Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

# Does Healthy City Development Improve Individual Health Human Capital? Evidence from a City-Level Health Index and the 2023 China Social Survey

**Mingcheng Gao**

gmc15840620730@163.com

Dongbei University of Finance & Economics

**Kangsi Zhang**

Dongbei University of Finance & Economics

**Article**

**Keywords:** healthy city development, health human capital, urban governance, public service accessibility, health behavior

**Posted Date:** April 7th, 2026

**DOI:** https://doi.org/10.21203/rs.3.rs-8989844/v1

**License:** This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

**Additional Declarations:** No competing interests reported.

# Does Healthy City Development Improve Individual Health Human Capital? Evidence from a City-Level Health Index and the 2023 China Social Survey

Mingcheng Gao[1],Kangsi Zhang[2*]

([1,2]School of Economics, Dongbei University of Finance & Economics, Dalian, CHN)

**Abstract**

Urban health-oriented governance has become increasingly central to improving population health and supporting sustainable economic development. This study examines whether healthy city development enhances workers' health human capital and explores the underlying mechanisms. We construct a multidimensional Healthy City Development Index using an entropy-weighted TOPSIS approach for Chinese provincial capital cities and match it with nationally representative microdata from the 2023 China Social Survey (CSS). Workers' health human capital is proxied by a composite index derived from physical and mental health indicators using principal component analysis. Baseline regressions show that higher levels of healthy city development are significantly associated with improved health human capital. The results remain robust to alternative outcome measures, model specifications, and sample restrictions. Mechanism analyses indicate that improved public service accessibility and healthier individual behaviors serve as important transmission channels. Heterogeneity tests reveal stronger effects among workers in eastern regions and higher-income groups, suggesting unequal returns to urban health governance. To address potential endogeneity, we employ an instrumental-variable strategy using dialect diversity and historical post office density, and the findings remain qualitatively unchanged. These results provide micro-level evidence on the health returns to urban governance and offer policy implications for narrowing emerging health disparities.

* Corresponding authors: .kangsi@126.com

**Keywords:** healthy city development; health human capital; urban governance; public service accessibility; health behavior

## 1. Introduction

Health is a fundamental component of human capital and a central determinant of long-term economic development. Early human capital theory emphasized education as a key source of productivity growth[1][2]. Subsequent theoretical developments extended this framework to health, conceptualizing it as a durable capital stock that yields both utility and productive returns over time[3]. Empirical evidence further demonstrates that improvements in population health contribute substantially to labor productivity, earnings capacity, and aggregate economic performance[4]. In particular, health capital influences mortality risks, labor supply decisions, and lifetime income trajectories, thereby shaping long-run growth dynamics[5].

Beyond individual characteristics, health outcomes are embedded in broader social and institutional contexts. The social determinants of health framework highlights that environmental conditions, public infrastructure, and governance capacity play a decisive role in shaping health inequalities[6]. As urbanization accelerates, cities have become primary arenas for health governance interventions. The World Health Organization's Healthy Cities initiative explicitly frames urban planning and public governance as critical instruments for improving health equity and sustainability[7]. Urban environmental quality, transportation systems, and public service provision jointly affect exposure to health risks and access to healthcare resources[8].

A growing body of empirical research confirms that improvements in urban environmental conditions are associated with better health outcomes. For example, reductions in air pollution significantly decrease mortality and morbidity risks, while increased urban green space is linked to improved physical and mental health[9].

Recent studies using large-scale microdata further document that green space exposure enhances psychological well-being in Chinese cities[10]. Innovative urban planning models, such as the superblock approach, have also been shown to generate measurable improvements in health and environmental sustainability[11]. Moreover, systematic reviews emphasize the importance of multidimensional urban health indicator systems for capturing the complexity of governance–health interactions[12].

Despite these advances, two important gaps remain. First, most existing studies rely on aggregate indicators such as life expectancy or mortality rates, leaving limited micro-level evidence on how urban governance influences individual health human capital accumulation. Second, few studies evaluate healthy city development as a comprehensive governance framework integrating environmental management, health resources, and institutional capacity.

Urban health-oriented governance may influence workers' health human capital through multiple transmission channels. Improvements in environmental quality reduce exposure to health risks, while expanded healthcare infrastructure enhances accessibility and service efficiency. According to the behavioral model of healthcare utilization, enabling resources and institutional accessibility are central determinants of medical service use[13]. In addition, healthier urban environments may encourage individuals to increase health-related investment and adopt healthier behaviors, consistent with the health investment framework derived from the Grossman model[14].

Based on this theoretical foundation, we propose:

H1: Higher levels of healthy city development are positively associated with workers' health human capital.

H2: Healthy city development enhances workers' health human capital through improved public service accessibility and increased health-related consumption.

