee and Lemieux (2010), we estimated the effect of retirement using local linear regression. We chose a non-parametric instead of a parametric approach, because the former can reduce potential bias by avoiding the assumption of particular functional form for the assignment variable (Imbens & Lemieux, 2008; Lee & Lemieux, 2010). In practice, we estimated the effect of retirement using regressions over the observations within a small bandwidth on either side of the statutory retirement age threshold, which is equivalent to using the following two-stage regression equation (Lee & Lemieux, 2010).

First-stage equation:

$$Retire_i = \alpha_0 + \alpha_1 Above_i + \alpha_2 f(Age_i) + \alpha_3 Above_i f(Age_i) + X_i \kappa + \nu_i$$

Second-stage equation:

$$Y_i = \beta_0 + \beta_1 Retire_i + \beta_2 f(Age_i) + \beta_3 Above_i f(Age_i) + X_i \phi + \varepsilon_i$$

where $Retire_i$, the treatment variable, is whether individual i retires in 2015 and Y_i is a measure of individual i 's stress, the outcome variable. $Above_i$ is an indicator variable equal to 1 for individuals that are older than the statutory retirement age. $f(Age_i)$ is a polynomial for age. $Retire_i$ represents the fitted values from the estimates of the first-stage equation. X_i is a vector of covariates (an individual's demographic and social characteristics) that are likely associated with stress.

In the primary analysis, we fitted local linear regression – treating the outcome variables as continuous – without covariates within an optimal bandwidth. We determined the bandwidth around the statutory retirement age threshold using the fully data-driven algorithm developed by Imbens and Kalyanaraman (Imbens & Kalyanaraman, 2012). Determining the bandwidth with a pre-determined algorithm rules out manipulation and biases due to arbitrary bandwidth choices. The choice of bandwidth is important since estimates using a smaller bandwidth will have lower bias but higher variance, while estimates using a larger bandwidth will have higher bias but lower variance. The algorithm developed by Imbens and Kalyanaraman identifies the bandwidth that optimizes the trade-off between bias and variance in the regression discontinuity estimation. The optimal bandwidth was 6 years, which we used in our baseline analysis. This bandwidth is comparable to previous studies exploring the effect of retirement on other outcomes using RDD. For example, Eibich used a bandwidth of 10 years for the main analyses and 5 years for robustness checks (Eibich, 2015). Other studies (Moreau & Stancanelli, 2015; Stancanelli & Van Soest, 2012) also used a bandwidth of 10 years. In secondary analyses, we conducted several robustness checks using different bandwidths, a quadratic term for age, and standard errors clustered by age (Calonico, Cattaneo, Farrell, & Titiunik, 2017; Calonico, Cattaneo, & Titiunik,

Table 1
Sample characteristics.

| Variable | Mean (SD) or N (%) | | | |
|---------------------------|---------------------------|--|--|---|
| | Full Sample (N = 5990) | Sample within optimal bandwidth (N = 1789) | Sample below threshold within optimal bandwidth (N = 768) | Sample above threshold within optimal bandwidth (N = 1021) |
| Outcome variables | | | | |
| Stress | 22.13 (6.28) | 22.03 (6.33) | 22.04 (6.42) | 22.02 (6.25) |
| Log(stress) | 2.04 (0.36) | 3.04 (0.36) | 3.04 (0.37) | 3.04 (0.36) |
| Treatment variable | | | | |
| Retirement | 0.39 (0.49) | 0.42 (0.49) | 0.13 (0.33) | 0.65 (0.48) |
| Control variables | | | | |
| Age in years | 52.83 (14.42) | 55.62 (6.26) | 51.95 (5.44) | 58.37 (5.36) |
| Share men | 3159 (52.74%) | 979 (54.72%) | 409 (53.26%) | 570 (55.83%) |
| Share high education | 2935 (53.26%) | 832 (49.88%) | 367 (50.76%) | 465 (49.21%) |
| Share urban | 3148 (57.75%) | 940 (57.32%) | 361 (52.17%) | 579 (61.08%) |
| Other variables | | | | |
| Income | 40457.43 (91297.59) | 35696.04 (55710.15) | 39238.62 (72138.37) | 33110.10 (39477.66) |
| Marital Status | | | | |
| Unmarried | 238 (3.98%) | 6 (0.34%) | 4 (0.52%) | 2 (0.20%) |
| Married | 5313 (88.79%) | 1701 (95.08%) | 740 (96.35%) | 961 (94.12%) |
| Divorced | 84 (1.40%) | 32 (1.79%) | 14 (1.82%) | 18 (1.76%) |
| Widowed | 328 (5.48%) | 45 (2.52%) | 9 (1.17%) | 36 (3.53%) |
| Separated | 8 (0.13%) | 1 (0.06%) | 0 (0%) | 1 (0.10%) |
| Don't know | 13 (0.22%) | 4 (0.22%) | 1 (0.13%) | 3 (0.29%) |

