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Effects of retirement on inpatient healthcare utilisation: an observational study in China

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ABSTRACT

Objective Previous studies have presented mixed evidence on retirement and inpatient healthcare utilisation. We aimed to examine the causal effect of retirement on inpatient healthcare utilisation in China and explore the heterogenous effects of sex, disease types and ways of hospital admission.

Design This was a retrospective observational study from the electronic medical record at 376 tertiary hospitals in China between 2013 and 2018.

Setting Nationwide data from China.

Participants We included the male sample aged between 50 and 70, and the female sample aged between 40 and 60 and with basic medical insurance system or public medical insurance. Observations with total expenditures per visit at the top or bottom 1% were excluded.

Primary and secondary outcome measures Inpatient expenditures per visit and inpatient days per visit.

Methodology We examined the effects by a non-parametric fuzzy regression discontinuity design, exploiting the mandatory retirement age as a source of exogenous variation in retirement status.

Results Retirement reduced drug expenditures (β=−467.46, p<0.05) and inpatient days per visit (β=−0.99, p<0.05). The mitigation effect was concentrated on people admitted into hospital due to chronic diseases (β=−551.28, p<0.05 for drug expenditures; β=−1.08, p<0.05 for inpatient days per visit) and people admitted into hospital through outpatient services (β=−353.75, p<0.001 for drug expenditures). For males, retirement significantly reduced diagnostic tests expenditures (β=−302.38, p<0.05) and drug expenditures (β=−728.31, p<0.05). Retirement significantly reduced inpatient days per visit (β=−1.13, p<0.05) for females.

Conclusion The empirical findings suggested that retirement may lead to a reduction in inpatient healthcare utilisation, which underlined the importance for policy-makers to consider the externalities of retirement policies on inpatient healthcare utilisation.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ We presented a large and nationwide patient sample between 2013 and 2018.
⇒ A non-parametric fuzzy regression discontinuity design was used to correct for potential endogeneity of retirement.
⇒ Data from the electronic medical record in 376 tertiary hospitals provide a wealth of information and can be considered as a proxy for health status without the bias of self-reporting.
⇒ Due to the institutional setting, we could only derive a causal effect of retirement on healthcare expenditures for inpatient people.

INTRODUCTION

Demographic changes in China are increasing the proportion of the elderly population. In the meanwhile, their health and life expectancy are improving.[1] However, China's legal retirement age (60 for males and 50 for most females) is among the lowest in the world.[2] The growing number of retirees imposes huge costs on public and private budgets, sparking an ongoing debate over whether to raise the retirement age.[3] The impact of retirement on healthcare utilisation has implications for policies on the official retirement age and labour supply for elderly population.[4] If retirement increases healthcare utilisation, raising the retirement age preserves healthcare utilisation resources. Conversely, if retirement reduces healthcare utilisation, an increase in the retirement age will lead to an increase in healthcare expenditures, which may partially offset pension fund savings. To fully understand the consequences of retirement policies, we must consider the impact of retirement on healthcare utilisation and its implications for the healthcare system.

Retirement can affect healthcare utilisation in several contradictory ways. On one hand, retirement may increase healthcare utilisation because of reduced time cost of using healthcare services or a negative health effect of retirement such as cognitive decline or obesity.[5] Retirees may no longer have an incentive to invest in their health in order to maintain their income.[6] In addition, work-related satisfaction, social contacts and physical activity are reduced due to retirement.[7] On the other hand, retirement may decrease

healthcare utilisation because retirement increases the amount of leisure time and people shift to healthier lifestyles that individuals can invest in their health by adequate physical exercise or sleep.[8] Retirement may also reduce work-related stress and tension, so retirement can have health-preserving effects.[7 9 10]

In terms of cost share, inpatient healthcare utilisation is a major type of healthcare utilisation as opposed to outpatient healthcare utilisation, and it imposes a heavier burden on the society. Previous studies on the causal effect of retirement on inpatient healthcare utilisation are inconclusive. Several studies based on data from developed countries found that retirement led to fewer doctor visits and expenditures in relation to hospitalisation.[4 11 12] While some other studies revealed that retirement had no significant effects on inpatient care utilisation,[8 13 14] such as acute hospital admissions or nights in the hospital.[11 15] Studies from China found that retirement increased hospital stays and doctor visits,[3] or that there was no change in inpatient care at retirement.[14] However, these two studies on retirement and inpatient healthcare utilisation have some limitations, such as insufficient sample representation and self-reported data of health service use.