To test these hypotheses, this study constructs a multidimensional Healthy City Development Index using an entropy-weighted TOPSIS approach and matches it with nationally representative microdata from the 2023 China Social Survey (CSS). By linking city-level governance indicators with individual-level health outcomes, this research provides micro-level evidence on the health returns to urban governance and contributes to a more integrated understanding of how institutional environments shape human capital formation.

## 2. Methods

### 2.1 Construction and Measurement of the Healthy City Development Index

#### 2.1.1 Indicator System

In 2022, China established the Health Development Evaluation Framework (Key Cities) based on the World Health Organization and other international public health evaluation systems, combined with the “Healthy China 2030” strategic indicator system. This framework aims to evaluate the level of health development in key cities.

The original evaluation system covered five themes: health resources, health environment, health investment, health governance, and health outcomes. Following the principles of data availability and statistical comparability, this study retains observable indicators and excludes items without publicly accessible city-level statistics. The final indicator system consists of four dimensions and 21 specific indicators, covering health outcomes, health resources, health environment, and health governance.

The detailed indicator system is presented in Table 1.

Table 1. Healthy City Development Evaluation Indicator System

| Dimension | Code | Indicator | Definition | Type |
|---|---|---|---|---|
| Health Outcomes | A1 | Life expectancy (years) | Estimated using life tables based on overall mortality and birth rates | Positive |
| | A2 | Infant mortality rate (‰) | Number of deaths within the first year per 1,000 live births | Negative |
| | A3 | Maternal mortality rate (1/100,000) | Number of maternal deaths per 100,000 births due to pregnancy or delivery-related causes | Negative |
| | A4 | Under-five mortality rate (‰) | Number of deaths of children under five per 1,000 children | Negative |
| | A5 | Health literacy level (%) | Percentage score measuring residents' health knowledge, behavior, and management capacity | Positive |
| Health Resources | B1 | Health institutions per 1,000 persons | Average number of health institutions per 1,000 population | Positive |
| | B2 | Hospital beds per 1,000 persons | Number of hospital beds available per 1,000 permanent residents | Positive |
| | B3 | Licensed physicians per 1,000 persons | Number of licensed (assistant) physicians per 1,000 permanent residents | Positive |
| | B4 | Registered nurses per 1,000 persons | Number of registered nurses per 1,000 permanent residents | Positive |
| | B5 | Health technicians per 1,000 persons | Number of health technical personnel per 1,000 permanent residents | Positive |
| | B6 | Hospitals per 10,000 persons | Number of hospitals per 10,000 population | Positive |
| | B7 | Health expenditure as share of fiscal expenditure (%) | Share of health-related expenditure in total government fiscal expenditure | Positive |
| | B8 | Elderly care beds per 1,000 elderly | Number of elderly care institution beds per 1,000 elderly population | Positive |
| Health Environment | C1 | Public water supply coverage (%) | Proportion of population covered by public water supply services | Positive |
| | C2 | Air quality compliance days (%) | Proportion of days with air quality meeting national standards | Positive |
| | C3 | Annual PM10 concentration (mg/m³) | Annual average concentration of inhalable particulate matter (≤10μm) | Negative |
| | C4 | Urban green coverage rate (%) | Proportion of built-up urban area covered by green vegetation | Positive |
| | C5 | Per capita park green area (m²) | Average park and green area per urban resident | Positive |
| Health Governance | D1 | Pension insurance coverage (%) | Ratio of urban employees enrolled in pension insurance to permanent population | Positive |
| | D2 | Medical insurance coverage (%) | Ratio of urban residents enrolled in medical insurance to permanent population | Positive |
| | D3 | Maternity insurance coverage (%) | Ratio of urban residents enrolled in maternity insurance to permanent population | Positive |

### 2.1.2 Measurement Method: Entropy Weight－TOPSIS

**Step 1: Original Decision Matrix**

Let mmm denote the number of cities and nnn the number of indicators. The original decision matrix is:

$$x'_{ij}=\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \qquad (1)$$

**Step 2: Standardization**

Negative indicators (A2, A3, A4, C3) are transformed using reciprocal conversion $(1/x'_{ij})$. Vector normalization is then applied:

$$z_{ij}=\frac{x'_{ij}}{\sqrt{\sum_{i=1}^{m}\left(x'_{ij}\right)^2}} \qquad (2)$$

**Step 3: Entropy Weight Calculation**

$$P_{ij}=z_{ij}/\sum_{i=1}^{m} z_{ij},(j=1,2,\cdots, n) \qquad (3)$$

$$E_j=-\frac{1}{\ln n}\sum_{i=1}^{m} P_{ij}\ln P_{ij},\left(j=1,2,\cdots, n\right) \qquad (4)$$

$$G_i=1-E_j,\left(j=1,2,\cdots, n\right) \qquad (5)$$

$$w_j=\frac{G_j}{\sum_{i=1}^{m} G_j},\left(j=1,2,\cdots, n\right) \qquad (6)$$

The entropy-based weights of the 21 indicators are reported in Table 2.

