Pol. J. Environ. Stud. Vol. 33, No. 3 (2024), 3337-3351
DOI: *10.15244/pjoes/175781* ONLINE PUBLICATION DATE: 2024-02-28

Original Research

Green Surroundings, Wellness Abounding: The Impact of Ecological Environment Quality on Residents' Health Expenditure

Xin Ma[1], Xinzi Xia[2]*, Huobao Xie[1, 3]**

[1]Dong Fureng Institute for Economic and Social Development,Wuhan University, Wuhan 430072, China
[2]School of Public Finance and Taxation, Zhongnan University of Economics and Law, Wuhan 430072, China
[3]School of Economics and Management, Wuhan University, Wuhan 430072, China

Received: 30 August 2023
Accepted: 23 November 2023

Abstract

In order to reduce the health damage caused by ecological environment pollution and alleviate the burden of residents' health expenditure, it is of great significance to study the impact of ecological environment quality on residents' health expenditure. In this study, we use the Ecological Environment Index (EI) in China from 2009-2019 and the SYS-GMM model. The conclusions are as follows: (1) The decline of ecological environment quality significantly increased residents' health expenditures. (2) The ecological environment mainly affects the residents' health expenditure through the health effect and driving effect. (3) Compared with economically developed regions and lower environmental emphasis, residents in economically undeveloped regions and high environmental emphasis are more sensitive to health expenditures. (4) Through a series of robustness test and use thermal inversion as an instrumental variable for endogeneity analysis, the regression results remain robust. Therefore, this study provides important evidence for further improving the ecological environment and reducing the residents' health expenditures.

Keywords: ecological environment quality, health expenditure, ecological index, health effect, driving effect

Introduction

In 2023, a storm of healthcare reform is taking place across China. Healthcare, as one of the three mountains in China, imposes a heavy financial burden on residents [1]. Data shows that from 2010-2022, the growth rate of China's per capita healthcare expenditure is as high as 2.39%. Meanwhile, the growth rate of per capita disposable income is only 1.95%, with the growth rate of per capita health expenditure being greater than its income growth rate. According to the National Economic and Social Development Statistics Bulletin of the People's Republic of China 2022, per capita healthcare expenditure is as high as RMB 2,120 per capita in the country's per capita

*e-mail: Xiaxinzi1126@163.com
**e-mail: xie_hb@263.net

consumption expenditure, accounting for 8.6% and ranking fifth.

In addition, as the largest developing country, China's unbalanced and uncoordinated ecological environment remains a prominent problem [2]. The China Ecological Environment Status Bulletin released by the Ministry of Ecology and Environment in 2022 shows that 126 of the country's 338 cities above prefecture level still have air quality exceeding the standard. These pollutants can enter the human body through the respiratory tract, resulting in disorders in residents' self-regulatory functions and a decline in immunity, bringing health risks, illness and even death to residents [3-6]. The 2010 Global Burden of Disease study showed that air pollution is the fourth largest health risk factor for Chinese people [7]. In China, between 350,000 and 500,000 premature deaths are caused by air pollution each year. It can be seen that China's environmental pollution is still serious, and residents are at increased risk of disease [8-11].

Therefore, it is of great significance to investigate the mechanism of ecological environment quality on health expenditure in China. Based on this, this study adopts the China's Ecological Environment Index (EI) from 2009 - 2019 and the SYS-GMM method to study it. Since the residents' health expenditure is susceptible to the influence of the previous period's health expenditure, there is a strong endogeneity problem, and the common panel estimation method is biased and non-consistent. Furthermore, differential GMM is susceptible to weak instrumental variables and small sample bias. For this reason, Blundell et al. (2000) proposed the systematic GMM method, but the consistency of the systematic GMM estimator depends on two conditions, one is the absence of autocorrelation of the perturbation terms, which is identified by the AR test, and the validity of the instrumental variables, which is judged by the Sargan test adopted by some literatures, but the Sargan statistic provided by the official order assumes that the perturbation terms are independently and identically distributed, which is an overly strict and unsupported assumption. However, the Sargan statistic provided by the official command assumes that the perturbation terms are independently and identically distributed, which is too strict and often does not correspond to the reality. Therefore, in this paper, we use the unofficial command xtabond2 to report the heteroskedasticity-robust Hansen statistic to judge the validity of the instrumental variables in the estimation of the systematic GMM [3].

In summary, the research focuses on the following three aspects: (1) To study in depth the health effect and driving effect of ecological environment quality on residents' health expenditure, so as to reduce the burden of residents' health expenditure. (2) To adopt the ecological environment index as a proxy variable for environmental quality, with a view to comprehensively evaluating the level of ecological environment quality in China. (3) Considering the great differences in resource allocation in China, heterogeneity analyses are conducted from both subjective and objective perspectives, so as to deeply explore the differences in the impact of ecological environment quality on residents' health expenditures in different regions.

Materials and Methods

Literature Review and Research Hypotheses

Against the backdrop of the COVID-19 pandemic, the surge in health expenditures has emerged as a pivotal concern for many developing nations [12, 13]. According to the health expenditure theory, factors affecting health expenditure can generally be divided into two main categories: income factors and non-income factors. Among them, income factors mainly include economic growth [14, 15]. Non-income factors are mainly classified into six primary categories, namely: (1) Demographic factors [16-18]; (2) Non-medical health determinants [19, 20]; (3) Societal characteristic factors [21, 22]; (4) Medical technological advancements [23, 24]; (5) Environmental pollution factors [25-27]; and (6) Other macroeconomic elements [28, 29]. Based on existing research, non-income factors play an important role in influencing health expenditures, with this study primarily focusing on ecological environmental quality factors. Many researchers have identified that environmental degradation often leads to increasing health expenditures [30-32].

Ecological Environmental Quality and Residents' Health Expenditure

The theoretical research on the impact of ecological environmental pollution on health expenditure dates back to Grossman's study [33]. The Grossman's health demand model suggests that the present stock of an individual's health capital is a function of their health capital investment and health capital depreciation. Environmental pollution accelerates the rate of residents' health depreciation. As ecological environment quality deteriorates, health depreciation increases, and health stocks decrease. In line with the principle of diminishing marginal utility, when health capital stocks decrease significantly, the utility brought about by residents increasing one unit of health expenditure is higher than the utility brought by increasing the same unit of other normal consumer goods [34]. Therefore, based on the utility maximization theory, the decline in ecological environment quality will lead to frequent occurrences of various chronic diseases, and people will inevitably increase the additional health expenditure costs in order to overcome the diseases. At the same time, the increase in residents' health expenditure will also bring about many adverse effects. Among them, most scholars believe that health expenditure may crowd out other economic capital investments, which is detrimental to economic and social development [35,

36]. Research estimates that health costs caused by the decline in environmental quality in China resulted in economic losses of $10.14 billion, accounting for 0.9% of the country's total GDP in 2016 [37]. Overlooking the additional health expenditure burden caused by environmental pollution may underestimate the adverse impact of declining environmental quality on residents' actual income. Thus, this study proposes Hypothesis 1.

