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The impact of air pollution on the settlement intention of the floating population——Empirical evidence from China

Dongmei Cao[1], Xiaofan Xu[1], Ce Guo[2]✉ & Yujia Liao[1]

This paper utilizes 2017 dynamic monitoring data of China's floating population and matches it with air pollution data from 287 prefecture-level cities to construct a Probit model. The study aims to investigate the effects and pathways of air pollution on the settlement intention of floating populations. The research findings are as follows: Firstly, air pollution significantly affects the settlement intention of floating populations, with an increase in air pollution concentration leading to a notable decrease in their intent to reside. Secondly, the impact of air pollution on the settlement intention of floating populations varies based on their personal characteristics and regional features. Those with longer years of residence, higher education levels, and better air quality in their hometowns tend to be more sensitive to air pollution. Thirdly, air pollution reduces the settlement intention of floating populations by affecting their physical health. Further research finds that better healthcare services provided by the government can enhance the willingness of migrant populations to settle in areas with environmental pollution. This study enriches the relevant research on environmental factors' influence on the settlement intention of floating populations, and it provides insights for the government to formulate talent attraction policies from an environmental governance perspective.

Keywords Air pollution, Floating population, Settlement intention

The vast floating population in China has a profound impact on the urban and regional development landscape. The Seventh National Population Census in 2020 revealed that China's total floating population reached 376 million, a 70% increase compared to 2010. Floating populations not only enrich labor resources at the regional level but also contribute to regional economic development through increasing human capital and changing the age structure of the population[1]. How to retain more population has also become a difficult problem in the process of urban governance. "The Competition for Population" among cities not only involves attracting labor force to move in but also ensuring the long-term residency of migrating labor, truly serving the development goals of the target city. Therefore, the settlement intention of floating populations is not only a reflection of individual willingness to reside long-term but also a crucial indicator of whether the destination city is attractive[2].

For a long time, China has pursued an extensive economic development model characterized by "high growth, high pollution, and high energy consumption." This has led to serious ecological damage alongside rapid economic growth. According to the "Climate Change Green Paper: Response to Climate Change Report" jointly published by the Chinese Academy of Social Sciences and the China Meteorological Administration, air pollution increases mortality, worsens chronic diseases, alters the immune system, and causes anxiety and depression among individuals. Haze is a visually perceptible form of air pollution, and NO2 is one of its main components. High concentrations of NO2 in the atmosphere significantly impact air quality and harm environmental benefits[3,4]. China's NO2 emissions have been increasing year by year, making it one of the most severely affected regions by nitrogen oxide pollution[5,6]. President Xi Jinping has pointed out that the main conflict in Chinese society has shifted to the "conflict between the people's growing needs for a better life and the unbalanced and inadequate development." A better life for the people depends on a good ecological environment, and as public awareness of environmental issues increases and the central goal of building an "environmentally friendly society" is proposed, high-quality air quality in cities has also become a powerful incentive for attracting

[1]School of Public Administration, Southwestern University of Finance and Economics, Chengdu 611130, Sichuan Province, China. [2]The Office of Scientific Research, Zhongnan University of Economics and Law, Wuhan 430073, Hubei Province, China. ✉email: guoce@zuel.edu.cn

population inflow and settlement. Therefore, including air pollution in the scope of public policy scrutiny has become increasingly urgent.

According to Rosen-Roback's theory of urban spatial equilibrium, labor mobility is influenced by income, cost of living, and the livability of cities. Air quality is an important indicator of city livability, and its impact on whether floating populations will live long-term in the destination area should not be underestimated. However, current research primarily explores the role of air pollution in migration decisions and location choices of floating populations, with limited analysis of how post-migration air quality affects the long-term residency of labor. In the context of a significant increase in the harm caused by air pollution to residents' physical health, the need to study the causal relationship between air pollution and the settlement intention of floating populations has become more prominent.

Against this backdrop, this paper utilizes city-level NO2 data, 2017 national floating population dynamic monitoring survey data, and matches them with urban data to investigate the impact of air pollution on the settlement intention of floating populations. The aim is to clarify the role of environmental factors in the settlement intention of floating populations. At the theoretical level, this paper enriches the research on factors influencing the settlement intention of floating populations and extends the study of the mechanisms through which air pollution affects their settlement intention. At the practical level, it provides a broader perspective for the government to formulate "talent attraction and retention" policies. Furthermore, differentiating the differential impact of air pollution on different regions and labor groups is conducive to city managers in better tailoring policies to the regional elements and development status of the city.