In this study, we examined the impact of retirement on inpatient healthcare utilisation, using a large dataset from the electronic medical record (EMR) in 376 tertiary hospitals in China. Our study contributes to a growing body of literature by identifying retirement effects for the different categories of inpatient healthcare expenditures, which is unprecedented in China. We addressed the endogeneity problem with a fuzzy regression discontinuity design (RDD), by using mandatory retirement age as a source of exogenous variation in retirement.[8 16] We also explored the heterogenous effects of sex, disease types and ways of hospital admission. To the best of our knowledge, it provides the first evidence of an effect of retirement on inpatient healthcare utilisation in China from a large sample. The analysis will be informative for other developing countries with similar characteristics.

METHODS

Data and sample

The data we used came from the EMR in 376 tertiary hospitals in China from year 2013–2018. The EMR was derived from the National Health Commission in China. The originally unstructured data of the following variables was unified for analysis: (1) inpatient code (IP code, unique for each admission); (2) demographic characteristics, including age, sex, marriage, medical insurance; (3) clinical characteristics, including department of discharge, discharging diagnosis (diseases identified by the International Classification of Diseases Tenth Revision (ICD-10)), laboratory test, prescription, information for surgery and cost for hospital stay.

The mandatory retirement age in China is 60 years for males, and 50 years for most female employees (online supplemental text 1). For female civil servants, the mandatory retirement age is 55. However, they were a relatively small group among females,[17] and the distinction between civil servants and other public sector employees was poorly measured in our data. We therefore proxied the mandatory retirement age to age 50 for all females. We restricted the male sample to those aged between 50 and 70, and the female sample to those aged between 40 and 60 (10 years before and after the cut-off point). It reduced the sample size from 67 588 579 to 17 839 077 individual-year observations. We further kept those urban employees with basic medical insurance system or public medical insurance, since the two types of medical insurance indicated that people worked in formal sectors and were subject to the retirement system. This reduced the sample size to 1 816 480 observations. Finally, we excluded observations with total expenditures per visit at the top or bottom 1%, leaving a final sample of 1 780 150 individual-year observations (online supplemental table 1).

Treatment variable

In general, retirement implies that an individual exits the labour market. This encompasses also individuals who are technically unemployed, but are not actively searching for a job. On the other hand, some retirees might exit their main occupation, but continue to work in another occupation, for example, to generate additional income, meet other people or engage in meaningful work. In this paper, we used self-reported retirement status in the EMR as the treatment variable.

Normalised age

Online supplemental figure 1 shows the retirement rate (the sample fraction of individuals in retirement) by age and sex. It presented a clear discontinuity in the retirement rate at age 50 for females and at age 60 for males. We defined the normalised age a as the actual age minus the corresponding mandatory retirement age for each sex: a=age − 60 for males, and a=age − 50 for females. This is the assignment variable for the fuzzy RDD in our main analysis.

Outcome variables

We considered the following outcome variables in our main analysis: (1) total inpatient expenditures per visit: the total expenditure for inpatient healthcare utilisation per visit, that is, fees paid to the hospital. It can be further divided into: (a) medical service expenditures; (b) diagnostic tests expenditures; (c) drug expenditures; (d) medical consumables expenditures. Total inpatient expenditures per visit also include rehabilitation expenditures, blood expenditures and other expenditures. But due to their small amount, they were not reported in tables. The expenditures in tables and graphs are in RMB or CNY (both mean Chinese Yuan).[2] Inpatient days per visit: the number of days the respondent stayed in hospital per visit.

Control variables

We controlled for predetermined variables such as individual's sex (males vs females), marriage (partnered vs unmarried/widowed/divorced), medical insurance (urban employee basic medical insurance vs public medical insurance), disease types (acute diseases vs chronic diseases) and ways of hospital admission (emergency admission vs outpatient admission).

Empirical strategy

Our aim is to estimate the causal effect of retirement on inpatient healthcare utilisation. Retirement might be endogenous to inpatient healthcare use. For example, both retirement decisions and inpatient healthcare utilisation might be influenced by an unobserved component of health or another unobserved factor. To correct for potential endogeneity of retirement, we used a non-parametric fuzzy RDD for our analysis, avoiding restrictive assumptions on functional form.[8] The RDD exploits the mandatory retirement age as a source of exogenous variation in retirement status. Since not all individuals retire exactly at their mandatory retirement age, this RD framework is fuzzy.[18] The treatment effect can be estimated as the ratio of the jump in the outcome variable and the jump in the probability of being retired at the mandatory retirement age.