Hypothesis 1: The decline in ecological environmental quality leads to an increase in residents' health expenditure.

Health Effects and Driving Effects of Ecological Environmental Quality

This paper delves extensively into the channels through which ecological environmental quality affects residents' health expenditures. On one hand, ecological environmental quality has health effects [38-40]. Ceteris paribus, as ecological environmental quality worsens, heightened environmental pollution is set to introduce heightened health risks and perils to residents [41]. Research indicates that a decline in environmental quality can lead to an increase in a series of diseases, especially respiratory diseases, cardiovascular and cerebrovascular diseases [42], thereby increasing residents' health costs. Generally speaking, the decline in environmental quality affects the health status of residents, and since residents' health expenditure is closely related to their health status, which is the "health effect" of environmental quality. On the other hand, the decrease in environmental quality prompts residents to pay more attention to ecological pollution [43], further influencing consumers' demand preferences. When the public environmental consciousness awakens, residents will actively participate in activities like healthcare and low-carbon consumption. During the consumption process, they consciously choose high-value eco-friendly or green products and services, consequently diminishing resource consumption and emissions of environmental pollutants. This, in turn, drives an increase in residents' health expenditure, which is the "driving effect" of environmental quality (health effects and driving effects, refer to Figure 2). Based on the above analysis, this study proposes Hypotheses 2a and 2b.

Hypothesis 2a: Ecological environmental quality affects residents' health expenditure through the health effects of ecological environment quality.

Hypothesis 2b: Ecological environmental quality affects residents' health expenditure through the driving effects of ecological environment quality.

Heterogeneous Impact of Environmental Quality on Residents' Health Expenditure

Economic development varies among regions in China, and their abilities to resist the deterioration of environmental quality also differ [44]. For economically developed regions, residents possess greater employment opportunities and relatively higher levels of actual income. When individuals endowed with the capability and greater disposable income, they are inclined to acquire more advanced and relatively costlier pollution abatement equipment, like air purifiers, to alleviate the influence of ecological environment pollution. Additionally, regions with elevated economic development inherently harbor higher health expenditure costs, and residents with higher income levels are less sensitive to health expenditures [45]. Therefore, this paper estimates that a decline in ecological environmental quality will not significantly affect the health expenditure in economically developed areas. However, for less economically developed regions, when the ecological environmental quality declines, residents, in order to maintain higher health human capital health, are more likely to increase their health costs. This aligns with the logic that economically underdeveloped areas are prone to the "environment-health-poverty trap" [44]. Additionally, regional disparities in the emphasis on ecological environmental quality can influence residents' health expenditure levels [43]. Enhancing environmental

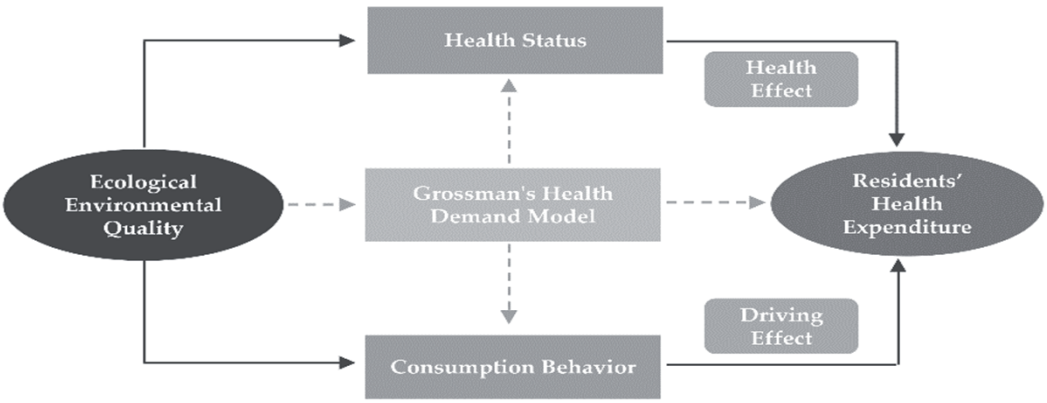

Fig. 1. Relationship between Ecological Environment Quality and Residents' Health Expenditure. The outer circle highlights the channel by which the environment affects health expenditure, while the inner circle provides the theoretical underpinnings that support these channels. Source: Organized by the author.

stewardship is vital to achieving synergistic growth between the environment and economy, in line with the "Porter Hypothesis." Compared to the central government, local governments are better acquainted with the environmental characteristics and pollution types within their jurisdictions, enabling them to formulate governance decisions that are better suited to practical needs. However, this also depends on how much emphasis the local government places on ecological environmental issues. The higher degree of emphasis local governments assign to environmental pollution control, the larger the allocation of resources for enhancing regional environmental resources. The greater the efforts in environmental governance, the better the improvement in environmental quality, resulting in a reduction in residents' health expenditure. Building upon the aforementioned analysis, the study advances Hypotheses 3a and 3b.

Hypothesis 3a: The decline in environmental quality does not have a significant impact on residents' health expenditure in economically developed areas, but it significantly increase the health expenditure costs of residents in economically underdeveloped areas.

Hypothesis 3b: Compared to regions with a lower emphasis on environmental governance, areas with a higher emphasis on environmental governance can significantly reduce residents' health expenditure costs.

Research Design

Sample Selection

This analysis employs dynamic panel data from 30 Chinese provinces spanning 2009 to 2019. Data on ecological environmental quality is sourced from the annual "Ecological Environmental Status Bulletin" published by China's Ministry of Ecology and Environment, in conjunction with the ecological index meticulously assembled by the author. Due to data limitations in certain provinces, the author actively sought ecological index from provinces with missing data through email and by submitting the government's public application documents (Tibet, Hong Kong, Macau were excluded due to significant data absence). It should be noted that, during the years 2009 to 2014, the provinces across China adhered to the evaluation indicators and calculation methods delineated in the "Ecological Environmental Status Evaluation Technical Specifications (Trial)" (HJ/T 192-2006). In the wake of national amendments to the technical specifications, since 2015, the revised "Ecological Environmental Status Evaluation Technical Specifications" (HJ 192-2015) has been used as the standard. Although the calculation method of the ecological index of each province after 2015 is different from that of the previous years, the information remains indicative of the region's ecological environment quality. It's noteworthy that the "China Health Statistics Yearbook" began publishing health expenditure data in 2009. Considering the significant outbreak of COVID-19 in early 2020, which could distort the causal relationship between ecological environment quality and residents' health expenditure [46], the chosen sample period for this study is confined to 2009-2019. Health-related data is sourced from the "China Health and Wellness Statistics Yearbook", while additional data have been procured from the "China Statistical Yearbook" and respective provincial statistical yearbooks.