Table 2. Weights of Healthy City Development Evaluation Indicators

| Dimension | Dimension Weight | Code | Entropy (Ej) | Weight (Wj) |
|---|---|---|---|---|
| Health Outcomes | 41.07% | $A_1$ | 0.9999 | 0.04% |
| | | $A_2$ | 0.9899 | 4.67% |
| | | $A_3$ | 0.9354 | 29.79% |
| | | $A_4$ | 0.9916 | 3.86% |

| Dimension | Dimension Weight | Code | Entropy (Ej) | Weight (Wj) |
|---|---|---|---|---|
| Health Resources | 31.04% | $A_5$ | 0.9941 | 2.71% |
| | | $B_1$ | 0.9890 | 5.05% |
| | | $B_2$ | 0.9957 | 1.98% |
| | | $B_3$ | 0.9979 | 0.99% |
| | | $B_4$ | 0.9969 | 1.45% |
| | | $B_5$ | 0.9977 | 1.07% |
| | | $B_6$ | 0.9946 | 2.49% |
| | | $B_7$ | 0.9858 | 6.55% |
| | | $B_8$ | 0.9751 | 11.46% |
| Health Environment | 10.65% | $C_1$ | 0.9999 | 0.03% |
| | | $C_2$ | 0.9966 | 1.55% |
| | | $C_3$ | 0.9877 | 5.66% |
| | | $C_4$ | 0.9991 | 0.42% |
| | | $C_5$ | 0.9935 | 2.99% |
| Health Governance | 17.21% | $D_1$ | 0.9889 | 5.11% |
| | | $D_2$ | 0.9977 | 1.09% |
| | | $D_3$ | 0.9761 | 11.01% |

Note: Indicator weights are calculated using the entropy weight method. Dimension weights equal the sum of indicator weights within each dimension. Total weights sum to approximately 100% (rounding differences may exist).

**Step 4: Weighted Normalized Matrix**

$$Z_{ij}=w_j z_{ij} \qquad (7)$$

**Step 5: Ideal Solutions**

$$A^{+}=\left\{Z_1^{+},\cdots,Z_j^{+},\cdots,Z_n^{+}\right\}=\left\{\left(\max_i Z_{ij}|j\epsilon J\right)|1,\cdots,m\right\} \qquad (8)$$

$$A^{-}=\left\{Z_1^{-},\cdots,Z_j^{-},\cdots,Z_n^{-}\right\}=\left\{\left(\min_i Z_{ij}|j\epsilon J\right)|1,\cdots,m\right\} \qquad (9)$$

The results are shown in Table 3.

Table 3. Positive and Negative Ideal Solutions of Healthy City Evaluation Indicators

| Code | Positive Ideal | Negative Ideal | Code | Positive Ideal | Negative Ideal |
|---|---|---|---|---|---|
| $A_1$ | 0.000 | 0.000 | $B_7$ | 0.002 | 0.002 |
| $A_2$ | 0.014 | 0.004 | $B_8$ | 0.018 | 0.001 |
| $A_3$ | 0.189 | 0.011 | $C_1$ | 0.000 | 0.000 |
| $A_4$ | 0.011 | 0.004 | $C_2$ | 0.004 | 0.002 |
| $A_5$ | 0.007 | 0.004 | $C_3$ | 0.021 | 0.007 |
| $B_1$ | 0.015 | 0.005 | $C_4$ | 0.001 | 0.001 |
| $B_2$ | 0.005 | 0.003 | $C_5$ | 0.010 | 0.004 |

| | | | | | |
|---|---|---|---|---|---|
| $B_3$ | 0.002 | 0.002 | $D_1$ | 0.017 | 0.006 |
| $B_4$ | 0.004 | 0.002 | $D_2$ | 0.003 | 0.002 |
| $B_5$ | 0.003 | 0.002 | $D_3$ | 0.044 | 0.009 |
| $B_6$ | 0.006 | 0.003 | | | |

Note: Positive and negative ideal solutions are derived from the weighted normalized decision matrix based on the entropy weight–TOPSIS method.

**Step 6: Distance Calculation**

$$D^{+}=\sqrt{\sum_{j=1}^{n}\left(Z_{ij}-Z_{ij}^{+}\right)^{2}} \quad (i=1,\cdots,m) \qquad (10)$$

$$D^{-}=\sqrt{\sum_{j=1}^{n}\left(Z_{ij}-Z_{ij}^{-}\right)^{2}} \quad (i=1,\cdots,m) \qquad (11)$$

**Step 7: Relative Closeness**

$$S_i=\frac{D_i^{-}}{D_i^{+}+D_i^{-}} \qquad (12)$$

The relative closeness Ci∈[0,1] represents the Healthy City Development Index (CityHealth). Higher values indicate better urban health development.

