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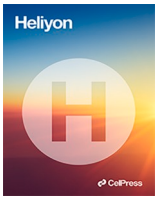

Research article

Can long-term care insurance prevent worsening of frailty among older Chinese adults? A difference-in-differences study based on CHARLS data

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ABSTRACT

Frailty, which is accompanied by negative health outcomes associated with aging, is an increasingly serious public health problem. Long-term care insurance (LTCI) is an effective intervention for frailty in older adults, but few studies have linked LTCI to frailty prevention. This study aimed to determine the role of LTCI in preventing worsening of frailty in older adults. This study used five-wave panel data from the China Health and Retirement Longitudinal Study (CHARLS) 2011 to 2020 to construct an indicator system to assess the frailty index (FI) of surveyed older adults and used a difference-in-differences (DID) method to assess the policy effect of LTCI on frailty among older adults. We found that the full-sample mean of the FI of older adults in China was 0.196, and the implementation of LTCI had a significant negative effect on the FI of older adults. The effect was heterogeneous across sex, age, education and medical insurance groups. LTCI had a more significant negative effect on male group, the middle-aged group, the less educated group, and the URRBMI group, while the effect was less significant for the female and the UEBMI group, and not significant for the more educated and other age groups. That is to say, older Chinese adults are generally frail to different degrees, and the implementation of a LTCI system can prevent worsening of frailty among them, but the effect is not equal across populations. The institutional coverage of LTCI should be further strengthened in the future to slow down the frailty process of the enrollees, so as to promote healthy aging.

1. Introduction

With the increasing aging of the global population, the issue of geriatric health has received widespread attention worldwide [1]. Older adults are often in the declining phase of the life cycle, and the symptoms of vulnerability caused by aging's physiological structures and degenerative changes in the organism predispose these individuals to a degree of susceptibility and vulnerability [2]. Frailty is a common and important geriatric syndrome, characterized by a multifaceted and dynamic decline [3]. Frailty can be seen as a range of age-related degenerative diseases, which can result in serious functional limitations and susceptibility to several negative health outcomes [4,5]. As a result, the continued rise in the proportion of the older population brings with it a greater burden of disease and demand for care, and has significant impacts on health care systems [6,7]. Long-term care (LTC) is a comprehensive service that

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Abbreviations

LTC	long-term care
LTCI	long-term care insurance
CHARLS	China Health and Retirement Longitudinal Study
DID	difference-in-differences
CI	confidence interval
FI	frailty index
UEBMI	Urban Employees Basic Medical Insurance
URRBMI	Urban-Rural Residents Basic Medical Insurance

integrates life care, medical care and social support, serving people with disabilities who cannot perform activities of daily living on their own for a period of time due to diminished physical, mental or cognitive functions [8]. Stabilizing health status and preventing frailty is one of the tasks of LTC [9]. Long-term care insurance (LTCI) is health insurance that provides reimbursement for the cost of care services for participants who need LTC due to old age, illness or disability to cope with the financing of LTC costs in old age and has been well used in developed countries such as Germany and Japan [10]. The Global Strategy and Action Plan for Ageing and Health for 2016–2020, developed by the World Health Organization, states that every country should have an integrated LTC system focused on older people that provides the best and most effective care for older people [11]. Evidence from Japan suggests that frail older adults are more likely to need care from the LTCI system and that the LTCI system provides interventions to prevent the progression of frailty [12,13].

Although developed countries have formed a relatively mature LTC system, the construction of an LTC system in a vast number of less developed countries is lacking [11]. As a developing country that is aging before it becomes rich, the rapid growth of the elderly population poses a major public health challenge for China, especially in improving health care for the elderly population [14]. A study predicted that China would have a rapidly aging society in 2022 and a super aging society in approximately 2030, and the scale of disabled and semidisabled older people and their proportion will also rise from 45.64 million and 17.11 % in 2020 to 69.53 million and 17.44 % in 2030 and further to 120.06 million and 22 % in 2050 [15]. To cope with the rapidly increasing demand for LTC in the future and improve the social security system, China's Ministry of Human Resources and Social Security issued the policy "Guidance on the Piloting of the LTCI System" in 2016, which stipulates the coverage of LTCI, insured objects, fundraising, and treatment payments, and listing 15 cities as the first batch of pilot cities to explore the establishment of China's LTCI system [16]. The LTCI system has made some progress in the pilot areas, and the pilot cities expanded to 49 in 2020. The number of participants reached 108 million in that year, and 835,000 people received insurance benefits [17]. However, it remains to be determined whether the LTCI system has achieved the desired policy effects and whether it can effectively address the health problems of older adults.