Model Design

In our effort to investigate the impact of ecological environmental quality on residents' health expenditures, this study designates health expenditure as the dependent variable, with ecological environmental quality serving as the independent variable. However, because health expenditure is difficult to meet the strict exogenous requirements, the individual effect makes the dynamic panel model inherently endogenous [47]. Consequently, in order to tackle the endogenous problem, this study harnesses the SYS-GMM empirical approach [48], adding the health expenditure of the previous period to the control variable $hex_{i,t-1}$. The foundational configuration of the model is articulated as follows:

$$hex_{it}=\alpha_0+\alpha_1 hex_{i,t-1}+\alpha_2 eco_{it}+\partial X_{it}+\varepsilon_{it} \quad (1)$$

In the above equation, i represents the province, while t delineates the specific year. The hex_{it} represents the level of health expenditure in region i during period t. The eco_{it} represents the ecological environment quality in region i during period t. X_{it} represents a series of other control variables affecting residents' health expenditure. ε_{it} represents the random error term. The primary focal point of this model resides in the estimation of the coefficient α_2 parameter.

Aiming to illuminate the channels through which environmental quality affects residents' health expenditures, this research establishes the following mediation model to dissect both the health effect and driving effect behind ecological environmental quality.

$$Z_{it}=\gamma_0+\gamma_1 eco_{i,t}+\tau X_{it}+\varepsilon_{it} \quad (2)$$

$$hex_{it}=\delta_0+\delta_1 eco_{it}+\delta_2 Z_{it}+\mu X_{it}+\theta_{it} \quad (3)$$

In Equation (2) and Equation (3), Z_{it} represents two mediator variables that affect residents' health expenditure by ecological environment quality, namely, the number of residents' medical visits (mev) [49] and the Baidu Index of environmental concern (eindex) [50]. In this study, we use the number of medical visits as a proxy variable of health effect, while the Baidu index of environmental concern serves as the proxy variable of driving effect. Other variables have the same meanings as model (1). We focus on the estimated parameters of coefficients γ_1 and δ_2.

Table 1. Descriptive Statistics of Variables.

Variable	N	Mean	Standard Deviation	Min	Max
eco	330	2.723	0.069	2.437	3.034
hex	330	1.174	0.591	0.253	3.742
edu	330	9.061	0.908	6.910	12.68
agp	330	12.18	2.993	5.190	22.48
gov	330	0.243	0.101	0.096	0.628
ope	330	0.262	0.284	0.011	1.458
lnGDP	330	9.690	0.885	6.987	11.59

Source: Author's own contribution.

Variable Selection

(1) Dependent Variable. In this study, residents' health expenditure is taken as the dependent variable (hex). Some scholars regard hospitalization cost as a proxy variable of health expenditure [51], while this paper uses per capita health expenditure data [52]. Since China only publishes health expenditure at the provincial level, this study calculates the per capita health expenditure using a weighted average of the health expenditures of urban and rural residents. The respective proportions of the urban and rural populations serve as the weights.

(2) Independent Variable. The core explanatory variable was ecological environmental quality (eco). In the current scholarly landscape, environmental pollution metrics predominantly pivot around singular indices – encompassing the likes of PM concentration, SO_2emissions, or metrics rooted in industrial effluents and particulate emissions, while some scholars also use a multi-index system to assess ecological environment quality [53]. This analysis opts for the Ecological Index as the pivotal gauge in assessing the measurement indicator of ecological environmental health [54].

The Ecological Environment Index, denoted as EI, integrates multiple facets of a region's ecological and environmental conditions. It incorporates five primary determinants: the Biological Abundance Index (BAI), Vegetative Coverage Index (VCI), Water Network Density Index (WNDI), Land Degradation Index (LDI), and Pollutant Burden Index (PBI). An auxiliary variable, the Environmental Constriction Index (ECI), further refines the insights of these metrics. These indices jointly elucidate regional biodiversity, vegetative cover distribution, water resource availability, land degradation severity, and pollution burden. Notably, the calculation of EI utilizes a weighted approach:

$$EI = 0.35 \times BAI + 0.25 \times VCI + 0.15 \times WNDI + 0.15 \times (100 - LDI) + 0.10 \times (100 - PBI) \quad (4)$$

(3) Control Variables. Several determinants influence the health expenditure patterns of residents. Drawing from pertinent literature, this study incorporates the following salient control variables:

First, population aging process (agp). Aging Demographics (agp): The old-age dependency ratio serves as the chosen indicator. As the population skews older, prevalent ailments like lung diseases and hypertension become more commonplace. Addressing these health concerns amplifies labor costs, consequently elevating health expenditure [55]. Second, education attainment (edu). The study employs the mean educational years of residents per province as the metric. It's calculated as: average years of education = (illiteracy count×1+primary education count×6+junior high count×9+high school or secondary count×12+college or higher count×16)/population aged over 6. A rise in educational standards not only augments residents' income but those with elevated income levels also tend to allocate more towards healthcare. Furthermore, better education fosters heightened health-consciousness, prompting greater resource allocation towards health [56]. Third, economic growth (GDP). The logarithm of per capita GDP is harnessed as the evaluative metric. Economically prospering regions typically feature enhanced medical facilities, which indirectly influences residents' health outcomes [31, 57]. Fourth, government intervention (gov). For empirical assessment, the proportion of the general public budgetary expenditure relative to GDP is utilized. The governmental prioritization towards public health notably affects the residents' healthcare spending [47]. Fifth, external economic engagement (ope). This research leverages the GDP-relative proportion of the aggregate import-export volume for quantitative scrutiny. Amplified external economic assimilation translates to heightened economic production dynamics, which subsequently catalyzes a crescendo in residents' health-related outlays [58]. Table 1 provides a descriptive breakdown of each variable.