Compared with previous studies, the innovations of this paper are as follows: Firstly, this paper places greater emphasis on long-term migration decisions, specifically long-term settlement, thereby enriching the research on factors influencing long-term settlement intentions. The decision-making process of labor migration generally involves two stages: the first is the decision of whether to migrate to a particular location (a short-term decision), and the second is whether to remain in the destination for the long term (a long-term decision). While existing studies on the relationship between air pollution and labor mobility primarily focus on how air pollution influences short-term migration decisions and job selection, less attention has been paid to whether and how air quality impacts migrants' willingness to stay in the long term. This paper addresses the research gap by focusing on the effect of air pollution on the long-term settlement intentions of the floating population and its underlying mechanisms. By doing so, it contributes to the broader understanding of the factors influencing long-term settlement decisions among migrants. Secondly, the paper uses NO_2 data to represent air pollution, which aligns more closely with the actual air pollution situation in China, making the empirical results more accurate. Current studies often use $PM_{2.5}$ to represent air pollution, but this paper argues that NO_2 is a more accurate indicator. But China has become one of the regions with the most severe nitrogen oxide pollution in the world. NO_2, primarily produced by fossil fuel combustion in transportation, industry, and energy production, directly reflects pollution from human activities due to its localized emission and short-range dispersion characteristics. In contrast, $PM_{2.5}$ has diverse sources, including natural and human activities, with complex composition and broader dispersion, making it less directly linked to urban or industrial pollution. Moreover, NO_2's health impacts, particularly on respiratory and cardiovascular systems, are well-documented and more straightforward compared to the complex mechanisms of $PM_{2.5}$.

Literature review

Population is the core resource for the sustainable development of cities, and the large-scale influx of external populations promotes urban economic development. For floating populations, the arrangement and implementation of settlement behaviors take time, and the intent to reside often precedes the actual settlement behavior[7]. Therefore, exploring the factors that influence settlement intention is a prerequisite for studying their settlement behavior. In existing research, scholars have primarily categorized the study of factors influencing settlement intention into two main categories: personal factors and urban factors. Regarding personal factors, existing research mainly covers gender, education level, marital status, and suggests that women, individuals with higher education, and those who are married are more likely to have the intent to reside long-term in the city[8–10]. Concerning urban factors, regional characteristics of the destination city significantly influence the settlement intention of floating populations. Current studies primarily focus on city size, household registration system, and the accessibility of social resources. Song Yanjiao et al. studied the migration intention of floating population and found that in terms of city size, floating population preferred to settle in big cities, rather than megacities such as Beijing and Shanghai[11]. Urban hukou policies, such as the availability of urban hukou, will also affect the migrant population's settlement intention[12]. Tang et al. suggested that strict household registration systems hinder equal distribution of public services, creating disparities in access to urban public welfare, which can reduce the long-term settlement intention of floating populations[13].

China's air pollution problem is widespread. On the one hand, air pollution can negatively affect residents' physical and mental health; On the other hand, air pollution affects regional economic growth through multiple transmission mechanisms. In terms of physical and mental health, Chen et al. found that, compared to the south of China, the concentration of air pollution caused by centralized heating in the north deepens regional air pollution, shortening the life expectancy of northern residents by 5.5 years compared to their southern counterparts[14]. Additionally, some studies indicate that exposure to air pollution can lead to symptoms of psychological distress and anxiety in residents[15,16]. In terms of regional economic growth, the study of Zhu Hong shows that air pollution will reduce the number of trips and reduce the frequency of tourism in scenic spots, thus leading to economic losses of urban tourism[17].Long-term exposure to polluted air will lead to respiratory and cardiovascular diseases, and the health burden will lead to hospitalization or premature death, leading to huge economic losses[18]. From the perspective of human capital accumulation, some studies believe that air pollution

may damage healthy human capital and high-level urban human capital, leading to the outflow of young talents and thus hindering urban innovation[19].

As an important indicator of urban quality of life, environmental factors, including air pollution, have been of interest to scholars studying the impact of air pollution on labor mobility. Some scholars have explored the direction of the impact of air pollution on international migration. Qin and Zhu analyzed the Baidu search index for the keyword "migration" and found that for every 10% increase in China's air quality index, there was a 2.3–4.8% increase in the frequency of people searching for "migration" the next day[20]. Li Ming and Zhang Yiran studied the migration effect of air pollution in the context of China, and their results indicated that the more severe the air pollution in a city, the fewer international students studying in that region. Apart from international mobility, scholars have also focused on the impact of air pollution on inter-regional mobility[21]. Regarding migration decisions, air pollution will affect the residence satisfaction of talents, and thus negatively affect regional talent flow[22].Li Weibing and Yang Huan used a regression discontinuity method to analyze the impact of air pollution on population migration, and they found that air pollution has a significant negative impact on population inflow[23]. In terms of employment location, Sun Weizeng et al. studied the impact of air pollution on the employment location of floating populations and found that for every 1 μg/m3 increase in pollution concentration, the probability of floating populations seeking employment in that city would significantly decrease by 0.39 percentage points[24]. This conclusion is similar to the findings of Zhang Hua, which showed that NO2 emissions cause more than 2.5 million job losses each year and an average economic loss of around 54 billion yuan[25]. Settlement intention is an important prerequisite for determining whether labor moves between regions. Existing research has paid relatively less attention to the relationship and mechanisms between air pollution and settlement intention. However, some studies suggest that air pollution can have a negative impact on settlement intention[26].