Many studies have been conducted to verify the effects of LTCI on health. Chen et al. (2020) summarized the progress of LTCI systems in different countries, with evidence from Germany suggesting that public LTCI beneficiaries experienced substantial improvements in physical health [18]. Sohn et al. (2020) used Korean data to conclude that LTCI health effects were heterogeneous across income groups, with the risk of death higher among low- and middle-income individuals than among high-income individuals among those receiving LTC treatment, and the risk of death was highest among low-income groups not participating in LTCI [19]. In China, Han and Wu (2022) demonstrated the dual effect of "health suppression" and "health promotion" of LTCI [20], but most scholars are more concerned with the improvement or prevention of adverse health outcomes by LTCI among middle-aged and older adults. Ma et al. (2019) found that the implementation of the LTCI system reduced the average medical expenses and medical frequency of middle-aged and elderly residents in Qingdao, which generally had a positive effect on the health level of middle-aged and elderly people [21]. Lei et al. (2022) also found that LTCI was associated with better self-reported health and lower mortality risk for Chinese older adults [22]. Most of the existing studies recognize the positive effect of LTCI on health, but studies in China are still limited: first, they mainly use single indicators such as medical costs or mortality rates, lacking a comprehensive measure of health in old age; and second, they are mostly performed in a single pilot city, and the findings are not generalizable at the national level. Health or frailty largely determines people's quality of life in old age, and one of the original purposes of the LTCI pilot in China was to improve disabled people's quality of life. While few studies have yet linked LTCI with frailty, and relevant studies are mainly from Japan. For example, Yoshiyuki et al. (2023) found that using adult day services lowered the risk of frailty in older adults with low care needs [23]. To further explore whether the implementation of LTCI can prevent worsening of frailty in the elderly population in China, this paper used five-period panel data from the China Health and Retirement Longitudinal Study (CHARLS) to evaluate the policy effects of the LTCI pilot using a difference-in-differences (DID) model. This study validates the preventive role of the LTCI pilot, aiming at better care and healthier aging for older people.

2. Materials and methods

2.1. Samples and data sources

The data in this paper are from five waves of CHARLS in 2011, 2013, 2015, 2018 and 2020. CHARLS is a nationwide, large-scale, multidisciplinary social tracking survey project that aims to collect large-scale microsurvey data on health, work and retirement issues

of middle-aged people over 45 years of age in China. The baseline survey was conducted in 2011 and is tracked every 2–3 years, with the latest data updated in 2020 [24]. The survey was conducted in July and August of the survey year using a stratified random sampling method, with a sample of more than 10,000 households in 150 counties and 450 communities (villages) in 28 provinces, which is nationally representative. The survey covers basic personal information, family structure and health status, medical service utilization and medical insurance, retirement and pension, etc. The details of the CHARLS data are available at its website (http://charls.pku.edu.cn/en).

The LTCI system has been officially piloted in 15 cities since 2016, and CHARLS data for five periods from 2011 to 2020 make it possible to study the differences before and after the implementation of the policy pilot using DID. Of particular note is that although China launched the second batch of LTCI pilot projects in 2020, the pilot cities were announced in September, and the wave 5 of CHARLS research ended in September. It can be said that the second batch of pilot projects had few effects on the research, therefore this study only selected the first batch of pilot cities as intervention areas. This paper makes the following notes on data processing: the elderly population aged 60 years and above at the time of the 2020 survey was selected as the study population, with respondents located in pilot cities who meet the coverage of LTCI as the treatment group and the rest as the control group; the data of respondents from Changchun, Nantong and Shihezi were not collected in the CHARLS database, so this paper mainly evaluates the effect of the LTCI policy in the remaining 12 pilot cities; at the same time, the data of key variables with missing values or outliers were screened out. This paper finally obtains unbalanced panel data with a total sample size of 25060, of which the treatment group sample size is 643 (2.6 % of the total).

2.2. Model construction

To assess the relationship between LTCI and frailty in older adults, this paper uses DID for analysis. As a quasi-experimental analysis method, DID, based on a counterfactual framework, divides different economic individuals suffering from policy shocks and different economic individuals not suffering from policy shocks into treatment and control groups and explores the changes in the dependent variable in two states of policy occurrence or nonoccurrence, which can avoid the effects of externalities and selection bias and has been widely used in econometrics as well as sociology [25].

The benchmark regression model in this paper is set as follows.

$$Y_{it} = \alpha + \beta Treat_i \cdot Post_t + \theta X_i + \mu_i + \gamma_t + \varepsilon_{it}$$

In this equation, i and t denote individual and time; Y_{it} denote the explanatory variables; $Treat_i$ is the treatment group dummy variable indicating whether individual i is covered by LTCI, set to 1 for the treatment group and 0 for the control group; $Post_t$ is a policy pilot dummy variable set to 1 for the year after the pilot and 0 for the year before the pilot; the interaction term $Treat_i \cdot Post_t$ indicates whether individual i is covered by LTCI in year t and is used as an explanatory variable; X_i is a set of control variables, μ_i represents individual fixed effects, γ_t represents time fixed effects, and ε_{it} denotes random error terms.

2.3. Variables and operationalization

2.3.1. Dependent variable: frailty index

The explanatory variable in this paper was the frailty index (FI) of older adults. The FI and the frailty phenotype are the two most commonly employed frailty measures [26]. Among them FI is the proportion of accumulated health deficits, which is calculated as the number of items in which people reported a deficit divided by the number of items considered [27]. The results of the frailty index are stable across different studies, as long as they include the main health domains, even if the type and number of deficits are not the same [28,29]. This is due to the fact that different signs and symptoms show close inter-relatedness in complex patterns in health [30]. And the more health deficits a person has, the weaker they are and the more vulnerable they are to poor health outcomes. The validity of FI has been demonstrated in various populations [31,32]. Studies have shown that FI is more suitable as a reliable predictor of health change, health care utilization, as well as death [29,30,33]. The indicators of FI include mainly biological indicators, disease diagnosis, mobility, mental health and cognitive function [34–36]. According to the selection criteria for health deficits and the availability of data, we selected 44 health assessment questions covering the dimensions of physical health, mental health, functional status, and cognitive status. All variables included in FI are recoded with 0 indicating no deficit, i.e., the healthiest state and 1 indicating the maximum expression of deficit, i.e., the least healthy state. FI is measured by summing the scores of the indicators using different dimensions and dividing them by the theoretical maximum score, and the results are taken in the range of 0–1. The higher the score, the worse the health status of the sample individuals.