Table 2. The Impact of Environmental Quality on Residents' Health Expenditure.

	hex		
	(1)	(2)	(3)
	OLS	FE	SYS-GMM
eco	-0.017**	-0.783***	-0.449***
	(-1.981)	(-4.610)	(-2.986)
$hex_{i,t-1}$			0.764***
			(8.205)
lnGDP	0.005	-0.482***	-0.169
	(0.156)	(-4.692)	(-1.331)
edu	0.314***	0.185***	0.046
	(20.582)	(3.652)	(1.386)
agp	0.026***	0.011**	-0.000
	(4.863)	(2.224)	(-0.082)
gov	0.543**	-0.315	-0.252
	(1.996)	(-0.639)	(-0.689)
ope	0.131**	-0.749***	-0.303*
	(1.980)	(-5.864)	(-1.659)
_cons	-2.513***	5.671***	3.489**
	(-6.783)	(4.820)	(2.039)
N	330	330	300
AR(1)			0.014
AR(2)			0.579
Hansen_overid			1.00

Note: ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Results and Discussion

Baseline Regression Results

Table 2 presents the basic regression results examining the impact of ecological environment quality on residents' health expenditures. Alongside the SYS-GMM model's estimations, we also include regression outcomes from the OLS and fixed effect (FE) models. Column (1) of Table 2, displaying OLS regression, indicates that an enhancement in ecological environment quality corresponds to a reduction in residents' health expenditure. At the same time, in light of effect factors encompassing geography, politics, and historical nuances, Chinese provinces manifest pronounced individual heterogeneities, and these individual fixed effects might influence the ecological environment, so we use the two-way fixed effects model in column (2). After further controlling the individual fixed effect, the negative impact of ecological environment quality on residents' health expenditure was further enhanced. However, since the ecological environment quality includes the impact of the residents' health expenditure delayed by a period, there are some errors in the above estimates. Consequently, this investigation harnesses the SYS-GMM model as the benchmark model. And the regression outcomes are displayed in column (3) of Table 2. Since the Hansen statistic of the overidentification test is non-significant, thereby attesting to the validity of the selected instrumental variables. Following this, the AR (2) test accepts the null hypothesis, suggesting the absence of autocorrelation in the disturbance term. This underscores the reasonableness of our estimation methods.

The regression outcomes derived from the SYS-GMM model highlight the significant negative repercussions of ecological environment quality on residents' health expenditures, which is also consistent with the relevant results of Narayan et al. [25, 59]. On the one hand, the degradation of environmental quality stands as a cardinal etiological factor for diverse ailments. The decline of ecological environment quality will greatly reduce labor productivity [60]. In a bid to sustain healthy human capital, individuals invariably

Table 3. Health Effects of Environmental Quality.

	(1)	(2)	(3)
	hex	mev	hex
eco	-1.493***	-0.124*	-1.445***
	(-6.128)	(-1.790)	(-6.004)
mev			0.114***
			(3.054)
lnGDP	0.764***	-0.799***	0.737***
	(13.679)	(-3.433)	(13.230)
edu	0.262***	-0.086	0.254***
	(5.300)	(-0.760)	(5.219)
agp	0.054***	0.026**	0.049***
	(9.323)	(2.393)	(8.419)
gov	4.246***	-2.469**	4.111***
	(8.314)	(-2.229)	(8.131)
ope	-0.687***	0.636**	-0.758***
	(-3.757)	(2.186)	(-4.171)
_cons	-6.035***	14.686***	-6.428***
	(-7.297)	(5.701)	(-7.786)
N	330	330	330
R^2	0.8487	0.2618	0.8534
adj. R^2	0.8307	0.1448	0.8354

Note: ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

escalate their health spending. On the other hand, environment pollution will increase infant mortality. Since infants are the main drivers of economic growth in the future, their untimely demises can accentuate the distortion of the demographic fabric, amplifying the challenges of an aging populace. As the elderly demographic swells in proportion within the population structure, it invariably propels an upsurge in residents' health outlays. In conclusion, hypothesis 1 is confirmed.

Channel Analysis of Environmental Quality Affecting Residents' Health Expenditure

The Channel of Health Effect

Table 3 provides a detailed exposition on how ecological environmental quality, through the health effect, influences residents' health expenditure. Within the scope of this study, we employ the number of medical visits as a proxy, capturing the dynamics of residents' health status [49]. Delving into the regression outcomes, it emerges distinctly that the ecological environmental quality and medical visits share a pronounced negative association, and there's a notable positive correlation between medical visits and residents' health expenditure. Such findings intimate that deteriorations in the ecological environmental quality invariably precipitate a surge in the frequency of residents' medical visits, which escalates the overarching health expenditure. This is because environmental pollution is the main cause of various chronic diseases (such as lung maladies), in the quest to mitigate the health adversities spawned by an attenuating environmental quality and to maintain their health capital or endowments, individuals must to amplify expenditures geared towards addressing pollution-affiliated maladies (as corroborated by extant literature). In light of these elucidations, the hypothesis 2a, stands robustly corroborated.

The Channel of Driving Effect

Table 4 illustrates how environmental quality influences residents' health expenditure via the driving effect of public behavior. This research exploits the magnitude of public attention to environmental issues, as measured by the Baidu search index, is used as a proxy variable for the behavioral driving effect [61]. The justification for this choice is manifold: on the one

Table 4. Driving Effects of Environmental Quality.

	(1)	(2)	W
	hex	eindex	hex
eco	-1.493**	-1.470***	-0.818**
	(-2.677)	(-3.017)	(-2.053)
eindex			0.287***
			(7.960)
lnGDP	0.764***	1.140***	0.758***
	(8.967)	(9.856)	(5.667)
edu	0.262***	0.137*	0.254***
	(5.335)	(1.765)	(5.763)
agp	0.054***	0.029*	0.026**
	(6.085)	(1.826)	(2.198)
gov	4.246***	4.212***	4.518***
	(5.611)	(3.681)	(8.767)
ope	-0.687	0.729**	-0.396
	(-1.592)	(2.474)	(-0.776)
_cons	-6.035***	-5.956***	-8.724***
	(-3.306)	(-3.012)	(-5.382)
N	330	270	270
adj. R^2	0.8459	0.6122	0.8707
F	102.176	162.214	73.360

Note: ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

hand, being the preeminent Chinese search engine, Baidu, given its expansive reach and robust data availability, can adeptly analyze regional disparities in China based on search frequency and geographic statistics. On the other hand, the term "green" can not only encapsulates residents' proclivities and actionable intent regarding environmental amelioration, thereby shedding light on potential endeavors to enhance their ambient living conditions and holistic health. Consequently, the research posits the Baidu Search Index (eindex), which searches for "green" keywords on PC and mobile terminals, as the proxy variable driven by residents' behavior. Regression outcomes robustly attest to a pronounced inverse correlation between ecological environment quality and the public's environmental concern, while a pronounced positive correlation exists between environmental awareness and health expenditure. That is, the worse quality of the ecological environment, the residents' environment attention will be significantly increased, and thus increases residents' health expenditure. This may be due to an augmented public consciousness in environmental degradation, nudging consumers towards high-value green health commodities. This shift augments the appetite for green health-centric products, ultimately inflating the residents' health costs [62]. Cumulatively, these insights affirm the veracity of hypothesis 2b.