2014a, b; Lee & Card, 2008). In addition, we adjusted for gender, educational attainment and rural vs. urban residence in secondary analyses. Adjusting for additional covariates can help eliminate small sample biases in the specification and improve the precision of the RDD estimate (Imbens & Lemieux, 2008; Lee & Lemieux, 2010). Education level was categorized as low (highest degree achieved includes elementary school, middle school, and high school), or high (highest degree achieved includes vocational school, “two-/three-year college/associate degree”, “four-year college/bachelor degree”, master degree, or doctoral degree). We did not include other covariates, such as household wealth and marital status, because they may lie on the causal pathway between retirement and stress (Stancanelli, 2013) and their inclusion would thus bias our effect estimation.

Results

Summary characteristics

Table 1 shows the sample characteristics. In the full sample, 53% of all participants were men and 58% were urban residents. The probability of retirement for individuals below and above the retirement age threshold was 13% and 65%, respectively. To better interpret the stress scores, we show the distributions of both the total perceived stress score and its log transformation (Fig. 1). In our sample, the stress score ranged from 0 to 52, with a mean of 22, a median of 24, and an interquartile range of 9. After log transformation, the stress score ranged from 0 to 3.95, with a mean of 3.04, a median of 3.18, and an

interquartile range of 0.4. The solid red and green lines in Fig. 1 represent, respectively, the mean and median of the stress scores in the sample. Other labeled numbers represent the minimum, 25% percentile, 75% percentile, and maximum values.

Table 1 shows the stress outcomes, retirement status, and other demographic and socioeconomic factors, for the overall sample and for the within-bandwidth samples (2015 wave, CHNS). Stress is the total perceived stress score calculated according to the methodology of PSS-14, log (stress) is the log transformation of the total perceived stress score. Income is in 2015 Renminbi (RMB). The sample size for education, urban residence, income, and marital status varied slightly due to missing values. The regression discontinuity bandwidth for our baseline analysis was 54–66 years of age for men and 44–56 years of age for women.

Discontinuity in retirement probability

As is shown in Fig. 2, there are significant discontinuities in retirement probability at the 60-year threshold for men and at the 50-year threshold for women. Using age 60 as the threshold for men and age 50 as the threshold for women, our formal statistical test shows that statutory retirement policy increased the probability of retirement by 22% (95% confidence interval (CI): 13%–32%, p-value < 0.001) for all participants, 29% (95% CI: 16%–43%, p-value < 0.001) for men, and 20% (95% CI: 9%–31%, p-value < 0.001) for women (see S2 Appendix Table S2).

The grey areas in Fig. 2 represent the 95% confidence intervals. Red points and blue points represent the probability of being retired for women and men, respectively. The solid lines at 50 and 60 years of age in both Figs. 2 and 3 represent, respectively, the statutory retirement age for women and men in China. Our sample size was 5990.

The continuity of potential outcomes

Fig. 3 shows the distribution of age. It allows us to visually test for manipulation of the assignment variable at the threshold. The red solid line represents the statutory retirement age threshold. We found no visual evidence of substantial bunching around the cutoff, which would have been suggestive of manipulation. Based on the formal test developed by McCrary (McCrary, 2008), we also failed to reject the null hypothesis of a smooth density across the threshold, providing further support against manipulation of the assignment variable (see S2 Appendix Fig. S2).

We further tested whether control variables were continuous near the threshold following the methods of Lee et al. (Lee et al., 2004) and Imbens and Lemieux (Imbens & Lemieux, 2008), using the control variables as outcomes and age as assignment variable. We found no significant “jumps” of these variables at the threshold, indicating that all covariates were continuous near the threshold (see S2 Appendix Table S1). These tests strengthen our belief in the validity of the key assumption for regression discontinuity, the continuity of potential outcomes assumption.

Causal effect estimates

Table 2 shows the causal effect of retirement on stress. We also present the ordinary least squares (OLS) estimates to show the association between retirement and stress for comparison. While retirement and stress are strongly correlated, we found that the causal effects of retirement on stress were close to the null value and insignificant. These results remained robust after we controlled for covariates and used a quadratic polynomial in age. Thus, we were unable to reject the null hypothesis that retirement, on average, had no effect on stress.

