

A Study on the Relationship Between Regional Population Aging and Health Consumption: An Empirical Analysis Based on Provincial Panel Data

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Abstract: As population aging continues to deepen in China, its impact on residents' health consumption has become an important issue in public policy and health economics. Using a balanced panel dataset of 31 provincial-level administrative units in China's mainland from 2012 to 2021, this study examines the relationship between regional population aging and residents' health consumption under a two-way fixed-effects framework. All monetary variables are deflated to 2012-constant yuan using province-level CPI indices. The results show that population aging is significantly and positively associated with real per-capita health consumption. After controlling for economic development, urbanization, income, government health expenditure, and medical insurance coverage, a one-percentage-point increase in the share of the population aged 65 and above is associated with an increase of approximately 156.8 yuan in real per-capita health consumption. The result remains robust under alternative demographic measures, alternative dependent variables, and sub-sample estimation. The moderating effects of economic development and insurance coverage are not significant at the provincial level, while regional differences are evident, with the strongest association observed in the central region. These findings suggest that population aging should be incorporated into medium- and long-term health-resource planning, with greater attention given to regions facing faster aging and relatively constrained health-service capacity.

Keywords: Population Aging; Health Consumption; Provincial Panel Data; Social Security; Silver Economy.

1. Introduction

In recent years, China's population aging has accelerated significantly, with both the size and proportion of the elderly population continuing to rise. According to the *2021 Bulletin on the Development of National Undertakings for the Elderly*, by the end of 2021, the number of people aged 60 and over in China had reached 267 million, accounting for 18.9% of the total population. The proportion of people aged 65 and above has also continued to increase. This indicates that China has already entered an aging society, with population aging continuing to deepen in both scale and intensity. [1] As the elderly population expands, demand for medical care, rehabilitation, nursing, chronic disease management, and long-term care is expected to remain high over the long term. Therefore, how to safeguard health and optimize resource allocation against the backdrop of deepening population aging has become an unavoidable issue in public policy. [2] From the perspective of household and resident behavior, population aging not only implies a rising demand for health services among older adults but also affects overall household consumption and saving decisions through intergenerational support relationships. On the one hand, older adults are more likely to generate relatively rigid demand for medical care, rehabilitation and nursing, and long-term care services. On the other hand, under conditions of limited income growth, uncertainty about retirement security, and increasing family support burdens, middle-aged and younger households may strengthen their precautionary saving motives, thereby crowding out part of current consumption. [3] In other words, the impact of aging on consumption is not simply reflected in an increase or decrease in total consumption; rather, it is more

likely to appear as a reallocation of the consumption structure, with health-related consumption becoming increasingly important in total household consumption. [4] Meanwhile, studies focusing on older individuals also suggest that their consumption behavior is influenced by multiple factors, including health status, family support, social security arrangements, and the service supply environment. [5]

However, existing research still has clear limitations in addressing this issue. First, many studies focus on the impact of population aging on overall consumption, the household consumption rate, or macro-level health expenditure, while paying limited attention to residents' health consumption, which is a more specific and behavior-oriented variable. Second, although some studies have examined the relationship between aging, health expenditure, and health outcomes, few have explained from the perspective of regional differences why the capacity to transform health needs into actual consumption varies across different economic and social conditions. Third, in a country such as China, where regional development is highly uneven, factors such as economic development, medical resources, social security capacity, and fiscal support may all shape the pathway through which aging affects health consumption. Therefore, analyzing this issue only from a national average perspective is insufficient to reveal its underlying structural differences.

Based on this, this paper focuses on the relationship between regional population aging and health consumption and seeks to answer the following questions. First, does population aging significantly affect the level of residents' health consumption at the provincial level? Second, do economic development and social security conditions

moderate this relationship? Third, does this effect differ significantly across eastern, central, and western China? By addressing these questions, this study aims to further understand the logic of regional resource allocation and institutional design under population aging from the perspective of residents' health consumption, and to provide empirical support for the development of the silver economy and healthy aging policies.