In our main analysis, we chose non-parametric estimation to avoid assuming a particular functional form of the assignment variable. We 'residualised' the outcome variables.[18] We regressed outcome variables on control variables, and then conducted the non-parametric RD analysis described above based on the residuals. In non-parametric estimation, a crucial issue is the selection of bandwidth. The method for bandwidth estimation is the Imbens-Kalyanaraman (IK) optimal bandwidth selection procedure.[19] This method was proposed by Imbens and Kalyanaraman (2012) and aims to minimise the mean squared error of the treatment effect estimator. The IK optimal bandwidth selection procedure takes into account both the bias and the variance of the estimator, balancing the trade-off between the two. In result tables, we reported the bandwidth used in each regression, as well as the number of samples within the bandwidth.

A valid fuzzy RDD relies on two main assumptions.[20] The first assumption requires a discontinuity in the probability of treatment at the cut-off point. This assumption was verified in online supplemental figure 1, which shows how retirement rates vary with age. We can see a discontinuity at the mandatory retirement age (a=0) where the probability of being retired increases by around 20 percentage points. The second assumption requires continuity in potential outcomes as a function of the assignment variable around the cut-off point. This implies that in the absence of retirement, inpatient healthcare utilisation should not change at the cut-off point. In other words, 'all other factors' driving healthcare utilisation must be continuous at the cut-off point.[21] As shown in online supplemental figure 2, when the sample size is large enough, the individual heterogeneity such as sex, marriage status and diseases types tend to be stable on the whole.[22] In addition, continuity testing is an essential prerequisite for obtaining consistent estimates in RDD. To test for data heaping, a histogram of age distribution is shown in online supplemental figure 3. We found that there was no evidence of data heaping at the cut-off point for the sample; thus, the continuity assumption was satisfied.[23]

Next, we investigated the robustness of the results with respect to the data heaping test, the choice of the bandwidth and the specification of nearby cut-off points.[24 25] In addition, evidence of uncertainty and conflict may stem from effect heterogeneity.[8] Retirement may have different effects on inpatient healthcare utilisation due to different types of inpatient services and socio-demographic backgrounds. For heterogeneity tests, we explored effects of retirement on inpatient healthcare utilisation by disease types and ways of hospital admission. Due to differences in working characteristics and retirement age between males and females, we also explored the sex differences in the effects of retirement on inpatient healthcare utilisation. Online supplemental figure 4 showed a logic tree that visually illustrates the relationships between variables, the analysis steps and the outcomes, so as to better understand the structure and flow of the analysis. All analyses were performed in Stata V.16.0 (Stata Corp LLP).

RESULTS

Table 1 presents summary statistics. The sample consisted of 1 780 150 observations, among which 996 884 reported retired and 783 266 reported not retired. The average age was 57.24 years old. About 41.19% of them were males. The vast majority had partners (91.70%) and had urban employee basic medical insurance (97.65%). 73.31% of individuals in our sample were hospitalised for chronic illnesses and 82.28% were admitted into hospital through outpatient services. The average total inpatient expenditures per visit were 15 538.97 yuan, of which the medical service expenditures were 4009.09 yuan, the diagnostic tests expenditures were 3077.63 yuan, the drug expenditures were 5163.44 yuan, and the medical consumables expenditures were 2652.35 yuan. The average inpatient days per visit were 9.73 days.

Table 2 recorded effects of retirement on inpatient healthcare utilisation by the RDD design. Model 1 was unadjusted for any control variable. Model 2–4 adjusted for sex, marriage, medical insurance, disease types and ways of hospital admission step by step. We found that retirement had no effects on the total inpatient healthcare expenditures per visit (β=104.83, $p>0.05$ in model 4, table 2), but significantly reduced drug expenditures (β=−467.46, $p<0.05$ in model 4, table 2) and inpatient days per visit (β=−0.99, $p<0.05$ in model 4, table 2).