Each cell in the table represents the coefficient from a separate regression with 95% confidence intervals in parentheses. In all regressions, we used a triangular kernel function that gives more weight to

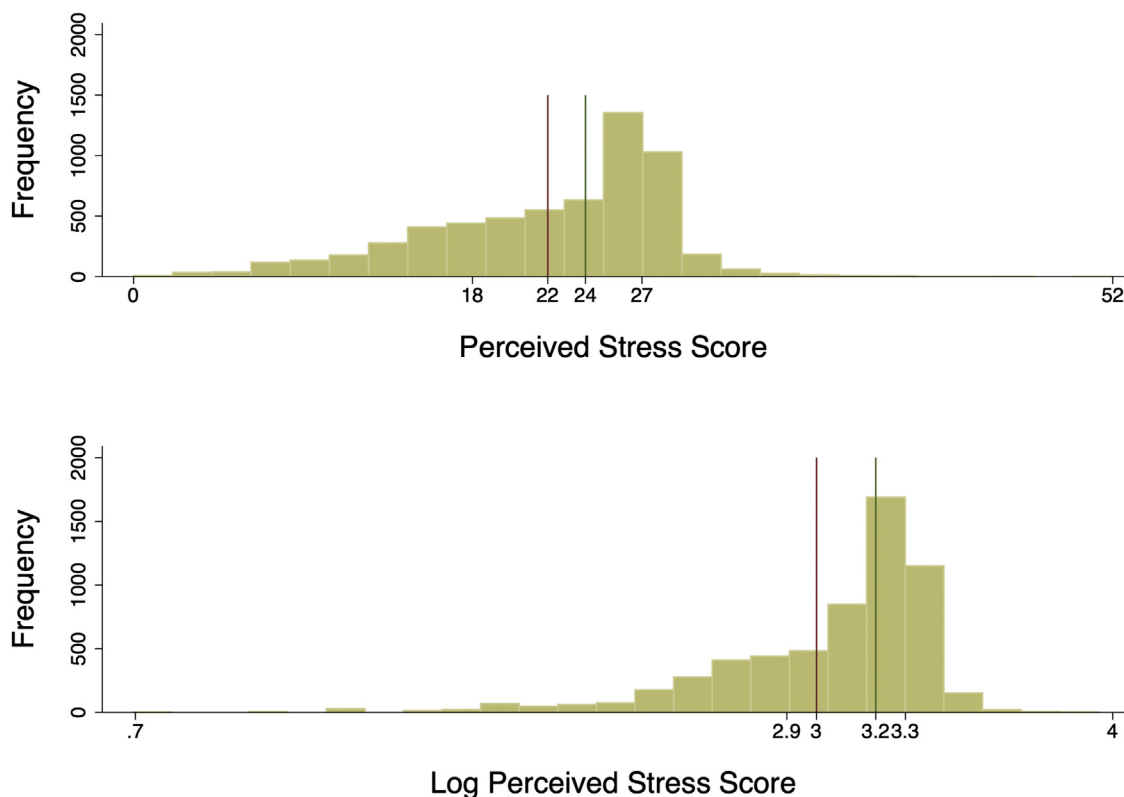


Fig. 1. Histogram of perceived stress score.

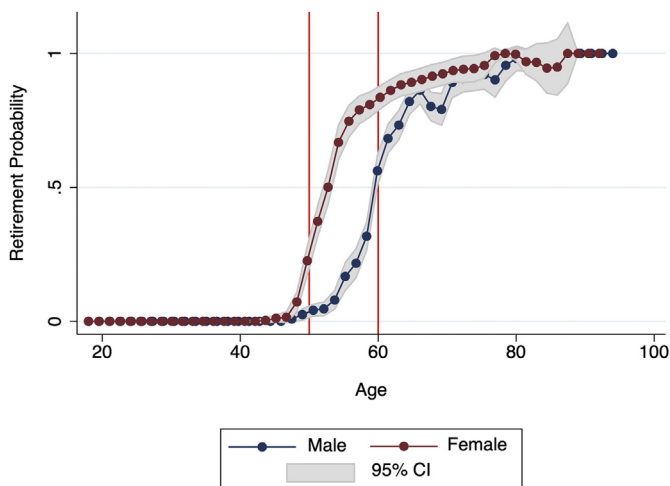


Fig. 2. Probability of retiring by age.

observations closer to the threshold. The models in columns (1) and (2) show the associations between retirement and stress and log (stress), using OLS regressions. We used the full sample of 5990 individuals in these regressions and controlled for age, gender, education, urban residence, and income. The models in columns (3) to (6) provide estimates of the causal effect of retirement on stress. In these regressions, we used the sample within the optimal bandwidth (1789). The models in columns (3) and (4) do not include covariates. The models in columns (5) and (6) additionally include gender, education, and urban residence as covariates.

Robustness checks

We tested the robustness of the causal relationship by examining the

significance and magnitude of coefficients over multiple age bandwidths of the statutory retirement age threshold. In addition to the optimal bandwidth, we also present results using bandwidths ranging from 3 to 10 years. To better map the relationship between the choice of bandwidth and estimated effect, we plotted the effect size against the bandwidth size. Our results showed that while the coefficients fluctuated as the sample size changed, all coefficients were broadly consistent with our baseline estimates (see S2 Appendix Figs. S2–S3). Similarly, our results remained essentially the same when we used quadratic terms for age (see S2 Appendix Table S3), and when we adjusted for clustering of standard errors by age (see S2 Appendix Table S4).