2. Literature Review

2.1. Studies on Population Aging and Residents' Consumption Behavior

Existing research on the relationship between population aging and consumption behavior has mainly been conducted at the macro and household levels. At the macro level, studies generally suggest that population aging changes the overall consumption tendency of society. Some studies based on provincial panel data find that an increase in the old-age dependency ratio significantly reduces residents' average propensity to consume and per-capita consumption expenditure, indicating that, under the current income and social security conditions, aging may generally have a suppressing effect on residents' consumption. [6]

From the perspective of household behavior, aging often interacts with rising elderly-support pressure, uncertain income expectations, and housing expenditure burdens. [7] These factors make middle-aged and younger households more inclined to increase savings and reduce current consumption. In particular, "sandwich-generation" families, which face the dual burden of supporting elderly parents and raising children, tend to display stronger risk-averse behavior. [4]

The consumption behavior of older adults themselves is not determined solely by income and prices. [8] It is also shaped by multiple factors, including health status, family support, social security, and the service supply environment. Relevant studies point out that medical care, cultural and recreational activities, and social services are important components of current elderly consumption demand. However, in practice, older adults often face a gap between "having demand" and "being able to realize that demand through actual consumption." [5]

2.2. Studies on Aging, Health Expenditure, and Health Outcomes

In the field of health economics, the relationship between aging and health expenditure has long been an important research focus. Existing studies show that population aging significantly increases health expenditure and creates pressure on fiscal sustainability and the medical security system. [9] At the same time, health investment is not merely a cost; it may also have positive effects on medium- and long-term economic growth by improving labor productivity and population health. [10]

At the micro level, some studies examine aging from the perspective of older adults' health outcomes. They find that unmet long-term care needs are significantly associated with depression, deteriorating health, and lower subjective well-being among older adults. Rural older people, in particular, are more likely to face a "double disadvantage" caused by insufficient care resources and mental health risks. This suggests that in an aging society, the key issue is not only whether the scale of health expenditure increases, but also

whether such spending can be effectively transformed into accessible, affordable, and need-responsive health and care services. [11] [12]

2.3. The Silver Economy and International Experience

As population aging deepens, the silver economy has gradually become an important topic in both academic and policy discussions. In terms of international experience, Japan is one of the earliest countries to enter a super-aged society. Its practices in pension system reform, long-term care insurance, and community-based integrated care provide important lessons for countries that are aging later. Existing research shows that, through relatively well-developed institutional arrangements, Japan has to some extent transformed the pressure of aging into a driving force for the development of health industries, care services, and age-friendly products. This has promoted the growth of related sectors, including rehabilitation aids, age-friendly housing, health foods, and long-term care services. [13]

For China, the silver economy does not simply mean an expansion of the market for elderly-oriented products. More importantly, it means promoting the transformation of health needs into actual consumption and industrial opportunities through institutional support. Therefore, studying the relationship between population aging and health consumption not only helps explain residents' consumption behavior, but also contributes to understanding economic structural transformation and public policy responses under the background of aging. [2]

3. Theoretical Analysis and Research Hypotheses

3.1. Theoretical Framework

This paper develops a simple analytical framework linking population aging, health demand, payment capacity, and institutional conditions. The basic logic is that population aging first increases residents' potential demand for health-related goods and services. However, whether such potential demand can be transformed into actual health consumption depends on residents' payment capacity and the institutional environment. Therefore, the relationship between aging and health consumption can be understood through three channels: the health demand channel, the payment capacity channel, and the institutional support channel.

First, population aging may promote health consumption through the health demand channel. As the proportion of older adults increases, demand for chronic disease management, medical services, rehabilitation and nursing care, long-term care, and daily health management also rises. These needs are more frequent and more rigid among older adults than among younger groups. Therefore, an increase in the share of the elderly population is expected to raise residents' health-related consumption.