Table 1 Summary statistics between those retired and not retired

Variable	Total (n=1 780 150)	Retired (n=996 884)	Not retired (n=783 266)
	Mean (SD)/N (%)	Mean (SD)/N (%)	Mean (SD)/N (%)
Outcome variables			
Total inpatient expenditures per visit*	15 538.97 (11.72)	15 524.65 (15.74)	15 557.06 (17.55)
Medical service expenditures	4009.09 (4.64)	3895.71 (6.05)	4152.34 (7.19)
Diagnostic tests expenditures	3077.63 (1.98)	3144.12 (2.66)	2993.62 (2.97)
Drug expenditures	5163.44 (4.84)	5217.39 (6.47)	5095.26 (7.28)
Medical consumables expenditures	2652.35 (6.01)	2644.24 (8.17)	2662.59 (8.87)
Inpatient days per visit	9.73 (0.0089)	10.03 (0.0097)	9.34 (0.016)
Treatment variable			
Retirement	0.56 (0.00037)	1.00	0.00
Running variable			
Age	57.24 (0.0050)	60.28 (0.0054)	53.41 (0.0071)
Control variables			
Sex			
Male	733 170 (41.19)	338 496 (34.06)	394 674 (50.18)
Female	1 046 980 (58.81)	655 196 (65.94)	65.94 (49.82)
Marriage			
Partnered	1 632 355 (91.70)	910 073 (91.59)	722 282 (91.84)
Unmarried/widowed/divorced	147 795 (8.30)	83 619 (8.41)	64 176 (8.16)
Medial insurance			
Urban employee basic medical insurance	1 738 399 (97.65)	976 776 (98.30)	761 623 (96.84)
Public medical insurance	41 751 (2.35)	16 916 (1.70)	24 835 (3.16)
Disease types			
Acute diseases	475 127 (26.69)	251 705 (25.33)	223 422 (28.41)
Chronic diseases†	1 305 023 (73.31)	741 987 (74.67)	563 036 (71.59)
Ways of hospital admission			
Emergency admission	315 442 (17.72)	191 202 (19.18)	123 129 (15.72)
Outpatient admission	1 464 708 (82.28)	805 682 (80.82)	660 137 (84.28)

*Total inpatient expenditures per visit also include rehabilitation expenditures, blood expenditures and other expenditures.
†Chronic diseases refer to neoplasms, blood or immune diseases, skin diseases, musculoskeletal diseases, urogenital diseases, mental and behavioural disorders, digestive diseases, endocrine, nutritional or metabolic diseases, eye diseases, ear diseases, circulatory diseases and respiratory diseases.

Robustness tests

To ensure the credibility of results, we conducted robustness tests with the varying bandwidths and different cut-off points in online supplemental table 2. In columns (1)–(3) of online supplemental table 2, the findings were robust to alternative specifications of different bandwidths for choosing the sample. columns (4)–(7) of online supplemental table 2 showed placebo tests at other nearby cut-off points, −1, +1, –5 and +5. As expected, there were no effects at other cut-off points. In addition, there are no other policies that use the age of 60/50 as the eligibility criterion in China.[26] Consequently, the effects arising from the cut-off points can solely be attributed to the impact of retirement policies, without being confounded by the effects of other policies.

Subgroup analyses

In table 3, we explored effects of retirement on inpatient healthcare utilisation by disease types, that is, acute or chronic diseases. Chronic diseases referred to neoplasms, blood or immune diseases, skin diseases, musculoskeletal diseases, urogenital diseases, mental and behavioural disorders, digestive diseases, endocrine, nutritional or metabolic diseases, eye diseases, ear diseases, circulatory diseases and respiratory diseases based on ICD-10. Model 1 and model 3 did not adjust for any control variables, while model 2 and model 4 adjusted for sex, marriage, medical insurance and ways of hospital admission. The mitigation effect of retirement on drug expenditures (β=−551.28, $p<0.05$ in model 4, table 3) and inpatient days per visit (β=−1.08, $p<0.05$ in model 4, table 3) was