Heterogeneity of treatment effects across groups

Next, we explored whether results differed among gender and education subgroups. Our results show that retirement reduced stress in people with low educational attainment and in men, while it raised stress in people with high educational attainment and in women. However, all causal effects of retirement on stress were insignificant in these subgroup analyses (see S2 Appendix Table S5). Since we found different effect size magnitudes for men and women, we added Table 3 to present these results. The average effect size estimate in the entire population was -0.82 . The effect size estimate was -4.84 for men and 7.07 for women.

Each cell in Table 3 represents the coefficient from a separate regression with 95% confidence intervals in parentheses. In all regressions, we used a triangular kernel function that gives more weight to observations closer to the threshold. The regression discontinuity bandwidth was 54–66 years of age for men and 44–56 years of age for women. The models in columns (2) and (3) do not include covariates. The models in columns (4) and (5) include education and urban residence as covariates.

Further robustness tests by gender subgroup showed that the effect

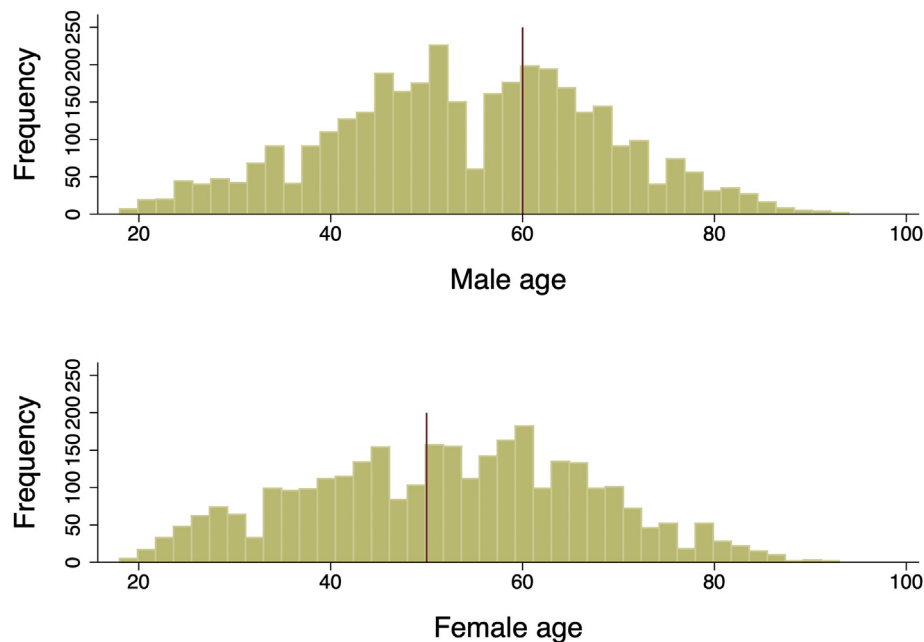


Fig. 3. Density of sample age distribution.

size was negative and small for men while it was positive and large for women across all bandwidth choices from 3 years to 10 years (Fig. S4 and Fig. S5). The effect estimates became significant for some bandwidth choices when the standard errors were clustered by age (Fig. S6 and Fig. S7). This suggests that retirement may have different effects on stress in men and women. Further analyses are needed to test this gender heterogeneity in stress effects in larger samples.

Discussion

On average, retirement did not affect stress in older adults in China. While the confidence intervals in our RDD were relatively wide, the point estimates were close to zero for all model specifications and RDD bandwidths. Subgroup analyses, however, revealed substantial gender heterogeneity in the retirement effects on stress. Retirement reduced perceived stress levels in Chinese men but raised perceived stress levels in Chinese women, and these effects were significant in some sensitivity analyses. Thus, the overall null effect of retirement on stress in the entire population appears to hide opposite gender-specific effects. Further analyses are needed to test whether the gender heterogeneity of retirement effects persists in larger samples.

Our study contributes to the broader literature that has explored the causal effects of retirement on mental health. Previous studies in China have found mixed evidence. Some studies showed that retirement can improve cognitive functioning (Deng & He, 2016; Lei & Liu, 2018), and reduce depressive symptoms (Deng & He, 2016) in men. Another study indicated that retirement can negatively affect mental health and lead to depression (Li, 2017). Yet, other studies found that retirement has no effect on mental health and life satisfaction (Zhang et al., 2018). One potential reason for these divergent findings across studies is the

measurement of mental health. For example, both Li (2017) and Zhang et al. (2018) used the China Health and Retirement Longitudinal Study as data source and non-parametric RDD as method to estimate the effects of retirement on emotions. They find conflicting results. Zhang et al. (2018) used the total score on a measurement scale ranging from 8 to 32, which is based on 8 questions about negative feelings last week. In contrast, Li (2017) used the total score on a measurement scale ranging from 10 to 40, which is based on 10 questions about the frequency of negative feelings in the past 10 weeks. Our study was the first to estimate the effect of retirement on stress in China, using a validated perceived stress scale.