Regarding the specific indicator variables and how they are coded, physical health covers 14 chronic diseases, with a score of 1 for the presence of that disease and 0 for its absence. Mental health was assessed using the CES-D scale, with frequent depressive mood scores of 1 and less frequent depressive mood scores of 0. Functional status included ADL, IADL and each activity was rated as independent (1 score), partially dependent (0.5 score), or totally dependent (0 score) by performance. Cognitive status was assessed using the MMSE scale with an incorrect response score of 1 and a correct response score of 0.

2.3.2. Independent variables

The explanatory variable in this paper is "whether covered by LTCI" (yes = 1, no = 0). The policy stipulates that LTCI mainly covers the population insured by Urban Employees Basic Medical Insurance (UEBMI), and cities with conditions can expand the scope of

coverage to Urban-Rural Residents Basic Medical Insurance (URRBMI). Therefore, the scope of pilot LTCI varies from city to city, with some including only employee health insurance and others including resident health insurance. This variable takes the value of 1 when the individual is located in a city where LTCI has been implemented and the individual is covered by the corresponding UEBMI or URRBMI; otherwise, it takes the value of 0. Older adults in a total of 12 pilot cities, including Chengde, Qiqihar, Shanghai, Suzhou, Ningbo, Anqing, Shangrao, Jingmen, Guangzhou, Chongqing, Chengdu, and Qingdao, who were eligible for LTCI were included in the treatment group, and the remaining older adults who were not covered by LTCI were included in the control group.

2.3.3. Control variables

Referring to previous literature [31,37,38], the control variables selected in this paper included age, sex, household nature, years of education, marital status, exercise, and smoking and drinking, covering the basic personal characteristics variables and health behavior characteristics variables, respectively. Age is a continuous variable set as the difference between the year of the questionnaire and the year of the individual's birth. Sex is a dummy variable, assigned a value of 1 for males and 0 for females. Years of education are calculated based on the highest level of education obtained by the individual, with values of 0, 3, 6, 9, 12, 15, 16, 19 and 23 assigned to illiterate, private or incomplete elementary, elementary, junior high, high school and junior college, college, bachelor's, master's and doctoral students, respectively. The household nature, also konwn as hukou, is a dummy variable, agricultural household = 1 and nonagricultural household = 0. Marital status was used as a dummy variable, married = 1, widowed, divorced or unmarried = 0. Exercise was used as a dummy variable, with exercise behavior in the past month = 1, otherwise 0. Smoking as a dummy variable, ever smoked = 1, otherwise 0. Drinking is a dummy variable, having consumed alcohol in the past month = 1, otherwise 0.

3. Results

3.1. Descriptive statistics

Table 1 reports the results of descriptive statistics for each variable according to the total sample, treatment group and control group. For the dependent variable, FI is usually divided into three levels: robust (frailty index $\leq$0.10), pre-frail (frailty index $>$0.10 to $<$ 0.20) and frail (frailty index $\geq$0.21) [39]. The mean values of FI reached pre-frail levels in both the treatment and control groups but were significantly lower in the treatment group than in the control group. Regarding the basic personal characteristics, the older adults in the treatment group were similar to the control group in age and marital status, but with more males and longer years of education, as well as a lower proportion of agricultural household. Regarding health behavior characteristics, older adults in the treatment group were more likely to participate in physical activity and drink alcohol, and less likely to smoke, but the difference is not significant. If the difference in FI before and after the implementation of the LTCI is still not explained after controlling for the above variables, especially after propensity score matching, then it may indicate that the difference is brought about by the implementation of the LTCI system. This paper will perform further analysis using an empirical model in the next section.

3.2. Parallel trend test

The DID regression is designed to find the difference between "the change in the FI after an individual is covered by LTCI" and "the change in the FI assuming that this part of the population is not covered by LTCI", and the latter is counterfactual. The validity of the DID estimation results is predicated on satisfying the parallel trend assumption that individuals in the treatment and control groups have a consistent trend of change in FI in the absence of LTCI policy intervention to ensure the randomization of the treatment and control groups. The time trend graph and the event study approach are two methods commonly used for parallel trend tests, where the event study approach is used to generate the interaction term between the year dummy variable and the treatment group dummy variable and add it to the econometric model for regression, and the coefficient of the interaction term obtained is the difference between the treatment and control groups in each period, which is more scientifically accurate than drawing a parallel trend graph [40].

This paper uses the event study approach to test the assumption of parallel trends in the data. After controlling for individual and time fixed effects, the estimated coefficients and their confidence intervals are shown in Fig. 1. The results showed that the coefficients

Table 1
Basic characteristics for variables.