Table 2 Main analysis: effects of retirement on inpatient healthcare utilisation

Dependent variable	Model 1	Model 2	Model 3	Model 4
Total inpatient expenditures per visit†				
Retirement (SE)	−240.62 (714.55)	−23.10 (424.11)	−93.44 (423.71)	104.83 (758.94)
Bandwidth	3.05	3.05	3.05	3.05
Sample size	226 552; 223 508	226 552; 223 508	226 552; 223 508	226 552; 223 508
Medical service expenditures				
Retirement (SE)	245.45 (321.95)	151.01 (196.95)	103.51 (194.95)	334.56 (342.81)
Bandwidth	2.52	2.52	2.52	2.52
Sample size	152 692; 164 663	152 692; 164 663	152 692; 164 663	152 692; 164 663
Diagnostic tests expenditures				
Retirement (SE)	−59.25 (112.91)	−16.71 (67.11)	−36.25 (65.59)	−30.29 (112.43)
Bandwidth	3.11	3.11	3.11	3.11
Sample size	226 552; 223 508	226 552; 223 508	226 552; 223 508	226 552; 223 508
Drug expenditures				
Retirement (SE)	−612.25** (205.10)	−270.23* (113.44)	−246.08* (111.29)	−467.46* (209.52)
Bandwidth	5.21	5.21	5.21	5.21
Sample size	370 721; 338 255	370 721; 338 255	370 721; 338 255	370 721; 338 255
Medical consumables expenditures				
Retirement (SE)	148.22 (218.75)	168.59 (124.31)	138.91 (122.89)	292.60 (231.62)
Bandwidth	4.60	4.60	4.60	4.60
Sample size	302 847; 286 512	302 847; 286 512	302 847; 286 512	302 847; 286 512
Inpatient days per visit				
Retirement (SE)	−1.03* (0.47)	−0.60* (0.29)	−0.63* (0.29)	−0.99* (0.45)
Bandwidth	2.29	2.29	2.29	2.29
Sample size	152 691; 164 663	152 691; 164 663	152 691; 164 663	152 691; 164 663
Covariates	Residualised	Residualised	Residualised	Residualised

Model 1: unadjusted.
Model 2: adjusted for sex, marriage and medical insurance.
Model 3: adjusted for sex, marriage, medical insurance and disease types.
Model 4: adjusted for sex, marriage, medical insurance, disease types and ways of hospital admission.
*Significant at 5%; ** at 1%. Numbers in parentheses show SEs clustered at the person level.
†Total inpatient expenditures per visit also include rehabilitation expenditures, blood expenditures and other expenditures.

concentrated on people admitted into hospital due to chronic diseases. For people admitted into hospital due to acute diseases, retirement had no effects on inpatient healthcare utilisation.

Next, we explored effects of retirement on inpatient healthcare utilisation by ways of hospital admission,that is, emergency admission or outpatient admission in table 4. Model 1 and model 3 did not adjust for any control variables, while model 2 and model 4 adjusted for sex, marriage, medical insurance and disease types. Retirement only significantly reduced drug expenditures (β=−353.75, p<0.001 in model 4, table 4) for people admitted into hospital through outpatient services. For people with emergency admission, retirement had no effects on their inpatient healthcare utilisation.

Lastly, we explored effects of retirement on inpatient healthcare utilisation by sex in table 5. Model 1 and model 3 did not adjust for any control variables, while model 2 and model 4 adjusted for sex, marriage, medical insurance, disease types and ways of hospital admission. For males, retirement significantly reduced diagnostic tests expenditures (β=−302.38, p<0.05 in model 2, table 5) and drug expenditures (β=−728.31, p<0.05 in model 2, table 5), while these effects were statistically insignificant for females. Retirement significantly reduced inpatient days per visit (β=−1.13, p<0.05 in model 4, table 5) for females.

DISCUSSION

Healthcare utilisation and its interaction with ageing population—including reducing the ratio of workers to retirees and the need to adjust retirement ages as people live longer—is of considerable policy implications for ageing countries. This paper offered evidence of the causal effect of retirement on inpatient healthcare

Table 3 Robustness tests: effects of retirement on inpatient healthcare utilisation by disease types