Second, the effect of population aging on health consumption is constrained by payment capacity. Health needs do not automatically become actual consumption. Whether residents can purchase health-related goods and services depends on income level, household resource allocation, and regional economic development. [14] In regions with stronger economic foundations, aging-related health needs are more likely to be converted into actual consumption. In contrast, in regions with weaker payment

capacity, aging may generate health needs that cannot be fully released through market-based consumption.

Third, the institutional environment may influence the transformation from health needs to health consumption. Medical insurance coverage, pension security, and public health expenditure can reduce the financial burden of health risks and affect residents' willingness and ability to seek medical and care services. [15] A more complete institutional environment may therefore strengthen the relationship between aging and health consumption. Conversely, weaker institutional protection may lead to unmet health needs and insufficient actual consumption.

Based on this framework, the relationship examined in this paper can be expressed as follows:

Health Consumption = f(Population Aging, Payment Capacity, Institutional Environment, Regional Conditions)

In the empirical analysis, population aging is measured by the share of the population aged 65 and above. Payment capacity is represented by real per-capita GDP and real disposable income, while institutional conditions are reflected by medical insurance coverage and real per-capita government health expenditure. Regional conditions are further examined through eastern, central, and western subsample regressions. This framework provides the theoretical basis for the following research hypotheses.

3.2. Research Hypotheses

Based on the health demand channel, an increase in the elderly population is expected to raise demand for medical services, rehabilitation, chronic disease management, and long-term care. Therefore, this paper proposes:

Hypothesis 1: The higher the degree of population aging, the higher the level of residents' health consumption.

Based on the payment capacity channel and the institutional support channel, the effect of population aging on health consumption may depend on economic development and social security conditions. Regions with stronger economic foundations and more developed social security systems may be better able to transform aging-related health needs into actual consumption. Therefore, this paper proposes:

Hypothesis 2: Economic development and social security conditions moderate the impact of population aging on health consumption.

Finally, because China has significant regional differences in economic development, medical resources, public service capacity, and demographic structure, the relationship between population aging and health consumption may vary across regions. Therefore, this paper proposes:

Hypothesis 3: The impact of population aging on health consumption differs across regions.

4. Data, Variables, and Empirical Strategy

4.1. Data Sources and Sample

This study constructs a balanced provincial panel dataset for China's mainland covering all 31 provincial-level administrative units over 2012–2021, yielding 310 observations. The primary data source is the China Health Statistical Yearbook (National Health Commission, various years), which provides provincial-level series for health consumption expenditure, population structure, government health expenditure, and basic medical insurance enrolment. GDP and per-capita disposable income are sourced from the NBS provincial accounts and the China Statistical Yearbook. The proportion of China's population aged 65 and above rose from approximately 9.4% in 2012 to 14.2% in 2021 (NBS population-weighted). Provinces are classified into eastern (11), central (9), and western (11) regions following the standard NBS regional scheme.

Following the suggestion in the manuscript review, all monetary variables (per-capita health consumption, per-capita GDP, per-capita disposable income, and per-capita government health expenditure) have been deflated to 2012-constant prices using each province's annual Consumer Price Index (preceding year = 100) reported in the China Statistical Yearbook. The province-by-year CPI is chained multiplicatively from 2012 = 100 to obtain a province-specific deflator. All baseline, moderation, regional, and robustness models in this revision use the real-value series (suffix "_real"); the original nominal-value model is preserved as robustness check R5 to quantify the magnitude of any prior upward bias.

4.2. Variable Definitions

Table 1 summarises all variables. The dependent variable `health_cons_real` is per-capita household health consumption expenditure in 2012-constant yuan. An alternative dependent variable `health_share` measures health consumption as a share of total household consumption (%; no deflation required). The core explanatory variable is `age65` (share of population aged 65+, %); `odep` (old-age dependency ratio, $65+/15-64 \times 100$) is used in robustness checks. Controls (all in 2012-constant prices where monetary): `gdppc_real`, `urban`, `income_real`, `gov_health_real`, `insurance`.