Characteristics	Total sample (n = 25060)	Treatment group (n = 643)	Control group (n = 24631)	*p* value
Frailty Index,	0.196 ± 0.101	0.163 ± 0.088	0.197 ± 0.101	0.000
Age, years	66.161 ± 7.320	66.463 ± 7.759	66.153 ± 7.309	0.289
Sex, male	11606 (46.3)	329 (51.2)	11277 (46.2)	0.012
Education, years	5.185 ± 4.073	6.519 ± 4.031	5.150 ± 4.068	0.000
Hukou, agricultural	17956 (71.7)	270 (42.1)	17686 (72.4)	0.000
Marital status, married	19972 (79.7)	526 (81.8)	19446 (79.6)	0.178
Exercise, yes	1941 (7.8)	64 (10.0)	1877 (7.7)	0.034
Smoking, yes	13078 (41.4)	238 (37.0)	10140 (41.5)	0.022
Drinking, yes	5838 (23.3)	168 (26.1)	5670 (23.2)	0.085

Data are expressed as mean(SD) for continuous variables and as n (%) for categorical variables.

were not significant in 2013, and 2015, indicating that there was no significant difference in the degree of frailty between the older adults in the treatment and control groups before the implementation of the LTCI pilot policy in 2016. And although there were significant differences in 2011, the treatment group was higher than the control group and would not affect the results of the DID analysis. Therefore, it can be said that it satisfies the parallel trend hypothesis. In addition, the estimated coefficients in 2018 decreased significantly after the LTCI pilot, indicating that the effect of LTCI on the frailty index for older adults was significantly negative.

3.3. Main results

This section examines the policy effects of LTCI on the frailty of older adults using panel data, as shown in Table 2. Model 1 and Model 2 respectively show the effect of LTCI on FI of older adults when no control variables are included and when all control variables are included. The results showed that the implementation of LTCI had a significant negative effect on FI of older adults after controlling for time fixed effects and individual fixed effects, and this finding was still supported after the inclusion of control variables, with estimated coefficients significant at the 1 % levels. This suggests that LTCI can prevent the development of frailty in older adults and that the pilot of the LTCI system in China has had some success.

3.4. Robustness tests

3.4.1. Replacing the explanatory variable

Using the self-rated health instead of FI to measure frailty in older adults, the results in Table 3 showed that the implementation of LTCI was indeed effective in preventing degradation of frailty and and improving the self-rated health level in older adults, confirming the baseline regression results.

3.4.2. Placebo test

To further test whether the policy effects of LTCI were driven by unobservable factors at the individual-year level, the treatment group was randomly selected for a placebo test. In this study, 100 individuals were randomly selected from the survey respondents as the treatment group, and the other individuals were selected as the control group. Since the “pseudotreatment” group was randomly generated, the “pseudotreatment” should not have a significant effect on the core variables, i.e., the regression coefficient should theoretically be zero, and the opposite is evidence of the influence of chance and other policy factors. Additionally, to avoid experimental errors from interfering with the results, the above process is repeated 500 times for regression in this section. The following figure reports the kernel density distribution of the regression estimated coefficients after 500 random samples with the scatter distribution of the estimated coefficient p values. It can be seen that the mean of the estimated coefficients after the randomization treatment is close to zero and nonsignificant, while the estimated coefficients in the previous paper significantly deviate from the value of zero (shown in Fig. 2). Thus, the effects of other chance factors are excluded, and the robustness of the previous baseline regression model estimates is demonstrated.

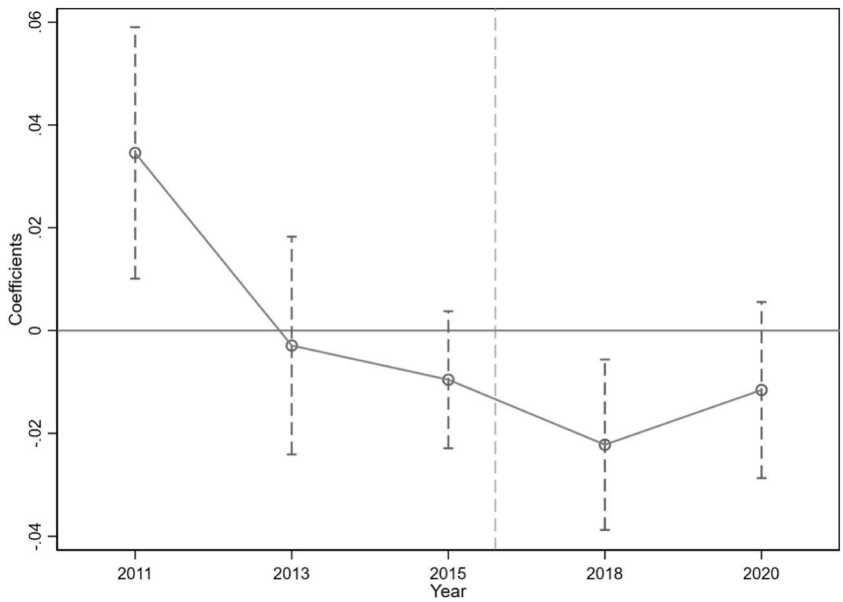

Fig. 1. Result of the parallel trend test.

Table 2
The benchmark regression results of DID.

Variables	Model 1 (n = 25060)		Model 2 (n = 25051)	
	Coeff. (95%CI)	*p* value	Coeff. (95%CI)	*p* value
Treat × *Post*	−0.017 (−0.028, −0.006)	0.003	−0.017 (−0.028, −0.006)	0.003
Constant term	0.196 (0.195, 0.197)	0.000	0.255 (0.162, 0.347)	0.000
Control variables	No		Yes	
Time fixed effects	Yes		Yes	
Individual fixed effects	Yes		Yes	
R-squared	0.699		0.699	

Model 1: control variables are not included; Model 2: all control variables are included.