	Acute diseases		Chronic diseases§	
Dependent variable	Model 1	Model 2	Model 3	Model 4
Total inpatient expenditures per visit‡				
Retirement (SE)	−965.22 (704.40)	−906.92 (764.26)	−402.74 (816.10)	48.22 (862.75)
Bandwidth	7.41	7.41	3.03	3.03
Sample size	122 370; 121 422	122 370; 121 422	166 084; 163 853	166 084; 163 853
Medical service expenditures				
Retirement (SE)	−288.55 (453.37)	−89.27 (487.54)	281.19 (329.44)	264.12 (355.05)
Bandwidth	4.94	4.94	2.59	2.59
Sample size	80 831; 76 471	80 831; 76 471	111 938; 120 714	111 938; 120 714
Diagnostic tests expenditures				
Retirement (SE)	−65.24 (181.03)	−48.16 (186.85)	−163.56 (84.78)	−50.53 (85.76)
Bandwidth	4.52	4.52	4.38	4.38
Sample size	80 831; 76 471	80 831; 76 471	222 016; 210 041	222 016; 210 041
Drug expenditures				
Retirement (SE)	−177.10 (651.13)	−161.06 (712.13)	−701.55† (264.81)	−551.28* (271.88)
Bandwidth	4.19	4.19	3.42	3.42
Sample size	80 831; 76 471	80 831; 76 471	166 084; 163 853	166 084; 163 853
Medical consumables expenditures				
Retirement (SE)	−212.45 (299.68)	−64.89 (332.37)	186.40 (319.76)	391.70 (339.75)
Bandwidth	5.01	5.01	3.79	3.79
Sample size	98 946; 90 281	98 946; 90 281	166 084; 163 853	166 084; 163 853
Inpatient days per visit				
Retirement (SE)	−0.63 (1.19)	−0.89 (1.26)	−1.22* (0.49)	−1.08* (0.45)
Bandwidth	2.11	2.11	2.70	2.70
Sample size	40 754; 43 949	40 754; 43 949	111 938; 120 714	111 938; 120 714
Covariates	Residualised	Residualised	Residualised	Residualised

Model 1 and model 3: unadjusted.
Model 2 and model 4: adjusted for sex, marriage, medical insurance, and ways of hospital admission.
*Significant at 5%
†at 1%. Numbers in parentheses show SEs clustered at the person level.
‡Total inpatient expenditures per visit also include rehabilitation expenditures, blood expenditures and other expenditures.
§Chronic diseases refer to neoplasms, blood or immune diseases, skin diseases, musculoskeletal diseases, urogenital diseases, mental and behavioural disorders, digestive diseases, endocrine, nutritional or metabolic diseases, eye diseases, ear diseases, circulatory diseases and respiratory diseases.

utilisation from the EMR in 376 tertiary hospitals in China. Using a RDD, the results indicated that retirement had no effects on total inpatient expenditures per visit, but reduced drug expenditures and inpatient days per visit. These RDD results were robust to the inclusion of different control variables and the choice of the bandwidth. Heterogeneity test further revealed that the effects were manifested in people admitted into hospital due to chronic diseases or people through outpatient admission. Males exhibited more reduction of inpatient expenditures from retirement than females.

In the broader context of retirement and healthcare utilisation in China, our findings revealed no evidence of any significant change in total inpatient care expenditures at retirement, which were in some way consistent with previous studies.[8 13 14] It suggests that retirement probably does not cause or exacerbate serious health problems that require inpatient treatment in the short term.[14] The insignificant change of inpatient care utilisation at retirement could also be related to undifferentiated cost sharing rates for outpatient and inpatient care within the Chinese social health insurance system. Chinese social health insurance traditionally focused on catastrophic insurance for serious diseases, with lower cost-sharing rates for inpatient care than for outpatient care, which might create incentives for moral hazard as patients might use more inpatient services to replace outpatient treatments, and thus might avoid using unnecessary inpatient services.[27] These findings underscore the importance of considering the potential effects of

Table 4 Robustness tests: effects of retirement on inpatient healthcare utilisation by ways of hospital admission

	Emergency admission		Outpatient admission	
Dependent variable	Model 1	Model 2	Model 3	Model 4
Total inpatient expenditures per visit†				
Retirement (SE)	−1145.29 (1268.15)	−36.66 (710.33)	1.09 (842.51)	−38.38 (498.15)
Bandwidth	4.69	4.69	3.05	3.05
Sample size	46 436; 43 932	46 436; 43 932	161 337; 159 169	161 337; 159 169
Medical service expenditures				
Retirement (SE)	−490.59 (427.41)	−337.80 (410.29)	525.92 (390.15)	223.36 (235.34)
Bandwidth	5.70	5.70	2.46	2.46
Sample size	56 844; 51 866	56 844; 51 866	108 738; 117 264	108 738; 117 264
Diagnostic tests expenditures				
Retirement (SE)	−224.80 (201.36)	−25.92 (108.65)	86.84 (151.41)	25.19 (88.99)
Bandwidth	4.91	4.91	2.63	2.63
Sample size	46 436; 43 932	46 436; 43 932	108 738; 117 264	108 738; 117 264
Drug expenditures				
Retirement (SE)	−287.79 (621.69)	−3.64 (364.42)	−844.93* (206.29)	−353.75* (101.93)
Bandwidth	3.89	3.89	6.80	6.80
Sample size	34 738; 34 271	34 738; 34 271	297 531; 282 575	297 531; 282 575
Medical consumables expenditures				
Retirement (SE)	309.01 (704.71)	396.70 (390.94)	196.50 (253.45)	134.71 (143.19)
Bandwidth	4.87	4.87	4.44	4.44
Sample size	46 436; 43 932	46 436; 43 932	215 670; 204 037	215 670; 204 037
Inpatient days per visit				
Retirement (SE)	−1.71 (0.97)	−0.65 (0.58)	−0.87 (0.52)	−0.58 (0.32)
Bandwidth	2.85	2.85	2.25	2.25
Sample size	23 413; 25 248	23 413; 25 248	108 738; 117 264	108 738; 117 264
Covariates	Residualised	Residualised	Residualised	Residualised