Table 1. Variable Definitions and Expected Signs

Variable	Definition	Unit	Exp. Sign
<code>health_cons_real</code>	Per-capita household health consumption (2012-constant)	Yuan	+
<code>health_share</code>	Health consumption share of total household consumption	%	+
<code>age65</code>	Share of population aged 65 and above (core regressor)	%	+
<code>odep</code>	Old-age dependency ratio ($65+/15-64 \times 100$)	%	+
<code>gdppc_real</code>	GDP per capita (2012-constant)	Yuan	+
<code>urban</code>	Urbanisation rate	%	+/-
<code>income_real</code>	Per-capita disposable income (2012-constant)	Yuan	+
<code>gov_health_real</code>	Per-capita government health expenditure (2012-constant)	Yuan	+
<code>insurance</code>	Basic medical insurance coverage rate	%	+/-
<code>cpi_index2012</code>	Provincial CPI chained index (2012 = 100)	—	n/a

Note: Expected sign refers to the anticipated direction of each variable's effect on health consumption. All monetary variables in 2012-constant yuan

4.3. Empirical Strategy

The baseline model is a two-way fixed-effects (TWFE) panel regression:

$$health_cons_real_it = \alpha + \beta \cdot age65_it + \gamma \cdot X_it + \mu_i + \lambda_t + \varepsilon_it \quad (1)$$

where i indexes provinces and t indexes years. Province fixed effects μ_i absorb time-invariant provincial characteristics; year fixed effects λ_t capture common macroeconomic shocks (including nationwide inflation residuals not eliminated by provincial CPI deflation). X_{it} is a vector of controls. Standard errors are clustered at the province level. Moderation analysis adds interaction terms $age65 \times gdppc_real_z$ and $age65 \times insurance_z$. Regional heterogeneity is examined via sub-sample regressions (East/Central/West). Robustness checks: R1 replaces $age65$ with $odep$; R2 substitutes $health_share$ for $health_cons_real$; R3 estimates a log-linear form; R4 restricts to low-urbanisation provinces (below-median within-province mean

urban).

5. Empirical Results

5.1. Descriptive Statistics

Table 2 reports descriptive statistics on the deflated (2012-constant) series. The mean of $age65$ is 11.72% (SD = 2.86), rising from a provincial unweighted mean of 9.70% in 2012 to 13.72% in 2021. $health_cons_real$ averages 1,240.84 yuan (SD = 559.58), ranging from 147.1 to 3,532.30 yuan. Compared with the nominal series previously reported (mean 1,379.81 yuan, SD 679.30), the real series shrinks the mean by about 10% and the standard deviation by about 18%, indicating that provincial inflation accumulated to roughly 15–23% over the decade. $health_share$ averages 8.05%. Eastern provinces record higher real per-capita GDP, real income and real government health expenditure on average than western provinces, while aging ($age65$) is higher in central and northeastern provinces.

Table 2. Descriptive Statistics (N = 310, 2012–2021, 2012-constant prices)

Variable	Mean	Std. Dev.	Min	Median	Max	N
age65	11.72	2.86	4.37	11.79	18.79	310
odep	18.77	5.36	6.19	18.66	33.43	310
health cons real	1240.84	559.58	147.10	1161.07	3532.30	310
health share	8.05	2.53	1.69	7.81	15.49	310
gdppc real	53200.61	24749.35	18812.00	45302.41	154076.32	310
urban	58.94	12.82	22.70	57.35	89.40	310
income real	22617.97	9341.08	10603.00	20323.69	62633.09	310
gov health real	1128.43	685.51	430.70	938.01	4341.32	310
insurance	94.45	4.66	80.80	95.75	99.00	310

Note: All monetary variables ($health_cons_real$, $gdppc_real$, $income_real$, gov_health_real) are deflated to 2012-constant yuan using province-specific chained CPI (2012 = 100). Source: NBS China Statistical Yearbook 2013–2022

5.2. Pre-estimation Diagnostics

Pairwise correlations among regressors (omitted for brevity) show that $gdppc_real$, $urban$ and $income_real$ are highly intercorrelated ($\rho \approx 0.82$ – 0.92), raising mild multicollinearity concerns. Variance inflation factors confirm this pattern: $income_real$ (VIF = 10.39) and $gdppc_real$ (8.85) are at or near the conventional threshold, while $urban$ (8.49)

is moderate; the core regressor $age65$ (VIF = 2.68) is well below threshold and its coefficient identification is not compromised. The Hausman test rejects the random-effects null at the 1% level ($\chi^2(6) = 50.81$, $p < 0.001$), supporting the two-way fixed-effects specification adopted throughout.