Table 3
The regression results of replacing the dependent variable.

Variables	Model 3 (n = 16845)	
	Coeff. (95%CI)	*p* value
Treat × *Post*	0.038 (−0.002, 0.077)	0.060
Constant term	0.402 (0.088, 0.716)	0.012
Control variables	Yes	
Time fixed effects	Yes	
Individual fixed effects	Yes	
R-squared	0.661	

Model 3: using self-rated health instead of the frailty index.

3.4.3. PSM-DID

To avoid the endogeneity problem caused by policy nonrandomness and to exclude possible selectivity bias, the effect of LTCI on frailty is estimated again in this paper using PSM-DID. There are two main steps: first, a logit model is used to predict the pilot probability of LTCI, and individuals who are closer to the treatment group in terms of propensity score are selected from the control group as the control group. To be specific, we adopt the nearest neighbor matching method within the caliper, with predictors including all control variables and a caliper width of 0.05. The bias of matched covariates is almost all less than 10 % and significantly smaller than unmatched covariates, and none of the *t*-test results are significant, indicating that there is no significant difference in the values of covariates between the two groups after PSM, thus excluding the potential influence of group differences in control variables on the results. Second, based on the matched treatment and control groups, Equation (1) was used to again identify the effect of LTCI on frailty in older adults. The model estimation results are shown in Table 4. After replacing the PSM-DID model approach, the coefficient of the interaction term the coefficient of the interaction term is still significantly negative, again proving the robustness of the

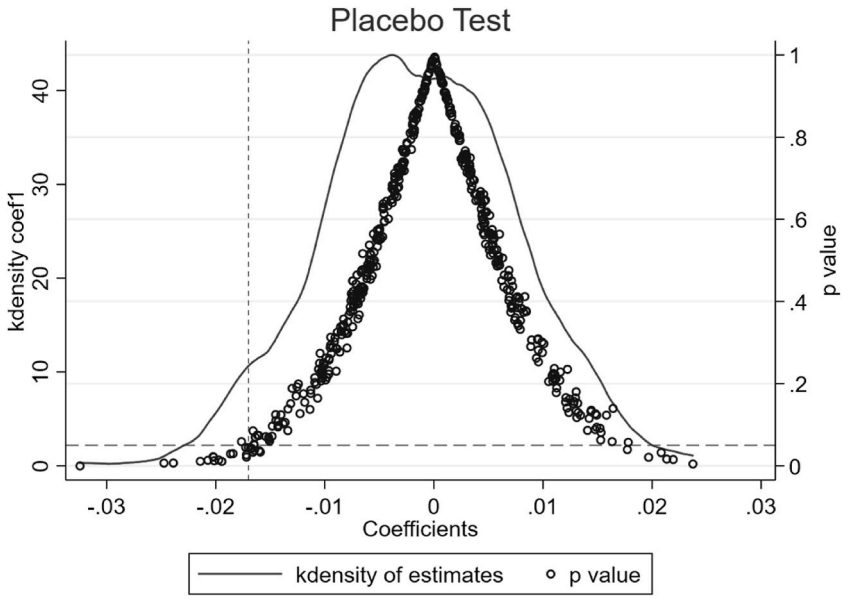

Fig. 2. Results of the placebo test.

study results.

3.5. Mechanism analysis

With regard to how LTCI prevents the deterioration of frailty in older adults, this study explores the mechanism in terms of care selection. The care provided by spouses, children, siblings and other relatives is defined as family care, and the care provided by employees, volunteers, community service personnel and nursing home personnel is defined as social care. LTCI in China exists in different forms, with all pilot cities providing reimbursement rates for professional care services, and some providing in-home services for participants, but both cash compensation and service provision contribute to the availability of social care. The 12 pilot cities involved in CHARLS can be categorized into two types, one offering only cash compensation and one offering both cash compensation and free services. The results in Tables 5 and 6 showed that both types of LTCI pilots significantly enhanced the use of social care, with a stronger effect in cities providing free services. Besides, both pilots also had a negative effect on family care, but the effect was not significant.

We further compared the difference in the impact of the LTCI on the FI under the two types (see Table 7). The results showed little difference between the coefficients of the two types, but the type that also provided service had a more significant effect, again illustrating the role of specialist social care. With the implementation of LTCI, participants have the opportunity to choose social care and enjoy more specialized services, which can better prevent the development of frailty than informal family care.

3.6. Heterogeneity analysis

To better explore the heterogeneity of the effect of LTCI on frailty in older adults, this paper also conducted subsample regressions on older adults along four dimensions: sex, age stage, education level and type of medical insurance. To be specific, sex was categorized as male group and female group. The respondents aged 60–69 are divided into a younger group, with the middle group aged 70–79 and the older group aged 80 and above. Survey respondents with 9 years of education or less, i.e., with an education level of junior high school or less, were categorized as the less educated group, and those with 10 years of education or more, i.e., with an education level of senior high school or more, were categorized as the more educated group. And the type of medical insurance included UEBMI and URRBMI. Table 8 showed that LTCI had a negative effect on FI for either males or females, however the effect on females is less significant. Table 9 showed that LTCI exerted a significant frailty suppression effect on the middle-aged older adults. But it is not significant for elderly people under 70 and over 80 years old. Table 10 showed that the inhibitory effect of LTCI on frailty in older adults occurred mainly in the less educated group, and the effect was not significant in the more educated group. Table 11 showed that the LTCI had a suppressive effect on FI for both UEBMI and URRBMI enrollees, but the effect was more significant for those enrolled in URRBMI.