Several mechanisms could explain our results. First, retirement can directly reduce work-related stress, leading to general stress reduction. Though we could not directly test this mechanism, our results showing that stress reduction is more likely in workers with low educational attainment than in workers with high educational attainment indirectly supports this argument. Workers with low educational attainment are more likely to work in physically demanding jobs, which may cause more work-related stress than the jobs that workers with high educational attainment are typically employed in. Second, retirement may induce changes in social interactions. For example, before retirement people spend more time at work, where they interact with coworkers. In contrast, after retirement they spend more time at home with their partners. This change in social interactions may either increase or decrease the stress level in older adults and the effects may differ by gender.

Our results have several policy implications. First, a possible explanation for the different findings in men and women are the gender-specific statutory retirement ages. Currently, the retirement age in China is among the earliest in the world, especially for women – who

Table 2
Relationships between retirement and stress – associations and causal effects.

| | (1) Association between retirement and stress | (2) Association between retirement and log(stress) | (3) Causal effect of retirement on stress | (4) Causal effect of retirement on log(stress) | (5) Causal effect of retirement on stress | (6) Causal effect of retirement on log(stress) |
|-------------|---|--|---|--|---|--|
| Coefficient | -1.15 | -0.05 | -0.82 | 0.04 | -1.16 | 0.005 |
| (95% CI) | (-1.70 to -0.59) | (-0.08 to -0.02) | (-7.32 to 5.68) | (-0.34 to 0.42) | (-6.97 to 4.65) | (-0.34 to 0.35) |
| P value | < 0.001 | 0.003 | 0.804 | 0.826 | 0.696 | 0.979 |
| Covariates | Yes | Yes | No | No | Yes | Yes |

Table 3
The causal effects of retirement on stress by gender.

| | Men | | Women | | Men | | Women | |
|-------------|---------------------------------------|------------------|--|-----------------|---------------------------------------|------------------|--|-----------------|
| | Causal effect of retirement on stress | | Causal effect of retirement on log(stress) | | Causal effect of retirement on stress | | Causal effect of retirement on log(stress) | |
| Coefficient | -4.84 | -3.98 | -0.24 | -0.21 | 7.07 | 4.44 | 0.59 | 0.45 |
| (95% CI) | (-11.70 to 2.02) | (-11.06 to 3.09) | (-0.62 to 0.13) | (-0.60 to 0.19) | (-4.74 to 18.88) | (-7.18 to 16.05) | (-0.18 to 1.36) | (-0.33 to 1.22) |
| P value | 0.167 | 0.270 | 0.206 | 0.302 | 0.241 | 0.454 | 0.132 | 0.260 |
| Covariates | No | Yes | No | Yes | No | Yes | No | Yes |

typically retire at age 50. For men, our findings indicate that retirement is less stressful than work. The opposite appears to be true for women. The role transition from worker to retiree at an age as early as 50 may threaten women's identities as economic contributors to their families and to society and consequently decrease their subjective self-worth. As the Chinese population is rapidly aging, the Chinese government has started to raise the retirement age. Our findings suggest that this policy change will benefit women in other than purely economic ways.

Second, policy makers should also consider harnessing the effect of retirement on stress in men. According to our findings, retired men will regain wellbeing and energy, which they could use to take on new responsibilities for the greater social good. For instance, retired men in China might welcome increased opportunities to volunteer for public service.

Third, policies raising the retirement age for men should be accompanied by interventions to reduce the stress that—according to our findings—such a policy change will cause. Such interventions may include a more flexible and friendly working environment, opportunities to share concerns with others, and targeted psychological support for older men who work.

Our study has several limitations. First, a general limitation of the RDD is that while its internal validity is strong, its external validity can be limited because it estimates effect sizes based on a sample that is restricted to those close to a policy threshold, such as the statutory retirement age. Our findings may thus not generalize well to individuals who retire at substantially younger or older ages. However, our RDD results are highly useful for the policy decision whether to incrementally increase or decrease the statutory retirement age. Second, our confidence intervals were fairly wide and both our overall population and gender-specific results need to be confirmed in larger datasets. Third, we used self-reports rather than biological markers to measure stress. Future research should replicate our analyses using biological markers of stress, such as cortisol levels. Lastly, due to limited data on occupation, we were unable to determine who in our sample was a civil servant and who was not. This distinction is important because the statutory retirement age is more strictly enforced among civil servants in China. Subgroup analyses of this group could thus have further strengthened our conclusions.