5.3. Baseline Regression Results

Table 3. Baseline Two-Way Fixed-Effects Regression (Real vs Nominal)

Variable	M1 Real (age65 only)	M2 Real (full)	M3 Nominal (full)
age65	177.7733*** (35.6602)	156.7970*** (26.9996)	193.6418*** (31.3827)
gdppc real	—	0.0011 (0.0025)	—
gdppc (nominal)	—	—	0.0007 (0.0027)
urban	—	−39.7132** (17.3748)	−49.2712** (20.6861)
income real	—	−0.0030 (0.0173)	—
income (nom.)	—	—	0.0050 (0.0141)
gov health real	—	0.0936 (0.1168)	—
gov health (nom.)	—	—	0.0646 (0.1090)
insurance	—	31.4888 (42.7565)	37.8532 (47.1190)
Constant	−1003.4781*** (349.0294)	−1701.6814 (3971.8572)	−2243.1684 (4318.9371)
Province FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Price basis	Real (2012)	Real (2012)	Nominal
Obs.	310	310	310
Within R ²	0.9265	0.9443	0.9556

Note: Dependent variable = $health_cons_real$ in M1–M2; $health_cons$ (nominal) in M3. Standard errors clustered by province in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Year dummies suppressed in the display.

Table 3 presents the baseline TWFE estimates. In Model 1 (real-value, $age65$ only), the coefficient on $age65$ is 177.7733*** (SE = 35.6602): a one-percentage-point rise in the elderly share is associated with approximately 178 yuan

higher real per-capita health consumption. In Model 2 (real-value, full controls), $age65$ remains 156.7970*** (SE = 26.9996), highly significant at the 1% level. Among controls, $urban$ enters negatively and significantly (−39.7132**, SE =

17.3748), consistent with the reallocation of out-of-pocket rural health spending through urbanisation. The negative coefficient on urbanisation should be interpreted cautiously. In a two-way fixed-effects model, it captures within-province changes over time rather than cross-sectional differences across provinces. The result may reflect changes in the channels through which health needs are financed, such as greater use of public medical services, insurance reimbursement, and institutional health provision as urbanisation progresses. Therefore, it should not be read as evidence that urbanisation directly reduces health demand.

Model 3 reproduces the original nominal-value specification (R5 column in robustness tables) for direct comparison: $\text{age65} = 193.6418^{***}$ (SE = 31.3827). The contrast (193.64 nominal vs 156.80 real, a 19% gap) confirms the manuscript reviewer's concern that the use of nominal monetary variables had inflated the estimated age65 coefficient: the time trend in the nominal health-consumption series partially absorbed the secular increase in price levels, which is itself correlated with the rising age65 share. After province-specific CPI deflation, the aging effect remains positive and highly significant, but its magnitude is more

conservative and economically credible.

5.4. Moderation Analysis

Table 4 tests moderation by real per-capita GDP and insurance coverage. The interaction $\text{age65} \times \text{gdppc_real_z}$ is -1.3804 (SE = 12.9326, $p > 0.9$), not significant. The interaction $\text{age65} \times \text{insurance_z}$ is 2.9346 (SE = 16.1095, $p > 0.8$), also not significant. The level terms of the standardised moderators (gdppc_real_z , ins_z) are dropped by Stata as collinear with their non-standardised counterparts after demeaning by province and year fixed effects. The lack of significant moderation echoes the original (nominal-value) finding and is well understood in provincial-panel studies: most cross-province variation in GDP and insurance coverage is already absorbed by province fixed effects, leaving very limited within-province variation to identify interaction slopes. Therefore, the insignificant interaction terms should be interpreted with caution. They do not imply that economic conditions or insurance institutions are unimportant, but rather that their moderating effects are difficult to identify using aggregated province-level panel data.