4. Discussion

Based on data from CHARLS 2011 to 2020, we calculated a full-sample mean value of 0.196 (standard deviation 0.101) for FI for Chinese older adults. Similar to our results, Yang and Wang (2016) used data from a total of four follow-up surveys from 2002 to 2011 of the CLHLS to measure the mean value of FI for middle-aged and elderly people as 0.18 [41]. Fan et al. (2020) obtained a mean FI of 0.099 (standard deviation 0.064) for all participants using the China Kadoorie Biobank [35]. The difference is mainly because the population surveyed in this study was adults between 30 and 79 years of age, and if the sample was limited to those aged 65 years and older, 29.2 % of cases were classified as robust, 61.9 % as pre-frail, and 8.9 % as frail [35]. In addition, a multicountry study including China, Ghana, India, Mexico, South Africa and Russia provided estimates of the prevalence of frailty in the elderly population, showing that the age-standardized prevalence of frailty in these six countries was 56.9 % in India, 38.0 % in South Africa, 37.9 % in Ghana, 30.8 % in Russia, 30.4 % in Mexico and 13.5 % in China [42]. To further compare the findings, this study divided the sample into three categories according to FI: 18.2 % of the older adults were robust, 56.5 % were pre-frail, and 25.3 % were frail. The results of this study regarding the current status of frailty among older Chinese adults are slightly higher than those of previous studies, but five waves data of CHARLS also shows an increasing trend in FI. Another study based on CHARLS also noted that the average FI at the baseline survey was 0.18, and it increased steadily at follow-up two waves [43], so this discrepancy can be understood.

Table 4
The regression results of PSM-DID.

Variables	Model 4 (n = 23201)	
	Coeff. (95%CI)	*p* value
Treat × *Post*	−0.016 (−0.029, −0.003)	0.013
Constant term	0.139 (0.122, 0.155)	0.000
Control variables	Yes	
Time fixed effects	Yes	
Individual fixed effects	Yes	
R-squared	0.140	

Model 4: PSM-DID.

Table 5
The regression results of care models in cities also providing free services.

Variables	Model 5 (n = 23569)		Model 6 (n = 23569)	
	Coeff. (95%CI)	*p* value	Coeff. (95%CI)	*p* value
Treat × *Post*	0.049 (0.009, 0.090)	0.016	−0.070 (−0.156, 0.017)	0.114
Constant term	0.007 (−0.138, 0.152)	0.928	0.432 (−0.128, 0.991)	0.130
Control variables	Yes		Yes	
Time fixed effects	Yes		Yes	
Individual fixed effects	Yes		Yes	
R-squared	0.428		0.520	

Model 5: Social care; Model 6: Family care.

Table 6
The regression results of care models in cities with cash compensation only.

Variables	Model 7 (n = 24185)		Model 8 (n = 24185)	
	Coeff. (95%CI)	*p* value	Coeff. (95%CI)	*p* value
Treat × *Post*	0.040 (−0.007, 0.088)	0.096	−0.085 (−0.187, 0.017)	0.104
Constant term	0.018 (−0.135, 0.171)	0.820	0.405 (−0.179, 0.988)	0.174
Control variables	Yes		Yes	
Time fixed effects	Yes		Yes	
Individual fixed effects	Yes		Yes	
R-squared	0.426		0.516	

Model 7: Social care; Model 8: Family care.

Table 7
The comparison of the effects of two types of LTCI pilots on FI.

Variables	Model 9 (n = 23569)		Model 10 (n = 24185)	
	Coeff. (95%CI)	*p* value	Coeff. (95%CI)	*p* value
Treat × *Post*	−0.015 (−0.029, −0.001)	0.041	−0.016 (−0.033, 0.002)	0.075
Constant term	0.242 (0.148, 0.337)	0.000	0.229 (0.139, 0.319)	0.000
Control variables	Yes		Yes	
Time fixed effects	Yes		Yes	
Individual fixed effects	Yes		Yes	
R-squared	0.700		0.698	

Model 9: Also provide services; Model 10: Provide cash only.

Table 8
The subsample regression results by sex.

Variables	Model 11 (n = 11578)		Model 12 (n = 13418)	
	Coeff. (95%CI)	*p* value	Coeff. (95%CI)	*p* value
Treat × *Post*	−0.017 (−0.033, −0.002)	0.029	−0.014 (−0.030, 0.001)	0.067
Constant term	0.295 (0.133, 0.457)	0.000	0.220 (0.113, 0.327)	0.000
Control variables	Yes		Yes	
Time fixed effects	Yes		Yes	
Individual fixed effects	Yes		Yes	
R-squared	0.677		0.707	

Model 11: Male; Model 12: Female.