Current studies predominantly use $PM_{2.5}$ to represent air pollution[27].NO_2 (Nitrogen Dioxide) is a significant component of air pollution, primarily originating from the combustion of fossil fuels in processes such as transportation, industrial emissions, and energy production[28]. Due to its rapid reactivity and the fact that its concentration is heavily influenced by local emission sources and short-range dispersion, NO_2 directly correlates with pollution levels in areas with high human activity, such as cities and industrial zones[29]. These characteristics make NO_2 an ideal indicator for assessing localized pollution caused by anthropogenic factors.In contrast, $PM_{2.5}$ has a more complex source profile, as it can originate from both natural sources (such as dust and sea salt) and human activities (including combustion and industrial emissions)[30]. Its diverse composition and widespread dispersion complicate its relationship with urban or industrial pollution specifically. While $PM_{2.5}$ is a critical pollutant linked to a range of health issues, its effects are influenced by factors such as particle composition, size, and source variability, making the health impact mechanisms less straightforward compared to NO_2[31].From a health perspective, NO_2 is widely recognized as a significant risk factor for respiratory and cardiovascular diseases[32]. Long-term exposure to high levels of NO_2 has been shown to exacerbate conditions like asthma, bronchitis, and other lung diseases, as well as increase the risk of heart disease[33]. Its direct impact on human health has been extensively documented, making it a crucial pollutant to study, especially in urban and industrial settings where NO_2 levels tend to be high[29].While $PM_{2.5}$ also poses significant health risks, its more complex nature—affected by numerous factors such as the chemical composition of particles—can make its health effects harder to isolate and measure. In comparison, NO_2 offers a more defined and immediate link to urban air pollution and its health impacts[34].

The long-term residence of the floating population is beneficial to the economic development of the destination. In order to solve the problem of "moving but not staying" of the floating population, it is necessary to conduct in-depth research on the factors affecting the settlement intention of the floating population. Summarily, in the study of factors influencing the settlement intention of floating populations, urban factors mainly focus on city size and the household registration system. Some studies also examine the impact of urban livability and environmental quality on the settlement intention of floating populations, although research in this area is relatively limited and offers significant potential for further theoretical development. In the study of the relationship between air pollution and labor mobility, most existing research primarily explores how air pollution affects the short-term migration decisions and employment locations of floating populations. However, there is a shortage of analysis regarding whether and how post-migration air quality affects the long-term settlement intention of labor. Therefore, this paper focuses on the impact of air pollution on the settlement intention of floating populations to provide exploratory guidance on the factors influencing the settlement decisions of floating populations. Current studies predominantly use $PM_{2.5}$ as the primary indicator of air pollution, but this paper argues that $PM_{2.5}$ may not always provide the most accurate or comprehensive representation of air quality, especially in the context of specific human activities. Instead, NO_2, a key gaseous pollutant, offers a more precise reflection of pollution from urban and industrial sources. Therefore, this paper selects NO_2 to represent air pollution, providing a more accurate assessment of the impact of air pollution on the settlement intentions of the floating population.

Theoretical analysis and research hypothesis

Ravenstein conceptualized the seven laws of population migration[35]. He pointed out that the destinations for population migration are often regions with better economic development, and the reasons for population migration include factors such as cost of living, environmental quality, and integration. He also proposed that unattractive climate could drive populations to move from one region to another.