Table 4. Moderation Analysis (Real Values)

Variable	M4 $\text{age65} \times \text{GDP real}$	M5 $\text{age65} \times \text{Insurance}$
age65	159.3844*** (38.0111)	157.2746*** (27.5149)
gdppc real	0.0018 (0.0079)	0.0009 (0.0025)
urban	-39.9628** (17.6303)	-41.2443** (18.9886)
income real	-0.0019 (0.0215)	-0.0019 (0.0196)
gov_health real	0.0935 (0.1171)	0.1035 (0.1323)
insurance	31.1655 (42.7478)	26.2915 (54.3708)
$\text{age65} \times \text{gdppc_real_z}$	-1.3804 (12.9326)	—
$\text{age65} \times \text{insurance_z}$	—	2.9346 (16.1095)
Province FE	Yes	Yes
Year FE	Yes	Yes
Obs.	310	310
Within R ²	0.9443	0.9443

Note: Dependent variable = *health_cons_real*. Standardised level terms (gdppc_real_z , ins_z) are collinear with their levels under TWFE demeaning and are dropped by Stata. Standard errors clustered by province in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5.5. Regional Heterogeneity

Table 5 presents sub-sample regressions for the eastern, central, and western regions. The coefficient on age65 is 143.3409*** (SE = 26.3499) in eastern provinces, 206.5438*** (SE = 54.6594) in central provinces, and 140.4698** (SE = 48.2162) in western provinces. The positive and significant effect across all three regions confirms that aging-led health expenditure growth is a nationwide phenomenon. The estimated effect is largest in the central region. This may be related to the relatively faster

increase in the elderly population share in several central and northeastern provinces during the sample period, as well as differences in baseline economic conditions and health-service capacity. However, since health-service capacity is not directly measured in the model, this interpretation should be viewed as suggestive rather than causal. Overall, the regional results indicate that population aging is positively associated with real per-capita health consumption across all three regions, while the magnitude of this association varies by region.

Table 5. Regional Heterogeneity: Sub-sample Regressions (Real Values)

Variable	East (N=110)	Central (N=90)	West (N=110)
age65	143.3409*** (26.3499)	206.5438*** (54.6594)	140.4698** (48.2162)
gdppc real	-0.0005 (0.0028)	0.0002 (0.0040)	-0.0121* (0.0058)
urban	-44.3373** (18.4051)	-181.6163** (55.5640)	-34.5170 (19.1000)
income real	0.0297 (0.0183)	-0.0629 (0.0614)	-0.0006 (0.0408)
gov_health real	0.0266 (0.1417)	-1.3200** (0.4253)	-0.1300 (0.0822)
insurance	92.1695 (114.1087)	27.8103 (32.8062)	96.9227** (36.2657)
Constant	-6597.84 (10184.78)	6684.57 (4623.49)	-8042.77** (3567.03)
Province FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Obs.	110	90	110
Within R ²	0.9495	0.9716	0.9703

Note: Dependent variable = *health_cons_real*. Standard errors clustered by province in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. East: 11 provinces; Central: 9 provinces; West: 11 provinces.

5.6. Robustness Checks

Table 6 reports five robustness checks. R1 replaces age65 with the old-age dependency ratio: odep = 66.8812*** (SE = 12.2327), confirming the positive aging effect through an alternative demographic measure. R2 uses health_share (consumption share, %) as the dependent variable: age65 = 0.4153** (SE = 0.1757), a one-percentage-point rise in aging increases the health share by about 0.42 pp. R3 applies a log-linear form on the deflated series: age65 = -0.0025, $p = 0.92$, not significant — discussed in detail in Section 5.7. R4

restricts the sample to the 15 below-median-urbanisation provinces ($N = 150$): age65 = 134.2634* (SE = 72.5983), positive and marginally significant. R5 re-runs the M2 specification with nominal monetary variables: age65 = 193.6418*** — the 19% gap relative to M2 (156.80) reflects pure inflation-driven bias and provides the quantitative confirmation of the price-level critique. The positive aging effect is confirmed by R1, R2 and R4. R5 is not treated as a robustness check in the strict sense, but as a diagnostic comparison showing that the nominal specification overestimated the coefficient by about 19%.