Heterogeneity Analysis

Heterogeneity of Economic Development Level

To scrutinize the potential variances in the influence of ecological environmental quality on residents' healthcare expenditure between economically developed regions and undeveloped regions, we classified provinces whose residents' income surpasses the median as economically developed regions, and the remaining provinces are delineated as economically undeveloped regions [63].

Columns (1) and (2) in Table 5 show that, although the effect of ecological environmental quality on the health expenditures of residents in economically advanced regions is negligible, a significant negative correlation is observed with the health outlays of denizens in economically undeveloped areas. This may be because residents of economically developed areas have higher real incomes relative to their standard of living, so they tend to pursue higher levels of happiness and spend more on health care. At the same time,

Table 5. Heterogeneity Analysis.

	hex			
	(1)	(2)	(3)	(4)
	underdeveloped	developed	low emphasis	high emphasis
eco	-1.164***	0.111	-1.457	-1.792*
	(-3.249)	(3.717)	(-1.589)	(-2.118)
lnGDP	-0.552***	-0.471***	0.702***	0.808***
	(-2.637)	(-4.779)	(7.703)	(5.337)
edu	0.324***	-0.016	0.234***	0.310***
	(3.460)	(-0.314)	(3.841)	(3.094)
agp	0.023***	-0.000	0.038***	0.060***
	(2.617)	(-0.008)	(4.446)	(4.467)
gov	-1.724	0.356	4.902***	3.562**
	(-1.455)	(0.823)	(5.139)	(2.724)
ope	-0.520**	-0.321	-1.378***	0.037
	(-2.544)	(-1.457)	(-3.656)	(0.083)
_cons	6.624**	3.975***	-5.092	-6.156**
	(2.468)	(3.746)	(-1.755)	(-2.380)
N	165	165	154	176
adj. R^2	0.8913	0.9556	0.8696	0.8440
F	86.310	222.928	112.994	49.907

Note: ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

residents in economically developed areas are relatively insensitive to changes in health expenditure due to their small elasticity of health income [64]. Contrastingly, in economically undeveloped regions, any deterioration in environmental caliber markedly escalates the residents' healthcare costs. On the one hand, the declination in environmental quality not only diminishes individual utility, but also compels individuals to redirect resources, originally intended for alternative tangible capital ventures, towards mitigating ailments induced by environmental contaminants. This reallocation consequently incurs heightened healthcare costs. On the other hand, residents in economically underdeveloped areas have relative lower income and higher elasticity of health income, rendering them acutely responsive to health expenditure perturbations, especially when addressing ailments borne out of environmental degradation [65]. In light of these elucidations, hypothesis 3a, stands robustly corroborated.

Heterogeneity in the Emphasis on Environmental Governance

To discern the potential correlation between environmental quality's impact on inhabitants' health-related expenditures and the respective region's focus on environmental administration, this research utilizes the 2016 elasticity coefficient of environmental pollution governance investment for different regions in China (elasticity coefficient of environmental pollution governance investment = environmental pollution governance investment growth rate /GDP growth rate). Consequently, regions in China have been bifurcated into two categories: those with high emphasis on environmental governance (coefficient values of 1 or above, denoting a growth rate in environmental investment either surpassing or matching the GDP progression) and those with low emphasis on environmental governance (coefficient values below 1, indicating a languid investment growth rate compared to GDP's rise) [66].

As elucidated in the columns (3) and (4) of Table 5, regions with high emphasis on environmental governance witness a marked diminution in health expenditures as a result of superior ecological quality. In contrast, in regions with a more subdued environmental focus, this influence remains insubstantial. This insinuates that when local administrative bodies amplify their concern towards environmental degradation, there's a commensurate escalation in the allocation of resources aimed at ameliorating the living environment for its residents.

Table 6. Robustness Test.

	(1)	(2)	(3)
	hex	hex	hex
$PM_{2.5}$	0.046**		
	(2.452)		
eco		-1.460***	-1.299***
		(-6.008)	(-5.620)
lnpatent		0.082**	
		(1.969)	
cx			0.243***
			(6.287)
lnGDP	-0.423***	0.595***	0.657***
	(-4.626)	(5.814)	(11.899)
edu	-0.004	0.256***	0.129**
	(-0.097)	(5.192)	(2.523)
agp	-0.000	0.050***	0.038***
	(-0.066)	(8.443)	(6.296)
ope	-0.148	-0.705***	-0.569***
	(-1.303)	(-3.870)	(-3.292)
gov	-0.585	3.853***	3.625***
	(-1.340)	(7.056)	(7.394)
_cons	4.454***	-4.877***	-4.095***
	(4.455)	(-4.822)	(-4.895)
N	330	330	330
R^2	0.9375	0.8507	0.8667
adj. R^2	0.9276	0.8324	0.8503

Note: ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Such endeavors not only enhance the overall well-being of the populace but also curtail the susceptibility to illnesses emanating from environmental contaminants, thereby attenuating associated healthcare outlays [43, 67]. Summing up the findings, the research hypothesis 3b, stands robustly corroborated.

An Examination of Robustness and Potential Endogeneity

Probing into the Robustness

In a pursuit to ascertain the robust nature of the regression outcomes, our study diligently embraces a triad of methodologies: a meticulous replacement of the dependent variable, an acute consideration for potentially omitted variables, and a thorough exclusion of influences stemming from other policy paradigms.

(1) Alternate the dependent variable's metric. Drawing inspiration from the plethora of extant scholarly contributions, our investigation pivots the environmental quality's evaluative criterion towards the PM2.5 concentration [26]. By channeling the regression through the fixed effects model, the insights derived from column (1) of Table 6 elucidate a significant negative correlation between PM2.5 concentration and the financial outlays residents earmark for health. This intriguing revelation harmoniously aligns with the findings echoed by our baseline regression model.

(2) Delving into the Omitted Variables. Prevailing scholarly discourses illuminate that the nuanced spectrum of green technological innovation across diverse regions profoundly influences the residents' health cost [59, 68]. In an endeavor to assiduously negate the potential distortions emanating from omitted variables, our study appropriates the volume of green invention patent applications across provinces

Table 7. Instrumental Variable Method.

	First Stage	Second Stage
	eco	hex
item	-0.1094***	
	(-2.87)	
eco		-0.7807**
		(-2.52)
lnGDP	-0.560**	-0.072
	(-2.55)	(-1.60)
edu	-0.310***	0.307***
	(-2.98)	(10.09)
agp	-0.030	0.039***
	(-1.08)	(4.05)
gov	-10.147***	-0.162
	(-5.62)	(-0.30)
ope	0.866***	-0.139
	(3.70)	(-1.25)
_cons	16.893***	19.488**
	(6.28)	(2.18)
N	319.000	319.000
r2	0.239	0.161
F	17.122	

Note: ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

as a surrogate for the green technological innovation, symbolized as (lnpatent), thereby exercising stringent controls over it. The revelations presented in column (2) of table 6 underscore that, even upon judiciously factoring in the green innovation cadence of individual provinces, the regression coefficient tethered to our independent variable retains significant.