## 2.2 Data and Variables

### 2.2.1 Data Sources

City-level data for the 21 indicators are collected from:

①China City Statistical Yearbook (2023)

②China Health Statistical Yearbook (2023)

③Provincial statistical yearbooks

④Municipal statistical bulletins

⑤National census data

When 2022 data are unavailable, 2021 data are used as supplements.

Individual-level data are obtained from the 2023 China Social Survey (CSS). After restricting the sample to individuals aged 18–70 and matching city identifiers, the final dataset contains 7,897 observations from 97 cities.

### 2.2.2 Dependent Variable

Health human capital is constructed using principal component analysis (PCA) based on self-reported physical and mental health. The first principal component is extracted as the composite health index.

### 2.2.3 Core Independent Variable

CityHealth represents the relative closeness score $C_i$ derived from the entropy weight–TOPSIS method.

### 2.2.4 Control Variables

Control variables include:

①Demographic characteristics: gender, age, hukou status, marital status, years of education

②Occupational characteristics

③Household characteristics: log household income per capita, number of children, and household size

Detailed definitions and descriptive statistics are reported in Table 4.

Table 4. Variable Definitions and Descriptive Statistics

| Variable Name | Symbol | Definition | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|
| Dependent Variable | | | | | | |
| Health Human Capital Index | Health Human Capital Index | First principal component of self-reported physical and mental health scores | 0.000 | 1.021 | -3.112 | 2.874 |
| Core Explanatory Variable | | | | | | |
| Healthy City Development | CityHealth | Composite healthy city development index (Ci) | 0.487 | 0.143 | 0.215 | 0.782 |
| Control Variables | | | | | | |
| Gender | Gender | 1 = Male; 0 = Female | 0.449 | 0.497 | 0 | 1 |
| Age | Age | Actual age (years) | 46.705 | 14.245 | 18 | 70 |
| Hukou Status | Hukou_status | 1 = Non-agricultural (urban hukou); 0 = Agricultural (rural hukou) | 0.264 | 0.441 | 0 | 1 |
| Marital Status | Marriage | 1 = Married (first or remarried); 0 = Others | 0.776 | 0.417 | 0 | 1 |
| Years of Education | Edu_year | Years of formal education completed | 8.807 | 2.217 | 6 | 19 |
| Log Household Per Capita Income | Ln_income | Natural logarithm of annual household per capita income | 9.415 | 1.358 | 0.916 | 9.663 |
| Number of Children | Children | Total number of children | 1.609 | 1.092 | 0 | 6 |
| Household Size | HH_size | Number of household members living together | 3.566 | 1.856 | 1 | 9 |

Note: Descriptive statistics are based on the full sample (N = 7,987).

### 2.3 Empirical Strategy

To examine the impact of healthy city development on health human capital, the following baseline regression model is estimated:

$$Health\ Human\ Capital_{ic} = \beta_0 + \beta_1\ CityHealth_c + \gamma\ X_{ic} + \delta_p + \varepsilon_{ic}$$

where i denotes individuals, c denotes cities, and p denotes provinces. Province fixed effects $\delta_p$ are included to control for time-invariant provincial characteristics.

Standard errors are clustered at the city level.

Consistent with the research hypothesis, $\beta_1$ is expected to be positive.

## 3 Results and discussion

### 3.1 Baseline Regression Results

Table 5 reports the baseline regression results. In Column (1), controlling only for individual characteristics, CityHealth is positively associated with health human capital ($\beta = 0.286$, $p < 0.01$).

After adding household controls in Column (2), the coefficient remains positive and statistically significant, although the magnitude decreases slightly ($\beta = 0.239$, $p < 0.01$). Column (3) includes both individual and household controls, and the estimate remains stable ($\beta = 0.252$, $p < 0.01$).

In Column (4), province fixed effects are further introduced. The coefficient of CityHealth remains positive and statistically significant at the 1% level ($\beta = 0.231$, $p < 0.01$).

Since CityHealth ranges from 0 to 1, a 0.1 increase in the Healthy City Development Index is associated with a 0.0231 standard deviation increase in individual health human capital.

The stability of the coefficient across specifications suggests that the positive association between healthy city development and individual health capital is robust, providing empirical support for Hypothesis H1.

Table 5. Baseline Regression Results

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| CityHealth | 0.286*** | 0.239*** | 0.252*** | 0.231*** |
| | (0.061) | (0.064) | (0.058) | (0.069) |
| Individual controls | No | Yes | Yes | Yes |
| Household controls | No | No | Yes | Yes |
| Province FE | No | No | No | Yes |
| Observations | 7,987 | 7,987 | 7,987 | 7,987 |
| R-squared | 0.087 | 0.159 | 0.211 | 0.226 |

Notes: Standard errors clustered at the city level are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

### 3.2 Robustness Checks: Alternative Core Explanatory Variables

Table 6 reports a series of robustness tests that modify the dependent variable, the core explanatory variable, and the sample.