Model 1 and model 3: unadjusted.
Model 2 and model 4: adjusted for sex, marriage, medical insurance and disease types.
*Significant at 0.1%. Numbers in parentheses show SEs clustered at the person level.
†Total inpatient expenditures per visit also include rehabilitation expenditures, blood expenditures and other expenditures.

healthcare financing structures on healthcare utilisation patterns in the context of retirement.

Different categories of inpatient healthcare utilisation may reflect individual-level health to varying extents.[4] Mainly, we interpreted drug expenditures and inpatient days per visit as indicators of an individual's health status. We found that retirement reduced drug expenditures and inpatient days per visit. These positive effects of retirement on inpatient healthcare utilisation mainly focused on people admitted into hospital due to chronic diseases or people through outpatient admission. Acute hospital admissions was unaffected by retirement status.[15] Improved health after retirement is one possible mechanism through which retirement affects inpatient healthcare utilisation,[8] especially in the reduction or mitigation of non-urgent diseases. The reduction in inpatient expenditures of males was significant, while for females it was statistically insignificant, which was also consistent with a previous study.[4] The sex difference might be mainly due to males' underinvestment in and less attention to health prior to retirement, which led to some improvement in health and thus reduced medical consumption after retirement.

To be exact, retirement can affect inpatient healthcare utilisation through several possible mechanisms. First, retirement relieves employees' work stress and reduces strain.[7 9 10] Employees from physically stressful occupations benefit particularly from the recovery of their physical health, whereas the majority of workers' self-rated and mental health improve after retirement.[8] Second, retirees can also get adequate sleep during weekdays, which may enhance their health.[28] Adequate sleep is essential for maintaining physical and mental well-being, and retirement can provide the opportunity for individuals to establish healthier sleep patterns. Third, retirees can use their extra leisure time to pursue a more active lifestyle

Table 5 Robustness tests: effects of retirement on healthcare utilisation by sex

	Male		Female	
Dependent variable	Model 1	Model 2	Model 3	Model 4
Total inpatient expenditures per visit†				
Retirement (SE)	−1603.96* (798.96)	−1418.64 (833.81)	−52.32 (570.93)	81.98 (633.47)
Bandwidth	3.71	3.71	4.80	4.80
Sample size	93 307; 92 054	93 307; 92 054	178 117; 168 510	178 117; 168 510
Medical service expenditures				
Retirement (SE)	−523.30 (377.42)	−429.22 (387.64)	86.52 (222.67)	125.13 (247.67)
Bandwidth	3.84	3.84	4.57	4.57
Sample size	93 307; 92 054	93 307; 92 054	178 117; 168 510	178 117; 168 510
Diagnostic tests expenditures				
Retirement (SE)	−207.95 (142.30)	−302.38* (140.28)	14.13 (106.79)	103.77 (111.55)
Bandwidth	3.82	3.82	4.15	4.15
Sample size	93 307; 92 054	93 307; 92 054	178 117; 168 510	178 117; 168 510
Drug expenditures				
Retirement (SE)	−733.70* (345.93)	−728.31* (350.62)	−414.66 (250.68)	−380.59 (270.45)
Bandwidth	4.62	4.62	5.31	5.31
Sample size	124 730; 118 003	124 730; 118 003	218 036; 198 942	218 036; 198 942
Medical consumables expenditures				
Retirement (SE)	214.14 (293.92)	270.05 (306.72)	421.45 (295.38)	463.62 (328.55)
Bandwidth	3.45	3.45	4.93	4.93
Sample size	93 307; 92 054	93 307; 92 054	178 117; 168 510	178 117; 168 510
Inpatient days per visit				
Retirement (SE)	−0.88 (0.79)	−0.99 (0.73)	−1.02 (0.56)	−1.13* (0.57)
Bandwidth	2.02	2.02	2.71	2.71
Sample size	62 887; 67 818	62 887; 67 818	89 804; 96 845	89 804; 96 845
Covariates	Residualised	Residualised	Residualised	Residualised