(3) Setting aside the influence of other policies. In the course of assessing the repercussions of environmental quality on the health expenditure of residents, one cannot overlook the potential perturbations from concurrent policies, potentially skewing the evaluative outcomes. Existing research indicates that a unified medical insurance system for urban and rural residents can significantly enhance health demands [47]. While the urban-rural medical insurance policy originated from a pilot program in 2008, its broad-based expansion ensued post the State Council's promulgation of the "Opinions on Integrating the Basic Medical Insurance System for Urban and Rural Residents" in 2016. Consequently, this paper incorporates a dummy variable pertaining to the fundamental medical insurance policy enveloping urban and rural inhabitants into the model, subsequently undertaking a regression analysis. As delineated in Table 6, column (3), controlling the unified urban-rural medical insurance policy, the regression coefficient associated with the independent variable retains its significance, underscoring the validity of our foundational assertions.

Probing Endogeneity Concerns

(1) Harnessing the SYS-GMM Approach. Grappling with the intrinsic endogeneity dilemmas that envelop our variable of interest, namely health expenditure, our discourse has meticulously sought validation through the SYS-GMM model. The empirical outcomes have been previously delineated and affirmed within the preceding sections of this study.

(2) Instrumental Variable Method. In a meticulous effort to disentangle and rectify biases in our empirical elucidations steered by potential endogeneity, a thermal inversion (characterized as 'item') to stand as an instrumental variable for the overarching ecological environmental quality, taking cues from both Fan Xia (2022) and Olivier Deschenes (2020) [26, 39]. A thermal inversion intriguingly encapsulates the scenario wherein atmospheric temperature exhibits

an upward trajectory commensurate with elevating altitudes. This particular dynamic unerringly aligns with the twin cardinal tenets of instrumental variables: On the one hand, the existence of thermal inversions makes the cold air below cannot rise and mix with the cleaner warm air above, thus affecting the ecological environment quality and meeting the correlation requirements. On the other hand, a thermal inversion is not directly related to the health expenditure of residents, thus satisfying requirements unrelated to the residual term. Delving into the specific results obtained by the 2SLS method as delineated in Table 7, our primary regression illuminates a decidedly positive and significant coefficient for the instrumental metric, while the F-statistic audaciously surpasses the benchmark of 10, signifying a triumphant traversal through the weak correlation test. In addition, the secondary stage regression phase witnesses a metamorphosis in the absolute coefficient value, yet its directional sign remains in harmonious with the benchmark findings. Synthesizing the entirety of this study, even when weighed against the backdrop of conceivable endogeneity quandaries, our articulated outcomes manifest unwavering robustness.

Conclusions

Research Conclusions

In a review of the content of this study, it is possible to arrive at several vital conclusions. In contrast to prior focus on aspects such as the pricing of medical services and health insurance, this study makes an incisive entry through the lens of ecological environmental quality, deeply investigating its influence on residents' health expenditure. Through a comprehensive analysis of provincial-level panel data spanning from 2009 to 2019 in China, the results compellingly reveal:

Firstly, a prominent negative correlation exists between the ecological environment quality and residents' health spending. This outcome serves to accentuate the critical role that the ecological environment plays in shaping the spending patterns related to residents' health.

Secondly, through a channel analysis, it is evident that the ecological environment's quality affects residents' health expenditure predominantly via two separate channels, namely, health effects and driving effects. This insightful finding broadens the theoretical paradigm concerning the interconnection between the environment and health, thereby furnishing additional references for the formulation of pertinent policies.

Thirdly, through an analysis of heterogeneity, the degradation in ecological environment quality seemingly doesn't markedly influence the health expenditure in economically developed regions, yet it conspicuously elevates the level of health spending in economically undeveloped areas. Simultaneously, in areas prioritizing environmental emphasis, ecological environment quality notably reduces residents' health expenses, whereas in locales where environmental concern is not as paramount, its influence is notably less significant. This difference elucidates the necessity for the government to tailor policies based on individual regional circumstances, giving due consideration to both the diverse stages of economic growth and the varying degrees of emphasis on the environment across different regions.

Acknowledgments

The authors gratefully acknowledge the financial support provided by "the Fundamental Research Funds for the Central Universities Zhongnan University of Economics and Law" (project number: 202310412) and "Ministry of Education of China Humanities and Social Sciences Research Planning Fund Project: The Effects and Mechanisms of Intelligent Manufacturing on Enterprise Resource Allocation and Outcome Sharing"(project number: 23YJA630103).

Conflict of Interest

The authors declare no conflict of interest.

References

1. YADAV M., ANEJA R., AHMED W. Do clean energy transition, environment degradation, and energy efficiency influence health expenditure: empirical evidence from emerging countries. J Clean Prod. **428** (139355), **2023**.
2. ALI S., JIANG J., HASSAN S.T., SHAH A.A. Revolution of nuclear energy efficiency, economic complexity, air transportation and industrial improvement on environmental footprint cost: a novel dynamic simulation approach. Nucl Eng Technol. **54** (10), 3682, **2022**.
3. DENG Q., QIN Y., AHMAD N. Relationship between environmental pollution, environmental regulation and resident health in the urban agglomeration in the middle reaches of yangtze river, china: spatial effect and regulating effect. Sustainability-Basel. **14** (13), 7801, **2022**.
4. LUO H., GUAN Q., LIN J., WANG Q., YANG L., TAN Z., WANG N. Air pollution characteristics and human health risks in key cities of northwest china. J Environ Manage. **269** (110791), **2020**.
5. BARZEGHAR V., SARBAKHSH P., HASSANVAND M.S., FARIDI S., GHOLAMPOUR A. Long-term trend of ambient air PM10, PM2.5, and o^3 and their health effects in tabriz city, iran, during 2006–2017. Sustain Cities Soc. **54** (101), **2020**.
6. ORTEGA-GIL M., MATA GARCÍA A., ELHICHOU-AHMED C. The effect of ageing, gender and environmental problems in subjective well-being. Land. **10** (12), 1314, **2021**.
7. YANG G., WANG Y., ZENG Y., GAO G.F., LIANG X., ZHOU M., WAN X., YU S., JIANG Y., NAGHAVI M. Rapid health transition in china, 1990-2010: findings