Columns (1) and (2) replace the composite health human capital index with self-reported physical health and mental health, respectively. The coefficient of CityHealth remains positive and statistically significant at the 1% level in both cases. A 0.1 increase in CityHealth is associated with a 0.0194 standard deviation increase in physical health and a 0.0217 standard deviation increase in mental health, indicating that the relationship operates through both physical and psychological dimensions.

Column (3) replaces the original CityHealth index with an alternative composite measure constructed from the Tsinghua Urban Health Index. The alternative measure aggregates four dimensions—health environment (HJ), health services (FW), health facilities (SS), and government governance (ZF)—capturing environmental quality, healthcare provision, infrastructure investment, and governance capacity. The coefficient remains positive and statistically significant at the 5% level ($\beta = 0.206$), suggesting that the main results are not sensitive to the specific construction of the index.

Column (4) excludes economically developed outlier cities to alleviate concerns about extreme observations. The estimated coefficient remains positive and statistically significant at the 1% level ($\beta = 0.234$), with a magnitude comparable to the baseline estimates.

Across specifications, the sign and statistical significance of the core explanatory variable remain stable, reinforcing the robustness of the baseline findings.

Table 6. Robustness Check Results

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Model | OLS(Physical) | OLS (Mental) | OLS | OLS |
| CityHealth | 0.194*** | 0.217*** | 0.206** | 0.234*** |
| | (0.052) | (0.057) | (0.063) | (0.069) |
| Controls | Yes | Yes | Yes | Yes |
| Province FE | Yes | Yes | Yes | Yes |
| Observations | 7,987 | 7,987 | 7,987 | 6,549 |
| R-squared | 0.186 | 0.203 | 0.218 | 0.224 |

Notes: Standard errors clustered at the city level are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

### 3.3 Endogeneity and Instrumental Variable Estimation

Although the baseline regressions control for a rich set of individual and household characteristics as well as province fixed effects, potential endogeneity concerns remain. Unobserved city characteristics—such as cultural norms or governance capacity—may simultaneously influence both urban health development and individual health outcomes. In addition, reverse causality may arise if cities with higher levels of health human capital demand better health services and environments, thereby inducing greater public investment in health construction.

To address these concerns, a two-stage least squares (2SLS) approach is employed. A valid instrument must satisfy both relevance and exogeneity conditions. Two instruments are constructed.

The first instrument is a Dialect Diversity Index (Dialect). Linguistic diversity reflects long-run historical migration patterns and the complexity of social networks within a region. Historical settlement patterns and cultural heterogeneity have been shown to shape institutional development and governance capacity[15].Areas with greater dialect diversity tend to exhibit distinct governance traditions and public goods provision preferences, which may influence contemporary urban health development. At the same time, dialect structures are shaped by historical processes

over centuries and are unlikely to directly affect the health status of contemporary individuals. Dialect diversity is constructed using data from the Chinese Language Atlas, measuring the number of major dialect groups within each provincial capital and standardizing the index.

The second instrument is historical post office density (Post_density_hist). The postal system was among the earliest nationwide public infrastructure networks in modern China. Its historical spatial distribution reflects early modernization, information flow capacity, and public service foundations. Persistent effects of historical public infrastructure on contemporary institutional development have been widely documented in the literature on historical persistence[16]. Such historical public service capacity may exert persistent effects on contemporary governance and public goods provision, including health construction. At the same time, after controlling for individual socioeconomic characteristics and province fixed effects, it is unlikely that post office density in the 1920s directly affects individual health outcomes in 2023 except through its influence on urban governance capacity. Historical post office density is constructed using data from the 1920s Chinese Postal Maps, calculated as the number of post offices per urban area.

Table 7 reports the 2SLS results. In the first stage, both Dialect and Post_density_hist are positively and significantly correlated with CityHealth at the 1% level. The Cragg–Donald Wald F-statistic equals 28.45, exceeding the Stock–Yogo critical value of 19.93 at the 10% maximal IV size, indicating that weak instrument concerns are unlikely. The Kleibergen–Paap rk LM statistic rejects the null of under-identification at the 1% level ($p = 0.002$). These statistics support the relevance and validity of the instruments.

The second-stage results are reported in Column (2). The coefficient of CityHealth is 0.268 and statistically significant at the 1% level. A 0.1 increase in instrumented CityHealth is associated with a 0.0268 standard deviation increase in individual health human capital. The magnitude is larger than the baseline OLS

estimate, suggesting that OLS may underestimate the effect due to attenuation from measurement error or reverse causality.

Overall, the IV results reinforce the conclusion that improvements in healthy city development exert a positive and economically meaningful impact on individual health human capital.