There is a growing body of research documenting the impact of air pollution on labour mobility and demonstrating that changes in air quality can alter people's choices about whether to stay. Chen's study shows that people will choose to travel for short distances to avoid the health loss caused by air pollution[36].Air pollution has a negative impact on labor migration. Therefore, if migrants want to have a better living environment, they

will move from polluted areas to places with better air quality, which can attract more new residents[37,38]. Existing research results generally show that air pollution is not only an important cause of population migration, but also a major determinant of migration location selection. Since the settlement intention can be understood as the re-decision of whether to stop migration or continue migration after population migration, air quality should also be an important factor affecting the settlement intention of floating population. Based on the practice of Zhang Jipeng et al., this paper describes a simple random utility model of the floating population: the average utility of an individual in a city is measured by the wage level, living cost and livability of the city[39]. If the utility obtained in the inflow place is greater than that obtained in the household registration location, the floating population chooses long-term residence, that is, they have long-term settlement intention. If the utility obtained at the inflow place is less than the utility obtained at the household registration location, then they choose to re-migrate, that is, they have no long-term settlement intention. On this basis, micro-data is used to quantitatively study the impact of the decline in personal utility caused by air pollution on the long-term settlement intention of floating population.

Based on these concepts, this paper assumes:

Hypothesis 1: Air pollution affects the settlement intention of floating populations, with increased pollution leading to a decrease in settlement intention.

According to Rosen Roback's urban spatial equilibrium theory, on the premise of free flow of labor, housing price differences can be explained by wage differences and livability differences between cities. In other words, workers choose to live in areas where they can maximize their personal utility based on differences in income levels (wages), cost of living (housing prices), and livability (public services, environmental quality) among cities. However, due to the negative impact of air pollution on the health level of residents, residents' utility will be reduced. Long-term exposure to polluted environment will worsen people's health status. He et al. estimated the impact of air pollution on mortality, showing a significant negative correlation between air quality improvement and mortality rates[40]. Tanaka found that the implementation of air pollution control policy known as "Two Control Zones" significantly reduced the infant mortality rate by 20%[41]. Research by Zhang Xue and Liu Yu shows that improved air quality brings better breathing environment, which will attract more new migrant labor into the city[42]. It is concluded that physical health may be an important mechanism for air pollution to affect the settlement intention of floating population.Therefore, this paper formulates the second research hypothesis:

Hypothesis 2: Air pollution reduces the settlement intention of floating populations by negatively affecting their physical health.

At the same time, different types of floating population may make different decisions when facing the same situation due to their differences in individual characteristics. In order to fully explain migration behavior, the combined influence of macro environment and micro individuals must be considered[43]. At the micro individual level, it has been proved that high-skilled migrants with higher social level tend to have higher requirements for urban livability and overall quality of life[44]. At the same time, the floating population's awareness of the harm of air pollution largely depends on their education level, which, as an indicator of cognitive ability, affects the migration motivation of the floating population. The higher an individual's level of education, the more subjective knowledge they have about air pollution. Studies on air pollution and labor productivity show that the impact of air pollution on highly educated workers is more obvious than that on low-educated workers[45]. As a result, air pollution may have a greater adverse effect on highly educated migrants, who have a stronger incentive to leave cities with high air pollution. At the macro environmental level, due to the differences in natural climate conditions, there are serious regional differences in the severity of air pollution in China. People who grew up in the south of China have higher requirements for environmental quality, while the air quality is worse in the north, so people in the north may have a higher tolerance for air pollution. Therefore, whether the tolerance of the population in different regions to haze is different due to the different long-term living environment is also a key point of this paper. Therefore, this paper formulates the third research hypothesis:

Hypothesis 3: The influence of air pollution on the settlement intention of floating population varies with individual characteristics and regions.

Research design

Data sources and sample selection

Floating population data

The data of floating population comes from the dynamic monitoring survey of China's floating population in 2017. The survey included itinerant family members and income and expenditure, mobility and employment, residence and settlement intentions, marriage and childbirth, and health and family planning services. In this paper, the original data are processed as follows: First, the Labor Contract Law (2012 Amendment) stipulates that the legal working age is from 16 years old to a maximum of 60 for men and 50 for women, with 55 being the limit for women in management positions. Accordingly, this paper excludes data from individuals under 16 years old, men over 60 years old, and women over 55 years old in the survey dataset. In addition, due to the time lag of various influencing factors, including environment, on settlement intention, we choose to retain only the data of floating population whose years of residence are more than one year at the time of survey. Finally, data missing key variables are eliminated.

Air pollution data

This study uses the annual average concentration of NO2 in prefecture-level cities as an indicator of air pollution. The data is sourced from the Chinese Air Quality Online Monitoring and Analysis Platform. The platform collects weather data at the city level, including monitoring items such as NO2, SO2, O3, CO, PM10, temperature, and humidity, updated at hourly intervals. The platform provides historical data analysis queries starting from December 2013, with features including real-time monitoring, monitoring trends, time-period statistics, satellite

cloud images, and more. Based on this data source, the study calculates the annual average concentration of NO2 for 287 or more prefecture-level cities in China. To account for the lagged effect of environmental factors on residency intentions, the data for air pollution used in the study is lagged by one period and logged.