This study found that LTCI was effective in preventing the degradation of frailty among older adults in China, which provides an empirical basis for its further piloting and full implementation in China. Frailty is a key concept in identifying older adults at risk for poor outcomes and in shaping health care design and response to population aging [44]. However, frailty is not just a concept in theoretical research; it is a difficult public health issue, and the real value of frailty measurement for patients, researchers, and health care systems lies in identifying populations at risk [45]. The benefits of identifying frailty in older populations may be minimal if interventions are not implemented to mitigate the adverse consequences of frailty in large populations [36]. The real challenge in dealing with frailty therefore lies in convincing governments to act early to find appropriate ways to prevent it [46]. Onishi et al. (2024) investigated the prevalence and characteristics of frailty using data from the LTCI system in Japan, and encouraged older adults to enter LTCI system and seek support at an early stage [47]. But this is more value-oriented than evidence-based.

The LTC system is an effective intervention for frailty in older adults. It has been shown that specialized LTC is beneficial to improve

Table 9
The subsample regression results by different age stages.

Variables	Model 13 (n = 10627)		Model 14 (n = 4871)		Model 15 (n = 848)	
	Coeff. (95%CI)	*p* value	Coeff. (95%CI)	*p* value	Coeff. (95%CI)	*p* value
Treat × *Post*	−0.014 (−0.036, 0.009)	0.226	−0.032 (−0.062, −0.001)	0.040	−0.044 (−0.120, 0.032)	0.256
Constant term	0.216 (−0.038, 0.471)	0.096	0.130 (−0.189, 0.449)	0.424	0.300 (−0.100, 0.701)	0.141
Control variables	Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes	
Individual fixed effects	Yes		Yes		Yes	
R-squared	0.746		0.746		0.763	

Model 13: Younger; Model 14: Middle aged; Model 15: Older.

Table 10
The subsample regression results by different education levels.

Variables	Model 16 (n = 2781)		Model 17 (n = 22111)	
	Coeff. (95%CI)	*p* value	Coeff. (95%CI)	*p* value
Treat × *Post*	−0.014 (−0.040, 0.012)	0.286	−0.017 (−0.029, −0.004)	0.008
Constant term	0.210 (−0.226, 0.647)	0.344	0.261 (0.171, 0.351)	0.000
Control variables	Yes		Yes	
Time fixed effects	Yes		Yes	
Individual fixed effects	Yes		Yes	
R-squared	0.644		0.692	

Model 16: More educated; Model 17: Less educated.

Table 11
The subsample regression results by type of medical insurance.

Variables	Model 18 (n = 4033)		Model 19 (n = 15716)	
	Coeff. (95%CI)	*p* value	Coeff. (95%CI)	*p* value
Treat × *Post*	−0.014 (−0.030, 0.002)	0.085	−0.016 (−0.031, −0.001)	0.038
Constant term	0.290 (−0.074, 0.655)	0.118	0.186 (0.090, 0.283)	0.000
Control variables	Yes		Yes	
Time fixed effects	Yes		Yes	
Individual fixed effects	Yes		Yes	
R-squared	0.645		0.677	

Model 18: UEBMI; Model 19: URRBMI.

the health of older adults with disabilities in their later years [48]. The logic of the LTCI system to effectively respond to the health problems of older adults lies in its ability to improve the quality of life of older adults through the provision of life care and nursing services [49]. On the other hand, by sharing the cost of care, LTCI not only reduces the financial burden of individuals and families but also promotes the development of the care service industry so that more older people can enjoy specialized care services [50]. Cai et al. (2022) found that enrollment in LTCI increased the probability that a family with incapacity would choose a social care model by 23.3 percentage points and decreased the proportion choosing a family care model by 20.5 percentage points [51]. This study also verified that LTCI promotes the substitution of social care for family care. In addition, a study by Wang and Feng (2021) found that LTCI improved care recipient health, significantly reduced individual health care utilization, resulted in an approximate 12.3 % decrease in hospital days and an approximate 10.5 % decrease in hospital costs and that for every 1 RMB invested in LTCI home care subsidies, approximately 8.60 RMB in health insurance funds would be saved [52]. This also validates the preventive role of LTCI, which mitigates the negative effects of frailty by front-loading interventions. The LTCI system not only has the social effect of preventing frailty in old age but also has the economic benefit of reducing health care expenditures, which is a better choice for less developed countries to address the public health problems caused by population aging.

The heterogeneity of LTCI implementation effects among different groups provides directions for its future institutional optimization. It could be seen that the frailty suppression effect of LTCI differ between the male and female groups. We speculate that this may be due to gender differences in frailty trajectories. Several studies have pointed out that frailty is more prevalent in female [53,54]. An estimation based on CLHLS showed that women had survival advantages while men had health advantages from a demographic perspective, while the cost of LTC for women may increase by up to 75 % compared to that for men [55]. Data analysis showed that the mean FI of females was 0.208, which was significantly higher than that of males (0.181). So LTCI may only ease mild frailty, and females tend to appear more frail and benefit less from LTCI.

In addition, we found that the process of LTCI preventing the deterioration of frailty mainly occurs in elderly people aged 70–79. It is easy to understand that frailty is a multifaceted decline related to age, and the FI increases exponentially with age [26,56].