Table 7. Instrumental Variable (2SLS) Regression Results

| | (1) | (2) |
|---|---|---|
| | **First Stage: CityHealth** | **Second Stage: Health Human Capital Index** |
| CityHealth | | 0.268*** |
| | | (0.093) |
| Dialect | 0.085*** | |
| | (0.021) | |
| Post_density_hist | 0.124*** | |
| | (0.035) | |
| Controls | Yes | Yes |
| Province FE | Yes | Yes |
| Observations | 7,987 | 7,987 |
| Cragg-Donald Wald F-statistic | 28.45 | |
| Kleibergen-Paap rk LM statistic (p-value) | 0.002 | |

Notes: Standard errors clustered at the city level are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Stock–Yogo weak identification critical value (10% maximal IV size) = 19.93.

### 3.4 Mechanism Analysis

The theoretical framework suggests that healthy city development may enhance health human capital through two primary channels: improved public service provision and strengthened individual health-related behavior. To empirically examine these mechanisms, more objective micro-level variables are employed.

**Public Service Provision**

Public service accessibility is measured using five items from the CSS questionnaire regarding barriers encountered during medical visits: distance to medical institutions, excessive appointment waiting time, long queuing time, high medical costs, and low medical quality. After reverse coding and summing these items, an index of healthcare accessibility (Preventive_Service) is constructed. Higher values indicate fewer obstacles and better access to medical services. Compared with subjective satisfaction measures, this index captures concrete constraints faced during actual medical utilization, reflecting accessibility, efficiency, affordability, and service quality.

Column (1) of Table 8 shows that CityHealth is positively associated with Preventive_Service ($\beta = 0.168$, $p < 0.01$). A 0.1 increase in CityHealth corresponds to a 0.0168 increase in healthcare accessibility.

Column (2) includes both CityHealth and Preventive_Service in the health human capital regression. Preventive_Service is positively associated with health human capital ($\beta = 0.109$, $p < 0.10$), and the coefficient of CityHealth remains significant though reduced in magnitude ($\beta = 0.193$, $p < 0.05$), indicating partial mediation through public service provision.

**Individual Health Behavior**

Individual health behavior is proxied by the logarithm of annual household medical and healthcare expenditure (Health_Consumption), reflecting individuals' ability to transform improved health environments into actual health investment.

Column (3) shows that CityHealth significantly increases Health_Consumption ($\beta = 0.142$, $p < 0.05$). A 0.1 increase in CityHealth is associated with a 1.42% increase in health-related expenditure.

Column (4) incorporates both CityHealth and Health_Consumption into the health human capital regression. Health_Consumption is positively associated with

health human capital ($\beta = 0.082$, $p < 0.10$), while the coefficient of CityHealth remains statistically significant ($\beta = 0.181$, $p < 0.05$), suggesting that individual health investment represents another transmission channel.

Overall, improvements in healthcare accessibility and health-related expenditure partially mediate the effect of healthy city development on individual health human capital, providing empirical support for the proposed mechanisms.

Table 8. Mechanism Analysis Results

Dependent variables vary across columns as indicated.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Dependent Variable | Preventive_Service | Health Human Capital Index | Health_Consumption | Health Human Capital Index |
| CityHealth | 0.168*** | 0.193** | 0.142** | 0.181** |
| | (0.051) | (0.079) | (0.058) | (0.083) |
| Preventive_Service | | 0.109* | | |
| | | (0.044) | | |
| Health_Consumption | | | | 0.082* |
| | | | | (0.047) |
| Controls | Yes | Yes | Yes | Yes |
| Province FE | Yes | Yes | Yes | Yes |
| Observations | 7,987 | 7,987 | 7,987 | 7,987 |
| R-squared | 0.118 | 0.224 | 0.091 | 0.218 |

Notes: Standard errors clustered at the city level are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

### 3.5 Heterogeneity Analysis

The effect of healthy city development may vary across regions and socioeconomic groups. To explore this possibility, heterogeneity analyses are conducted along regional and income dimensions, followed by interaction-based tests.

**Regional Heterogeneity**

Columns (1)–(3) of Table 9 report results for eastern, central, and western regions separately. The coefficient of CityHealth is largest and statistically significant at the 1% level in the eastern region ($\beta = 0.257$). The effect remains positive and significant in the central region ($\beta = 0.203$, $p < 0.05$), while it is positive but statistically insignificant in the western region ($\beta = 0.154$).

In economic terms, a 0.1 increase in CityHealth is associated with a 0.0257 standard deviation increase in health human capital in the eastern region, compared with 0.0203 in the central region. The weaker and statistically insignificant estimate in the western region suggests that institutional capacity and fiscal resources may condition the effectiveness of healthy city initiatives.

**Income Heterogeneity**

Columns (4) and (5) divide the sample by the median of household per capita income. The effect of CityHealth is positive and significant at the 1% level in the high-income group ($\beta = 0.248$), while remaining positive but weaker in the low-income group ($\beta = 0.171$, $p < 0.10$).