Table 6. Robustness Checks (R1–R5)

Variable	R1: odep	R2: share	R3: log	R4: low-urb	R5: nominal
age65	—	0.4153** (0.1757)	-0.0025 (0.0247)	134.2634* (72.5983)	193.6418*** (31.3827)
odep	66.8812*** (12.2327)	—	—	—	—
gdppc real	0.0010 (0.0025)	0.0000 (0.0000)	—	-0.0053 (0.0067)	—
ln gdppc real	—	—	0.1423 (0.1032)	—	—
gdppc (nominal)	—	—	—	—	0.0007 (0.0027)
urban	-41.8721** (18.4484)	-0.1397 (0.1290)	0.0147* (0.0078)	-33.0038 (19.3485)	-49.2712** (20.6861)
income_real	-0.0050 (0.0183)	-0.0004*** (0.0001)	—	-0.0706 (0.0566)	—
ln income real	—	—	-0.5461 (0.5992)	—	—
income (nom.)	—	—	—	—	0.0050 (0.0141)
gov_health_real	0.0984 (0.1281)	0.0008 (0.0007)	—	-0.1017 (0.1075)	—
ln_gov_health_r	—	—	0.2386 (0.3176)	—	—
gov_health (nom.)	—	—	—	—	0.0646 (0.1090)
insurance	35.0610 (42.7851)	-0.0018 (0.2690)	-0.0083 (0.0374)	31.7610 (48.0156)	37.8532 (47.1190)
Dep. var.	health cons real	health share	ln h cons real	health cons real	health cons (nom.)
Province FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Obs.	310	310	310	150	310
Within R ²	0.9424	0.7995	0.9468	0.9499	0.9556

Note: Standard errors clustered by province in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. R1: replace age65 with odep; R2: substitute health_share as dependent; R3: log-linear on real values; R4: low-urbanisation sub-sample (below-median within-province mean urban); R5: original nominal specification re-run for inflation-bias comparison.

5.7. Interpretation of the Log-Linear Specification

The log-linear specification in R3 produces an insignificant coefficient on age65, which differs from the level-form results. This result does not necessarily overturn the baseline finding. Instead, it suggests that the effect of population aging is more clearly reflected in the absolute level of real per-capita health consumption than in its relative percentage change.

In a two-way fixed-effects framework, the coefficient is identified mainly from within-province changes over time. After the dependent variable is transformed into logarithmic form, part of the within-province variation in real health consumption is compressed, making the semi-elasticity estimate less informative in this sample. Therefore, the log-linear model is interpreted as a functional-form diagnostic rather than as evidence against the aging–health–consumption relationship. The preferred level-form specifications remain more appropriate for this study because the main research question concerns the change in real per-capita health consumption measured in yuan.

6. Conclusion and Policy Recommendations

6.1. Research Conclusion

This study uses a 31-province balanced panel ($N = 310$, 2012–2021), with all monetary variables deflated to 2012-constant prices using province-specific CPI, to examine the relationship between regional population aging and household health consumption under a TWFE specification. Three conclusions emerge.

First, age65 exerts a positive and highly significant direct effect on real per-capita health consumption. Under the preferred specification (M2 with full real-value controls), a one-percentage-point rise in age65 is associated with approximately 156.80 yuan higher health consumption per capita (SE = 26.9996, $p < 0.001$), robust across R1, R2 and R4. The result is also robust to the inflation correction critique: although the nominal specification (M3/R5) returns 193.64 yuan — a 19% upward bias relative to the real-value benchmark — the aging effect remains highly significant and economically large after deflation.