The effect of retirement on stress should inform policy debates on changes to the retirement age. Simple multivariable regression analyses cannot validly answer this important research question because of reverse-causality and confounding problems. Given that the statutory retirement age is an arbitrary binary cutoff in the continuous variable age, this research question lends itself to RDD, which can identify causal effects. However, RDD requires large sample sizes because it effectively restricts the sample to individuals who retired at an age close to the statutory retirement age. Nonetheless, this study suggests that the overall null effect of retirement on stress hides large and opposite effects in men and women. Raising the retirement age in China may increase stress in Chinese men but decrease stress in women.

Ethical approval

This study used only publicly available de-identified data. The researchers from the Carolina Population Center who were responsible for

the collection of CHNS data received ethical approval from the University of North Carolina at Chapel Hill.

Acknowledgement

Till Bärnighausen was supported by the Alexander von Humboldt Foundation through the Alexander von Humboldt University Professor award, funded by the Federal Ministry of Education and Research, Germany.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2019.100462>.

References

- Adams, O., & Lefebvre, L. (1981). Retirement and mortality. *Aging and Work*, 4, 115–120.
- Adams, G. A., Prescher, J., Beehr, T. A., & Lepisto, L. (2002). Applying work-role attachment theory to retirement decision-making. *The International Journal of Aging and Human Development*, 54, 125–137.
- Atchley, R. C., & Robinson, J. L. (1982). Attitudes toward retirement and distance from the event. *Research on Aging*, 4, 299–313.
- Bärnighausen, T., Oldenburg, C., Tugwell, P., Bommer, C., Ebert, C., Barreto, M., et al. (2017). Quasi-experimental study designs series-paper 7: Assessing the assumptions. *Journal of Clinical Epidemiology*, 89, 53–66.
- Bertoni, M., & Brunello, G. (2017). Pappa Ante Portas: The effect of the husband's retirement on the wife's mental health in Japan. *Social Science & Medicine*, 175, 135–142.
- Bloom, D. E., Chen, S., Kuhn, M., McGovern, M. E., Oxley, L., & Pretzner, K. (2018a). The economic burden of chronic diseases: Estimates and projections for China, Japan, and South Korea. *The Journal of the Economics of Ageing* 100163 [Epub ahead of print].
- Bloom, D. E., Kirby, P., Sevilla, J., & Stawasz, A. (2018b). *Japan's age wave: Challenges and solutions*. VoxEU.org.
- Bor, J., Fox, M. P., Rosen, S., Venkataramani, A., Tanser, F., Pillay, D., et al. (2017). Treatment eligibility and retention in clinical HIV care: A regression discontinuity study in South Africa. *PLoS Medicine*, 14, e1002463.
- Bor, J., Moscoe, E., Mutevedzi, P., Newell, M.-L., & Bärnighausen, T. (2014). Regression discontinuity designs in epidemiology: Causal inference without randomized trials. *Epidemiology*, 25, 729–737.
- Calonico, S., Cattaneo, M. D., Farrell, M. H., & Titiunik, R. (2017). rdrobust: Software for regression discontinuity designs. *STATA Journal*, 17, 372–404.
- Calonico, S., Cattaneo, M. D., & Titiunik, R. (2014a). Robust data-driven inference in the regression-discontinuity design. *STATA Journal*, 14, 909–946.
- Calonico, S., Cattaneo, M. D., & Titiunik, R. (2014b). Robust nonparametric confidence intervals for regression-discontinuity designs. *Econometrica*, 82, 2295–2326.
- Case, A., & Paxson, C. (2005). Sex differences in morbidity and mortality. *Demography*, 42, 189–214.
- Cattell, V. (2001). Poor people, poor places, and poor health: The mediating role of social networks and social capital. *Social Science & Medicine*, 52, 1501–1516.
- Chen, S., Sudharsanan, N., Huang, F., Liu, Y., Geldsetzer, P., & Bärnighausen, T. (2019). Impact of community based screening for hypertension on blood pressure after two years: Regression discontinuity analysis in a national cohort of older adults in China. *BMJ*, 366, 14064.
- Coe, N. B., & Zamarro, G. (2011). Retirement effects on health in Europe. *Journal of Health Economics*, 30, 77–86.
- Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior*, 24, 385–396.
- Davidson, R. J., Kabat-Zinn, J., Schumacher, J., Rosenkranz, M., Muller, D., Santorelli, S. F., et al. (2003). Alterations in brain and immune function produced by mindfulness meditation. *Psychosomatic Medicine*, 65, 564–570.
- Deng, H., & He, X. (2016). The effects of retirement on physical and mental health outcomes in males: Based on the empirical evidences of regression discontinuity design. *Population & Economics*, 2016, 82–91.
- Eibich, P. (2015). Understanding the effect of retirement on health: Mechanisms and heterogeneity. *Journal of Health Economics*, 43, 1–12.