Model 1 and model 3: unadjusted.
Model 2 and model 4: adjusted for marriage, medical insurance, disease types and ways of hospital admission.
*Significant at 5%. Numbers in parentheses show SEs clustered at the person level.
†Total inpatient expenditures per visit also include rehabilitation expenditures, blood expenditures and other expenditures.

by investing more time into daily activities requiring a physical effort, and by more frequently exercising.[8] In addition, healthcare systems with primary care physicians as gatekeepers can effectively decrease healthcare utilisation after retirement.[11] By managing access to specialised care and coordinating services, primary care physicians can help ensure that retirees receive appropriate care while avoiding unnecessary healthcare utilisation.

There are several advantages in our study. First, we explored effects of retirement on healthcare expenditures, which was important in terms of financing the healthcare system; empirical evidence of causality will enable health insurance funds to make an informed assessment of future healthcare costs arising from retirement reforms, which is crucial for maintaining the sustainability of the healthcare system in an ageing society. Second, we used data from the EMR in 376 tertiary hospitals, which provides a wealth of information and can be considered as a proxy for health status without the bias of self-reporting.[29] Third, we explored different categories of healthcare utilisation, such as medical service expenditures, diagnostic tests expenditures, drug expenditures and medical consumables expenditures, which to some extent reflect individuals' health and is unprecedented in China. By providing a comprehensive analysis of healthcare expenditures and utilisation patterns, our findings can inform policy discussions and decision-making processes aimed at promoting the well-being of older adults and ensuring the sustainability of the healthcare system in the context of an ageing society.

Our analysis is subject to some limitations. Due to the institutional setting, we could only derive a causal effect of retirement on healthcare expenditures for inpatient people. Also, due to data censoring, we could estimate only short run effects of retirement. The data set we use does not include health indicators; thus, we could only

speculate about how health effects of retirement might influence our results. In addition, there could be potential regional differences in ageing, medical insurance coverage and public finance systems for pension coverage across various tiers of cities in China. However, due to the limitations in the available data, information regarding the individual's region or city is not accessible in our dataset. As a result, we are unable to explore the regional heterogeneity of retirement effects in the current study.

It was also worth noting that, living arrangement could have implications for the healthcare utilisation patterns of retired individuals in China. For instance, living with adult children might lead to increased informal care, which could reduce the need for inpatient healthcare services. Conversely, the availability of family support might also encourage retired individuals to seek medical care more frequently, as they have someone to accompany them to the hospital or help with post-treatment care. However, due to the limitations of our dataset, we are unable to directly measure the living arrangements of the individuals in our study or explore the potential impact of living with adult children on healthcare utilisation. Lastly, we could not account for aggregate pension contribution and healthcare expenditures due to the limitations of our dataset. Additional information would enable more informed policy recommendations that take into account the full range of economic factors associated with retirement and healthcare utilisation in China.

CONCLUSIONS

Taken together, our study revealed that reduced utilisation at retirement primarily comes in the form of drug expenditures and inpatient days per visit. Therefore, raising the mandatory retirement age as a cost-containment measure could increase costs in the healthcare systems, since older employees face higher opportunity costs to maintain their health status. Our findings may provide useful evidence for policy-makers in other cities in China and elsewhere who look to control medical spending for their burgeoning elderly populations.

Contributors PH initiated this study and was responsible for the overall content as the guarantor. XY and WL designed the study. XY analysed the data and drafted the manuscript. YW and MH helped analyse the data. PH, DZ and XS critically revised the manuscript for important intellectual content. All authors participated in the data collection and approved the final version of the manuscript.

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Competing interests None declared.

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Patient consent for publication Not applicable.

Ethics approval Since the data were from an anonymised database and had no influence on patient care, the Ethics Committee of Beijing University of Chinese medicine deemed this study exempt from ethical approval (No. 2019BZHYLL0201).

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