A 0.1 increase in CityHealth corresponds to a 0.0248 standard deviation increase in health human capital among high-income individuals, compared with 0.0171 in the low-income group. This pattern suggests that the ability to utilize health resources may differ across income groups.

**Interaction Effects**

Columns (6) and (7) introduce interaction terms to examine whether the association between healthy city development and health human capital varies across individual characteristics.

Column (6) includes the interaction between CityHealth and years of education. The interaction term is positive and statistically significant ($\beta = 0.015$, $p < 0.05$), suggesting that the marginal association between healthy city development and health human capital is larger for individuals with higher educational attainment. In other words, the estimated health returns to healthy city development increase with education.

Column (7) introduces the interaction between CityHealth and hukou status. The interaction term is positive and statistically significant at the 10% level ($\beta = 0.081$), indicating that the estimated association is stronger for individuals holding urban hukou. This pattern is consistent with differences in access to public services and institutional resources across hukou groups.

Overall, the results suggest that the health-promoting effect of urban health governance varies across socioeconomic groups and institutional statuses, with larger estimated effects observed among individuals with greater resource endowments or institutional access.

Table 9. Heterogeneity Analysis Results

| | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** |
|---|---|---|---|---|---|---|---|
| **Sample** | **East** | **Central** | **West** | **High Income** | **Low Income** | **Full Sample** | **Full Sample** |
| CityHealth | 0.257*** (0.072) | 0.203** (0.089) | 0.154 (0.103) | 0.248*** (0.067) | 0.171* (0.096) | 0.219** (0.084) | 0.213** (0.087) |
| CityHealth × Edu_year | | | | | | 0.015** (0.006) | |
| CityHealth × Hukou_status | | | | | | | 0.081* (0.044) |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Province FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 2,746 | 2,634 | 2,607 | 3,986 | 4,001 | 7,987 | 7,987 |
| R-squared | 0.229 | 0.214 | 0.198 | 0.236 | 0.205 | 0.221 | 0.223 |

Notes: Standard errors clustered at the city level are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

## 4. Conclusion and policy implications

This study investigates whether healthy city development contributes to the accumulation of individual health human capital. By linking micro-level data from the 2023 China Social Survey with a multidimensional Healthy City Development Index constructed at the city level, we provide consistent evidence that improvements in urban health governance are positively and economically significantly associated with individual health outcomes.

The empirical results demonstrate that healthier urban environments and stronger health governance capacity translate into measurable gains in standardized health human capital. The findings remain robust across alternative specifications and after addressing endogeneity concerns using an instrumental variable strategy. The IV estimates suggest that the positive association is unlikely to be driven by reverse causality or omitted variable bias, reinforcing the interpretation that healthy city development exerts a causal impact on individual health accumulation.

Mechanism analysis further reveals that public service accessibility and health-related consumption serve as key transmission channels. Improved healthcare accessibility reduces barriers to medical utilization, while enhanced urban health environments stimulate individual health investment. These channels illustrate how macro-level governance reforms can generate micro-level human capital returns.

The heterogeneity analysis indicates that the benefits of healthy city development are not evenly distributed. The effects are stronger in economically developed regions and among individuals with higher income, education, or urban hukou status. This suggests that institutional capacity, fiscal resources, and individuals' ability to utilize public services condition the effectiveness of urban health policies. Without complementary measures, disparities in health returns may persist.

Several policy implications follow. First, healthy city development should be understood as a long-term human capital strategy rather than solely a public health initiative. Investments in environmental quality, healthcare infrastructure, and institutional governance can yield sustained productivity gains through improved workforce health. Second, strengthening institutional capacity and reducing service accessibility barriers are essential for translating policy inputs into tangible health outcomes. Third, targeted interventions—such as improving information access, expanding coverage for migrant populations, and enhancing primary healthcare equity—are necessary to ensure that vulnerable groups benefit fully from urban health reforms.

This study is subject to limitations. The cross-sectional design restricts dynamic interpretation of health capital accumulation, and future research using panel data or quasi-experimental approaches would further strengthen causal identification. Nevertheless, the findings provide robust evidence that healthy city development plays a meaningful role in shaping individual health human capital.

Overall, urban governance reforms aimed at improving environmental conditions, expanding public health services, and enhancing institutional efficiency can generate substantial and economically meaningful health returns. Healthy city development therefore represents a critical component of sustainable and inclusive human capital formation.

## Declarations

### Author's contributions

Mingcheng Gao designed the study, conducted the empirical analysis, and drafted the manuscript. Kangsi Zhang contributed to the study design, provided overall guidance on the research framework and interpretation of the results, and revised the manuscript critically for important intellectual content. Kangsi Zhang is the corresponding author. Both authors read and approved the final manuscript.

**Duplicate publishing**

The authors declare that the article has not been republished.