from the global burden of disease study 2010. Lancet. **381** (9882), 1987, **2013**.
8. XU P., CHEN Y., YE X. Haze, air pollution, and health in china. The Lancet (British edition). **382** (9910), 2067, **2013**.
9. DAI J., CHEN B., HAYAT T., ALSAEDI A., AHMAD B. Sustainability-based economic and ecological evaluation of a rural biogas-linked agro-ecosystem. Renewable and Sustainable Energy Reviews. **41** (347), **2015**.
10. LIU Y., GAO C., LU Y. The impact of urbanization on ghg emissions in china: the role of population density. J Clean Prod. **157** (299), **2017**.
11. XIE Y., DAI H., HANAOKA T., MASUI T. Health and economic impacts of PM2.5 pollution in beijing-tianjin-hebei area. China Population, Resources and Environment. **26** (11), 19, **2016**.
12. BLOOM D.E., CHEN S., KUHN M., MCGOVERN M.E., OXLEY L., PRETTNER K. The economic burden of chronic diseases: estimates and projections for china, japan, and south korea. The Journal of the Economics of Ageing. **17** (100163), **2020**.
13. COCCIA M. High health expenditures and low exposure of population to air pollution as critical factors that can reduce fatality rate in covid-19 pandemic crisis: a global analysis. Environ Res. **199** (111339), **2021**.
14. MESKARPOUR AMIRI M., KAZEMIAN M., MOTAGHED Z., ABDI Z. Systematic review of factors determining health care expenditures. Health Policy Techn. **10** (2), 100498, **2021**.
15. HUSSAIN Z., MARCEL B., MAJEED A., TSIMISARAKA R.S.M. Effects of transport–carbon intensity, transportation, and economic complexity on environmental and health expenditures. Environment, Development and Sustainability. **2023**.
16. YANG X., LI N., MU H., AHMAD M., MENG X. Population aging, renewable energy budgets and environmental sustainability: does health expenditures matter? Gondwana Res. **106** (303), **2022**.
17. KRABBE-ALKEMADE Y., MAKAI P., SHESTALOVA V., VOESENEK T. Containing or shifting? Health expenditure decomposition for the aging dutch population after a major reform. Health Policy. **124** (3), 268, **2020**.
18. LOPREITE M., ZHU Z. The effects of ageing population on health expenditure and economic growth in china: a bayesian-var approach. Soc Sci Med. **265** (113513), **2020**.
19. ETTNER S.L., M. HARWOOD J., THALMAYER A., ONG M.K., XU H., BRESOLIN M.J., WELLS K.B., TSENG C., AZOCAR F. The mental health parity and addiction equity act evaluation study: impact on specialty behavioral health utilization and expenditures among "carve-out" enrollees. J Health Econ. **50** (131), **2016**.
20. ENEJI M.A., JULIANA D.V., ONABE B.J. Health care expenditure, health status and national productivity in nigeria (1999-2012). Journal of Economics and International Finance. **5** (7), **2013**.
21. ZHANG L., WU Y. Negative associations between quality of urban green spaces and health expenditures in downtown shanghai. Land. **11** (8), 1261, **2022**.
22. HAJIZADEH M., PANDEY S., PULOK M.H. Decomposition of socioeconomic inequalities in catastrophic out-of-pocket expenditure for healthcare in canada. Health Policy. **127** (51), **2023**.
23. HARDEMAN A.N., KAHN M.J. Technological innovation in healthcare: disrupting old systems to create more value for african american patients in academic medical centers. J Natl Med Assoc. **112** (3), 289, **2020**.
24. AHMAD H.F., RAFIQUE W., RASOOL R.U., ALHUMAM A., ANWAR Z., QADIR J. Leveraging 6g, extended reality, and iot big data analytics for healthcare: a review. Computer Science Review. **48** (100558), **2023**.
25. NARAYAN P.K., NARAYAN S. Does environmental quality influence health expenditures? Empirical evidence from a panel of selected oecd countries. Ecol Econ **65** (2), 367, **2008**.
26. XIA F., XING J., XU J., PAN X. The short-term impact of air pollution on medical expenditures: evidence from beijing. J Environ Econ Manag. **114** (102680), **2022**.
27. VYAS V., MEHTA K., SHARMA R. The nexus between toxic-air pollution, health expenditure, and economic growth: an empirical study using ardl. Int Rev Econ Financ. **84** (154), **2023**.
28. ODUSANYA I.A., ADEGBOYEGA S.B., KUKU M.A. Environmental quality and health care spending in nigeria. Fountain Journal of Management and Social Sciences. **2** (3), 57, **2014**.
29. HERNANDEZ M., WONG R., YU X., MEHTA N. In the wake of a crisis: caught between housing and healthcare. SSM - Population Health. **23** (101453), **2023**.
30. YAHAYA A., NOR N.M., HABIBULLAH M.S., GHANI J.A., NOOR Z.M. How relevant is environmental quality to per capita health expenditures? Empirical evidence from panel of developing countries. SpringerPlus. **5** (1), **2016**.
31. ZENG J., HE Q. Does industrial air pollution drive health care expenditures? Spatial evidence from china. J Clean Prod. **218** (400), **2019**.
32. DERYUGINA T., HEUTEL G., MILLER N.H., MOLITOR D., REIF J. The mortality and medical costs of air pollution: evidence from changes in wind direction. Am Econ Rev. **109** (12), 4178, **2019**.
33. GROSSMAN M. On the concept of health capital and the demand for health. J Polit Econ. **80** (2), 223, **1972**.
34. GROSSMAN M. The human capital model of the demand for health. Nber working paper. NBER Working Paper. 70, **1999**.
35. CHEN F., CHEN Z. Cost of economic growth: air pollution and health expenditure. Sci Total Environ. **755** (142543), **2021**.
36. CHEN F., ZHANG X., CHEN Z. Air pollution and mental health: evidence from china health and nutrition survey. J Asian Econ. **86** (101611), **2023**.
37. MAJI K.J., YE W., ARORA M., SHIVA NAGENDRA S.M. PM2.5-related health and economic loss assessment for 338 chinese cities. Environ Int. **121** (392), **2018**.
38. HEYES A., ZHU M. Air pollution as a cause of sleeplessness: social media evidence from a panel of chinese cities. J Environ Econ Manag. **98** (102247), **2019**.
39. DESCHENES O., WANG H., WANG S., ZHANG P. The effect of air pollution on body weight and obesity: evidence from china. J Dev Econ. **145** (102461), **2020**.
40. CHEN F., CHEN Z. Air pollution and avoidance behavior: a perspective from the demand for medical insurance. J Clean Prod. **259** (120970), **2020**.
41. YI F., YE H., WU X., ZHANG Y.Y., JIANG F. Self-aggravation effect of air pollution: evidence from residential electricity consumption in china. Energ Econ. **86** (104684), **2020**.
42. ZHANG X., OU X., YANG X., QI T., NAM K., ZHANG D., ZHANG X. Socioeconomic burden of air pollution in china: province-level analysis based on energy economic model. Energ Econ. **68** (478), **2017**.
43. MA P., SONG Y., ZHANG M. Mediating and spatial spillover effects of public participation in environmental