Therefore, elderly people under the age of 70 are not severely frail in general and are less likely to need LTC, so LTCI has not had a significant impact on them. As age increases and frailty intensifies, the professional services provided by LTCI begin to have a preventive effect, curbing the development of frailty. However, the current pilot of LTC insurance has not brought about much improvement to the more frail senior citizens. Unlike us, Cao et al. (2023) found that LTCI was more beneficial for younger adults (under 60) in ADL and IADL, but they also attributed the age heterogeneity to poorer health resilience in the older adults [57]. This inter-outcome variation may stem from the different trajectories of disability and frailty. Although Xie and Feng (2022) found that after using LTCI, the mortality rate of elderly people with higher levels of care, that is to say more frail, decreased significantly compared to those with lower levels of care [58]. But the system design of LTCI should not only ensure their survival, but also enhance their well-being, so more efforts are needed in preventing the worsening of frailty.

This study found that LTCI had a more significant effect on frailty suppression for those with lower levels of education than the more educated group. One study found a significant negative effect of LTCI on health prevention behaviors in the group with higher levels of education, while the effect of LTCI was not significant in the group with lower levels of education, and concluded that this was due to differences in the health information-increasing effect of LTCI across groups [20]. LTCI increased health knowledge for the less educated group, but for the more educated group, an ex ante moral hazard effect dominated, increasing their probability of engaging in unhealthy behaviors, explaining this heterogeneity to some extent. This study also argues that for older Chinese people, the level of education largely represents their social class, and those with lower levels of education also have fewer social resources. The services and subsidies brought by LTCI can effectively improve their health conditions and thus prevent frailty, while for those with higher levels of education, the effect of LTCI is less significant due to diminishing marginal utility. As stated by Cao et al. (2023), LTCI was a formal social support mechanism that could contribute to the social resources available to individuals with lower levels of education [57].

Current research views are divided on whether LTCI can mitigate health inequality. A Dutch study calculateda a negative horizontal inequity index, which implies that the poor receive more value from LTC than the rich [59]. Tian et al. (2024) pointed that the concentration index of LTCI was 0.5748 in China, indicating a possible 'pro-rich' health inequality in the implementation of it [60]. This study found that the role of LTCI was more significant for URRBMI enrollees, whose socioeconomic status was generally lower than those UEBMI enrollees. For reasons similar to those mentioned above, as a mutually supportive care system, LTCI provides care at low cost. It is particularly useful for those who have not had access to care services in the past. Lei et al. (2022) also reckoned that lower-income older adults benefited more from LTCI coverage in terms of most of the outcomes. So we consider that LTCI narrows the health gap among different socioeconomic groups to some extent.

Current research and practice in China pay more attention to disease and disability among the older people, while frailty and its prevention are neglected to some extent. Our results show that older Chinese adults are generally frail to different degrees, and the pilot of LTCI can prevent frailty among them, especially for those less educated or middle-aged older people. This study provides an empirical basis for the preventive effect of LTCI, which helps to increase confidence in its policy-making and further implementation. China should strengthen the promotion of LTCI and facilitate service coverage for the disabled, thereby preventing the worsening of frailty and reducing the healthcare burden in the future.

This study also has several limitations. Because public data such as CHARLS, as well as CLHLS and CLASS, do not include follow-up surveys on LTCI, we refer to similar studies and use the condition of whether the respondent is in a pilot city for LTCI and eligible for coverage to make inferences. But actually this does not necessarily equate to the respondent's participation in LTCI, and the selection of the experimental group may have some bias. Second, due to the lack of biomarker data from CHARLS, the FI in this study does not include objective health indicators. Thus, the information involved is self-reported and somewhat subjective. Third, this study validates the effect of a pilot LTCI in China on preventing frailty in older adults, but the generalizability of our results to settings outside of China is unclear. Both institutional and ethnic differences may have an impact on this, so it remains to be considered when extending the findings to other countries or regions.

5. Conclusion

The challenges of an aging society do not stem exclusively from the number or proportion of the older population but also from the health status of older adults. Across the globe, frailty in older adults is a growing problem for many countries as populations age, especially for countries with inadequate healthcare systems. The challenge is to quickly build care systems that are responsive to the needs of the population and to adequately train sufficient care providers. Compared to the welfare-based LTC services provided in developed countries, LTCI is mutually beneficial and can reduce the financial burden of LTC system implementation. And as a result, China's LTCI system can also provide lessons for other less developed countries. This study constructed a comprehensive FI indicator system and measured the policy effects of the LTCI pilot based on a national sample of older Chinese adults. This study found that frailty was prevalent among older Chinese adults to varying degrees. Andthe implementation of the LTCI system was able to prevent an increase in frailty among older adults by providing professional social care as an alternative to family care, but this effect was heterogeneous across groups. This study provides new empirical evidence on the relationship between LTCI and the health of older adults, making effective support for the implementation of LTCI systems in China as well as other developing countries which are facing the challenges of demographic transition and increasing LTC needs, and providing feasible intervention options to promote healthy aging around the world.

Ethics statement

Review and/or approval by an ethics committee was not needed for this study because [The data for this study were obtained exclusively from the China Health and Retirement Longitudinal Study (CHARLS). All waves of the CHARLS survey were approved by the Biomedical Ethics Committee of Peking University, and each respondent who agreed to participate in the survey was asked to sign two copies of the informed consent form, which did not need to be approved separately for this study].

Data availability statement

The original data is from China Health and Retirement Longitudinal Study. The authors do not have permission to share data.

CRediT authorship contribution statement

Yuqun Hu: Writing – original draft, Software, Methodology, Formal analysis, Conceptualization. **Yuan Liu:** Writing – review & editing, Validation, Conceptualization. **Tieying Feng:** Writing – review & editing, Supervision, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e37074.

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