- Elwell, F., & Maltbie-Crannell, A. D. (1981). The impact of role loss upon coping resources and life satisfaction of the elderly. *Journal of Gerontology*, *36*, 223–232.
- Hay, S. I., Abajobir, A. A., Abate, K. H., Abbafati, C., Abbas, K. M., Abd-Allah, F., et al. (2017). Global, regional, and national disability-adjusted life-years (DALYs) for 333 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2016: A systematic analysis for the global burden of disease study 2016. *The Lancet*, *390*, 1260–1344.
- Haynes, S. G., McMichael, A. J., & Tyroler, H. A. (1978). Survival after early and normal retirement. *Journal of Gerontology*, *33*, 269–278.
- Heller-Sahlgren, G. (2017). Retirement blues. *Journal of Health Economics*, *54*, 66–78.
- Imbens, G. W., & Kalyanaraman, K. (2012). Optimal bandwidth choice for the regression discontinuity estimator. *The Review of Economic Studies*, *79*, 933–959.
- Imbens, G. W., & Lemieux, T. (2008). Regression discontinuity designs: A guide to practice. *Journal of Econometrics*, *142*, 615–635.
- Johnston, D. W., & Lee, W.-S. (2009). Retiring to the good life? The short-term effects of retirement on health. *Economics Letters*, *103*, 8–11.
- Jokela, M., Ferrie, J. E., Gimeno, D., Chandola, T., Shipley, M. J., Head, J., et al. (2010). From midlife to early old age: Health trajectories associated with retirement. *Epidemiology*, *21*, 284–290.
- Kelly, S. J., & Ismail, M. (2015). Stress and type 2 diabetes: A review of how stress contributes to the development of type 2 diabetes. *Annual Review of Public Health*, *36*, 441–462.
- Kim, J. E., & Moen, P. (2002). Retirement transitions, gender, and psychological well-being: A life-course, ecological model. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *57*, 212–222.
- Kivimäki, M., & Steptoe, A. (2018). Effects of stress on the development and progression of cardiovascular disease. *Nature Reviews Cardiology*, *15*, 215–229.
- Lee, D. S., & Card, D. (2008). Regression discontinuity inference with specification error. *Journal of Econometrics*, *142*, 655–674.
- Lee, D. S., & Lemieux, T. (2010). Regression discontinuity designs in economics. *Journal of Economic Literature*, *48*, 281–355.
- Lee, D. S., Moretti, E., & Butler, M. J. (2004). Do voters affect or elect policies? Evidence from the US House. *Quarterly Journal of Economics*, *119*, 807–859.
- Lei, X., & Liu, H. (2018). Gender difference in the impact of retirement on cognitive abilities: Evidence from urban China. *Journal of Comparative Economics*, *46*, 1425–1446.
- Leinonen, T., Lahelma, E., & Martikainen, P. (2013). Trajectories of antidepressant medication before and after retirement: The contribution of socio-demographic factors. *European Journal of Epidemiology*, *28*, 417–426.
- Leung, D. Y., Lam, T., & Chan, S. S. (2010). Three versions of Perceived Stress Scale: Validation in a sample of Chinese cardiac patients who smoke. *BMC Public Health*, *10*, 513.
- Li, W. (2017). An empirical study on the health of retirement to the working population—based on China Health and Retirement Longitudinal Study. *American Journal of Industrial and Business Management*, *7*, 429.
- Lindeboom, M., Portrait, F., & Van den Berg, G. J. (2002). An econometric analysis of the mental-health effects of major events in the life of older individuals. *Health Economics*, *11*, 505–520.
- Li, H., Shi, X., & Wu, B. (2015). The retirement consumption puzzle in China. *The American Economic Review*, *105*, 437–441.
- Li, H., Shi, X., & Wu, B. (2016). The retirement consumption puzzle revisited: Evidence from the mandatory retirement policy in China. *Journal of Comparative Economics*, *44*, 623–637.
- McCrary, J. (2008). Manipulation of the running variable in the regression discontinuity design: A density test. *Journal of Econometrics*, *142*, 698–714.
- McGarry, K. (2004). Health and retirement: Do changes in health affect retirement expectations? *Journal of Human Resources*, *39*, 624–648.
- Mein, G., Martikainen, P., Hemingway, H., Stansfeld, S., & Marmot, M. (2003). Is retirement good or bad for mental and physical health functioning? Whitehall II longitudinal study of civil servants. *Journal of Epidemiology & Community Health*, *57*, 46–49.
- Miller, M. (1979). *Suicide after sixty: The final alternative*. New York City, New York: Springer Publishing Company.
- Moreau, N., & Stancanelli, E. (2015). Household consumption at retirement: A regression discontinuity study on French data. *Annals of Economics and Statistics/Annales d'Économie et de Statistique*, *117/118*, 253–276.