pollution governance mediated via traditional and new media. J Environ Manage. **342** (118046), **2023**.
44. QI Y., LU H. Pollution, health and inequality-overcoming the environmental-health-poverty-trap. Management World (9), 32, **2015**.
45. CHEN Y., SHI J., ZHUANG C.C. Income-dependent impacts of health insurance on medical expenditures: theory and evidence from china. China Econ Rev. **53** (290), **2019**.
46. PHAN T.N.T., NGO V.M., NGUYEN H.H. Drivers of medical spending behaviour amid the covid-19 pandemic: heuristic or systematic. Exploratory Research in Clinical and Social Pharmacy. **5** (100116), **2022**.
47. LIU K., ZHANG Q., HE A.J. The impacts of multiple healthcare reforms on catastrophic health spending for poor households in china. Soc Sci Med. **285** (114271), **2021**.
48. ARELLANO M., BOND S. Some tests of specification for panel data: monte carlo evidence and an application to employment equations. The Review of Economic Studies **58** (2), 277, **1991**.
49. WANG S., SHAFIQUE S., XIAO D., BARKER K., WANG K., XIE X. Clusters of substance use and mental health variables with emergency room visits in u.s. Adults: the 2020 national survey on drug use and health. J Affect Disorders. **339** (683), **2023**.
50. YU W., JIN X. Does environmental information disclosure promote the awakening of public environmental awareness? Insights from baidu keyword analysis. J Clean Prod. **375** (134072), **2022**.
51. FENG J., CAO D., ZHENG D., QIAN Z.M., HUANG C., SHEN H., LIU Y., LIU Q., SUN J., JIAO G., YANG X., MCMILLIN S.E., WANG C., LIN H., ZHANG X., ZHANG S. Cold spells linked with respiratory disease hospitalization, length of hospital stay, and hospital expenses: exploring cumulative and harvesting effects. Sci Total Environ. **863** (160726), **2023**.
52. LU W., WU H., GENG S. Heterogeneity and threshold effects of environmental regulation on health expenditure: considering the mediating role of environmental pollution. J Environ Manage. **297** (113276), **2021**.
53. CHEN S., GOLLEY J. 'green' productivity growth in china's industrial economy. Energ Econ. **44** (89), **2014**.
54. YAO Y., SHI-XIN W., YI Z., RUI L., XIANG-DI H. The application of ecological environment index model on the national evaluation of ecological environment quality. Remote Sensing Information. **27** (3), 93, **2012**.
55. AZAM M., AWAN A.M. Health is wealth: a dynamic sur approach of examining a link between climate changes and human health expenditures. Soc Indic Res. **163** (2), 505, **2022**.
56. LIAO L., DU M., CHEN Z. Air pollution, health care use and medical costs: evidence from china. Energ Econ. **95** (105132), **2021**.
57. ALI S., NASEEM M.A., JIANG J., REHMAN R.U., MALIK F., AHMAD M.I. "how" and "when" ceo duality matter? Case of a developing economy. SAGE Open **12** (3), 1999380135, **2022**.
58. YANG B., USMAN M., JAHANGER A. Do industrialization, economic growth and globalization processes influence the ecological footprint and healthcare expenditures? Fresh insights based on the stirpat model for countries with the highest healthcare expenditures. Sustainable Production and Consumption. **28** (893), **2021**.
59. LI H., LU J., LI B. Does pollution-intensive industrial agglomeration increase residents' health expenditure? Sustain Cities Soc. **56** (102092), **2020**.
60. YANG J., ZHANG B. Air pollution and healthcare expenditure: implication for the benefit of air pollution control in china. Environ Int. **120** (443), **2018**.
61. LIBO W., MEIMIN Y., KEGE S. Impact of public environmental attention on environmental governance of enterprises and local governments. China population, resources and environment. **32** (2), 1, **2022**.
62. GHOSH D., SHAH J., SWAMI S. Product greening and pricing strategies of firms under green sensitive consumer demand and environmental regulations. Ann Oper Res. **290** (1), 491, **2020**.
63. PEIZHEN J., DESHENG Y., ZHUANG J. Urban heterogeneity, institution supply and innovation quality
64. . The Journal of World Economy. (11), 99, **2019**.
65. CHEN Y., EBENSTEIN A., GREENSTONE M., LI H. Evidence on the impact of sustained exposure to air pollution on life expectancy from china's huai river policy. Proceedings of the National Academy of Sciences. **110** (32), 12936, **2013**.
66. APERGIS N., BHATTACHARYA M., HADHRI W. Health care expenditure and environmental pollution: a cross-country comparison across different income groups. Environ Sci Pollut R. **27** (8), 8142, **2020**.
67. WENLI X., LEI S. Market-incentive environmental regulation and energy consumption structure transformation. The Journal of Quantitative & Technical Economics (7), 133, **2023**.
68. NEWIG J., JAGER N.W., CHALLIES E., KOCHSKÄMPER E. Does stakeholder participation improve environmental governance? Evidence from a meta-analysis of 305 case studies. Global Environmental Change. **82** (102705), **2023**.
69. DONG S., REN G., XUE Y., LIU K. How does green innovation affect air pollution? An analysis of 282 chinese cities. Atmos Pollut Res. **14** (9), 101863, **2023**.

Appendix A

Table A1. Variable Defnitions.

Variables Type	Variables Name	Variable Symbol	Variable Definition
Dependent Variable	Residents' Health Expenditure	hex	Urban resident average health expense × urban population ratio + Rural resident average health expense × rural population ratio
Independent Variable	Ecological Environment Quality	eco	Ecological Environment Condition Index
Channel Variable	Health Condition	mev	Number of medical visits
	Environmental Concern	eindex	Baidu Index for the keyword "green" combined from both PC and mobile searches
Control Variable	Population Aging	agp	Ratio of individuals aged 65 and over to the total population
	Education Level	edu	Average years of education = (illiteracy count×1+primary education count × 6+junior high count × 9+high school or secondary count × 12+college or higher count × 16)/ population aged over 6
	Economic Development	lnGDP	Logarithm of per capita GDP
	Government Intervention	gov	General public budget expenditure as a percentage of GDP
	External Opening	ope	Total import and export value as a percentage of GDP

Source: Author's own contribution.