**Consent for publication**

All authors have agreed to publish.

**Funding**

This paper is a phased research output of the Key Project of the National Social Science Foundation of China, “New Trends, Emerging Issues, and Policy Mechanisms in Youth Employment” (Grant No. 24AJY021).

**Availability of data and materials**

The data used in this study are partly derived from the major project of the Chinese Academy of Social Sciences. The CSS2023 dataset is publicly available via the China Social Quality Database administered by the Institute of Sociology, Chinese Academy of Social Sciences, with the accessible official URL: http://csqr.cass.cn/index.jsp. An alternative link for the Chinese Social Survey (CSS) project is provided at http://css.cssn.cn/css_sy/. Users may register, complete real-name authentication, and download the CSS2023 dataset (including the questionnaire, codebook, and raw data in Stata/SPSS format) following approval.

**Competing interests**

The authors declare that they have no competing interests.

**Ethics approval and consent to participate**

All experiments were performed in accordance with relevant guidelines and reg ulations.According to Article 32 of Chapter 3 of the Measures for Ethical Revi ew of Life Sciences and Medical Research Involving Human Beings, issued by the Department of Science and Technology Education of the Chinese Health a nd Health Commission [2023] No.4(http://www.nhc.gov.cn/qjjys/s7946/202302/c3 374c180dc5489d85f95df5b46afaf5.shtml), "The use of human information data o r biological samples to carry out life science and medical research involving h uman beings in the following circumstances, does not cause harm to human be ings, does not involve sensitive personal information or commercial interests, c an be exempted from ethical review, in order to reduce the unnecessary burden

on scientific researchers and promote life science and medical research involvi ng human beings:(2) the use of anonymized information data to conduct resear ch.This paper uses anonymized information data to conduct research, which is i n accordance with (2), and therefore ethics does not require ethical review.

**Acknowledgements**

Part of the data used in this paper is drawn from the major project of the Chinese Academy of Social Sciences, the “2023 China Social Survey (CSS).” The survey was conducted by the Institute of Sociology, Chinese Academy of Social Sciences, and led by Guangjin Chen and Wei Li. The authors gratefully acknowledge the above institution and its staff for providing data support. The views and conclusions expressed in this paper are solely those of the authors.

## References

[1]Schultz, T. W. (1961). Investment in human capital. The American economic review, 51(1), 1-17.

[2] BECKER GARY, S. (1964). Human capital.

[3] Grossman, M. (1972). On the concept of health capital and the demand for health. Journal of Political economy, 80(2), 223-255.

[4] Bloom, D. E., & Canning, D. (2000). The health and wealth of nations. Science, 287(5456), 1207-1209.

[5] Cutler, D., Deaton, A., & Lleras-Muney, A. (2006). The determinants of mortality. Journal of economic perspectives, 20(3), 97-120.

[6] Marmot, M. (2005). Social determinants of health inequalities. The lancet, 365(9464), 1099-1104.

[7] World Health Organization. (2016). World Health Statistics 2016 [OP]: monitoring health for the sustainable development goals (SDGs). World Health Organization.

[8] Rydin, Y., Bleahu, A., Davies, M., Dávila, J. D., Friel, S., De Grandis, G., ... & Wilson, J. (2012). Shaping cities for health: complexity and the planning of urban environments in the 21st century. The lancet, 379(9831), 2079-2108.

[9] Browning, M. H., Rigolon, A., & McAnirlin, O. (2022). Where greenspace matters most: A systematic review of urbanicity, greenspace, and physical health. Landscape and urban planning, 217, 104233.

[10] Wei, Z., Jiejing, W., & Bo, Q. (2023). The relationship between urban greenness and mental health: A national-level study of China. Landscape and Urban Planning, 238, 104830.

[11] Nieuwenhuijsen, M., De Nazelle, A., Pradas, M. C., Daher, C., Dzhambov, A. M., Echave, C., ... & Mueller, N. (2024). The Superblock model: A review of an innovative urban model for sustainability, liveability, health and well-being. Environmental research, 251, 118550.

[12] Pineo, H., Glonti, K., Rutter, H., Zimmermann, N., Wilkinson, P., & Davies, M. (2018). Urban health indicator tools of the physical environment: a systematic review. Journal of urban health, 95(5), 613-646.

[13] Andersen, R. M. (1995). Revisiting the behavioral model and access to medical care: does it matter?. Journal of health and social behavior, 1-10.

[14] Cutler, D. M., & Lleras-Muney, A. (2010). Understanding differences in health behaviors by education. Journal of health economics, 29(1), 1-28.

[15] Acemoglu, D., Johnson, S., & Robinson, J. A. (2001). The colonial origins of comparative development: An empirical investigation. American economic review, 91(5), 1369-1401.

[16] Nunn, N. (2009). The importance of history for economic development. Annu. Rev. Econ., 1(1), 65-92.