- Moscoe, E., Bor, J., & Bärnighausen, T. (2015). Regression discontinuity designs are underutilized in medicine, epidemiology, and public health: A review of current and best practice. *Journal of Clinical Epidemiology*, *68*, 132–143.
- Oksanen, T., Vahtera, J., Westerlund, H., Pentti, J., Sjösten, N., Virtanen, M., et al. (2011). Is retirement beneficial for mental health? Antidepressant use before and after retirement. *Epidemiology*, *22*, 553.
- Oldenburg, C. E., Moscoe, E., & Bärnighausen, T. (2016). Regression discontinuity for causal effect estimation in epidemiology. *Current Epidemiology Reports*, *3*, 233–241.
- Oldenburg, C. E., Seage, G. R., Tanser, F., De Gruttola, V., Mayer, K. H., Mimiaga, M. J., et al. (2018). Antiretroviral therapy and mortality in rural South Africa: A comparison of causal modeling approaches. *American Journal of Epidemiology*, *187*, 1772–1779.
- Ong, A. D., Exner-Cortens, D., Riffin, C., Steptoe, A., Zautra, A., & Almeida, D. M. (2013). Linking stable and dynamic features of positive affect to sleep. *Annals of Behavioral Medicine*, *46*, 52–61.
- Patenaude, B. N., Chimbindi, N., Pillay, D., & Bärnighausen, T. (2018). The impact of ART initiation on household food security over time. *Social Science & Medicine*, *198*, 175–184.
- Picchio, M., & van Ours, J. C. (2018). *The causal effect of retirement on health and happiness. Working Paper*. Rotterdam: Erasmus School of Economics.
- Popkin, B. M., Du, S., Zhai, F., & Zhang, B. (2009). Cohort profile: The China Health and Nutrition Survey—monitoring and understanding socio-economic and health change in China, 1989–2011. *International Journal of Epidemiology*, *39*, 1435–1440.
- Richardson, V., & Kilty, K. M. (1991). Adjustment to retirement: Continuity vs. discontinuity. *The International Journal of Aging and Human Development*, *33*, 151–169.
- Schaie, K. W., & Carstensen, L. L. (2006). *Social structures, aging, and self-regulation in the elderly*. New York City, New York: Springer Publishing Company.
- Schünemann, J., Strulik, H., & Trimborn, T. (2017). The gender gap in mortality: How much is explained by behavior? *Journal of Health Economics*, *54*, 79–90.
- Seaward, B. L. (2017). *Managing stress: Principles and strategies for health and well-being*. Boulder, Colorado: Jones & Bartlett Learning.
- Stancanelli, E. (2013). *Divorcing upon retirement: A regression discontinuity study*. Bonn: IZA IZA Discussion Paper No. 8117.
- Stancanelli, E., & Van Soest, A. (2012). *Joint leisure before and after retirement: A double regression discontinuity approach*. Bonn: IZA IZA Discussion Paper No. 6698.
- Van Solinge, H., & Henkens, K. (2008). Adjustment to and satisfaction with retirement: Two of a kind? *Psychology and Aging*, *23*, 422–434.
- Van Tilburg, T. (2003). Consequences of men's retirement for the continuation of work-related personal relationships. *Ageing International*, *28*, 345–358.
- Vercambre, M.-N., Okereke, O. I., Kawachi, I., Grodstein, F., & Kang, J. H. (2016). Self-reported change in quality of life with retirement and later cognitive decline: Prospective data from the nurses' health study. *Journal of Alzheimer's Disease*, *52*, 887–898.
- Villamil, E., Huppert, F. A., & Melzer, D. (2006). Low prevalence of depression and anxiety is linked to statutory retirement ages rather than personal work exit: A national survey. *Psychological Medicine*, *36*, 999–1009.
- Vo, K., Forder, P. M., Tavener, M., Rodgers, B., Banks, E., Bauman, A., et al. (2015). Retirement, age, gender and mental health: Findings from the 45 and up Study. *Aging & Mental Health*, *19*, 647–657.
- Wang, M., & Shi, J. (2014). Psychological research on retirement. *Annual Review of Psychology*, *65*, 209–233.
- Wang, M., & Shultz, K. S. (2010). Employee retirement: A review and recommendations for future investigation. *Journal of Management*, *36*, 172–206.
- Westerlund, H., Kivimäki, M., Singh-Manoux, A., Melchior, M., Ferrie, J. E., Pentti, J., et al. (2009). Self-rated health before and after retirement in France (GAZEL): A cohort study. *The Lancet*, *374*, 1889–1896.
- Witek-Janusek, L., Albuquerque, K., Chroniak, K. R., Chroniak, C., Durazo-Arvizu, R., & Mathews, H. L. (2008). Effect of mindfulness based stress reduction on immune function, quality of life and coping in women newly diagnosed with early stage breast cancer. *Brain, Behavior, and Immunity*, *22*, 969–981.
- Zhang, Y., Salm, M., & van Soest, A. (2018). The effect of retirement on healthcare utilization: Evidence from China. *Journal of Health Economics*, *62*, 165–177.