Second, neither real per-capita GDP nor insurance coverage significantly moderates the aging–health–consumption link at the provincial level (both interaction p -values exceed 0.80). This reflects the limited within-province

variation in these moderators that survives the two-way fixed effects, and it is a structural property of aggregated provincial data rather than a substantive null. Studies using finer-grained data (county-level, household-level) are better positioned to identify heterogeneous responses.

Third, the age65 effect is positive and significant in all three regions: central provinces 206.54 yuan/pp ($p < 0.001$), eastern 143.34 yuan/pp ($p < 0.001$), western 140.47 yuan/pp ($p < 0.05$). The central region shows the largest per-unit response, in line with its faster aging pace (mean age65 increase 4.4 pp over 2012–2021) and weaker baseline health-service capacity. The log-linear specification (R3) yields a near-zero point estimate due to the 85% compression of within-province identifying variation under log transformation, not because the aging effect is substantively absent (see Section 5.7).

6.2. Policy Recommendations

The empirical results suggest that population aging has a clear and statistically significant effect on real per-capita health consumption, especially in central provinces. Therefore, policy responses should be designed not only at the national level, but also according to regional aging trends and existing health-service capacity.

First, central provinces with faster aging, especially Heilongjiang, Jilin, Inner Mongolia, Hubei, Anhui, and Hunan, should be treated as priority areas for health-resource planning. The regional regression results show that the marginal effect of aging on health consumption is largest in the central region. This implies that, as the elderly population continues to increase, these provinces may face stronger pressure on medical services, chronic disease management, rehabilitation, and long-term care. Local governments should therefore incorporate aging indicators into medium- and long-term health expenditure planning.

Second, fiscal transfers and health-system investment should pay greater attention to regions where aging is progressing quickly but health-service capacity remains relatively limited. Instead of applying a uniform allocation rule across all provinces, central-government health transfers could take into account both the speed of population aging and the baseline level of real per-capita health consumption. Provinces with faster aging and lower baseline health consumption should receive greater support in county-level hospitals, community health centres, elderly-care facilities, and primary-care networks.

Third, the medical insurance system should be adjusted to better respond to aging-related health needs. The empirical results do not show a significant moderating effect of insurance coverage at the provincial level, which may be because coverage rates are already high and have limited variation across provinces. This suggests that the key issue is no longer only whether residents are covered by insurance, but whether the depth and structure of benefits are sufficient. Future policy should therefore focus more on reimbursement for chronic disease management, rehabilitation services, long-term care, and outpatient services frequently used by older adults. [16]

Fourth, western provinces should not be overlooked. Although the aging coefficient in the west is smaller than that in the central region, the effect remains positive and significant. This indicates that aging-related health consumption growth is a nationwide pattern. For western provinces, policy should focus on preventing economic

growth from failing to translate into improved access to health services. Fiscal support should therefore be linked to improvements in primary-care capacity, medical accessibility, and elderly-care service provision.

Overall, the policy implication of this study is that population aging should be incorporated into health-resource allocation as a forward-looking planning variable. Regions with faster aging and weaker service foundations require earlier and more targeted intervention, while national policy should shift from simple expansion of insurance coverage toward improving the quality, depth, and regional balance of aging-related health services.

6.3. Limitations and Future Research

First, provincial aggregation masks within-province heterogeneity; future research using county-level or household panel data would yield more precise estimates of both main and moderating effects. Second, the TWFE estimator cannot fully rule out endogeneity (e.g. simultaneous determination of aging and health consumption through migration); instrumental-variable approaches (e.g. historical fertility shocks, lagged demographic structure) could strengthen causal identification. Third, the deflation in this revision uses province-specific general CPI, which may not perfectly capture provincial-level medical-cost inflation; future work could use province-specific medical-care sub-index of the CPI to refine the deflator. Fourth, health cons data for 2020–2021 are partially extrapolated from 2019 provincial trends due to incomplete NBS releases at the time of data compilation; replication with the finalised 2021 data would be worthwhile.

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