Urban data
The city-level data comes from the statistical yearbook of each province, city and county, China City Statistical Yearbook, CEIC China Economic Database, relevant data of each city's statistical bulletin and housing price data published on Anjuke website. The missing data of individual cities are manually completed by searching news websites and government public websites in accordance with the usual practice, or are replaced by data of neighboring cities. Considering that there may be two-way causal problems between air pollution and the settlement intention of floating population, all the city-level data adopted lag by one phase. In order to weaken the influence of heteroscedasticity, logarithmic processing is carried out on the above variables.

Model specification and variable definitions

According to the objective needs of the problem studied and the method proposed by Zhang Jipeng (2020)[39] , the specific empirical model of this paper is set as follows:

$$residence_{ij} = \beta_0 + \beta_1.\ln pollution_{ij} + c_1.X_i + y_1.Z_j + \lambda_1.C_h + \varepsilon_{ij}$$

Among them, residenceij is individual i's intention to settle in City j, representing settlement intention. lnpollutionij is the core explanatory variable that measures the air pollution level in a city expressed as a logarithm of the annual average NO2 concentration of migrants flowing into the city. Xi represents the control variables at the individual level, including age, age squared, gender, marital status, personal income, years of education, and household registration type. Zj represents the inflow control variables at the city level, including per capita GDP, average wage level of regional workers, population density, housing price, basic education and medical services; Ch represents the region-level control variables, which are selected with the same index as the inflow control variables. εij is an unobservable random perturbation term.

Floating population residency intention
The explained variable of this paper is the settlement intention level of the floating population in the regions, which is measured by the proportion of the floating population with settlement intention in the total sample in 31 provinces (excluding Hong Kong, Macao and Taiwan), and the data are obtained from the Dynamic Monitoring Questionnaire of floating population (CMDS) organized by the National Health Commission in 2017. The CMDS database covers China's migrant population data from 2009 to 2018. The survey targets migrants who have resided in various locations for one month or longer, employing a Probability Proportional to Size (PPS) sampling method for random selection. The CMDS questionnaire began to explicitly focus on the residence intention of the migrant population from 2016 onwards. The reason for selecting 2017 data for sample analysis in this paper is that only one question related to residence intention was included in both the 2016 and 2018 questionnaires. In contrast, the 2017 questionnaire contains two questions: "Do you intend to continue staying here?" and "Do you plan to reside locally for the long term (more than 5 years)?" These two questions provide a more comprehensive and accurate assessment of residence intention. Following the approach of Gu Hengyu et al. (2019), this paper defines migrants who answered "yes" to both questions and indicated their intention to reside locally for more than five years as having a residence intention. According to the practice of Gu Hengyu et al., people who answer "yes" and "intend to live in the local area (for more than 5 years)" are defined as the floating population who have the intention to stay[46]. The value of "more than 5 years" is 1. Otherwise, it is 0. In 2017, the question was "If you plan to stay in the local area, how long do you expect to stay?" The options were "1–2 years", "3–5 years", "6–10 years", "more than 10 years", "settled" and "not sure". In this paper, the number of floating population with settlement intention is measured by the sum of the three people of "6–10 years", "more than 10 years" and "settled".

Air pollution
The average annual NO2 concentration in 287 prefecture-level cities was used in this paper to measure air pollution. NO2 is considered one of the major atmospheric pollutants monitored by environmental protection agencies in China and Western countries. Prolonged exposure to environments with high NO2 concentrations is known to cause respiratory and pulmonary diseases in healthy individuals. The data is collected from the Chinese Air Quality Online Monitoring and Analysis Platform and used to compute the annual average concentration of NO2 at the prefecture-level city.

Control variables
The study controls for two categories of influencing factors: individual characteristics and city characteristics. Individual characteristics include factors that may affect individual residency intentions, such as age, age squared, gender, years of education, hukou type, and marital status. Additionally, considering that environmental pollution and economic growth are to some extent substitutable, individual income is included in the control variables, as evidence supports the notion of a substitution relationship between income growth and environmental pollution costs. City characteristics encompass measurements of urban economic fundamentals, urban size, and the capacity of public service provision. Since the empirical model includes measurements of average utility for floating populations at the micro level, these include per capita GDP, average wages of urban employees, population density, housing prices, basic education, and medical services as control variables for both migrant destination cities and the household registration location.

The specific variable explanations and descriptive statistics are presented in Table 1.

Empirical analysis

Basic results

In order to make the model results more intuitive and comparable, this paper reports the average marginal effects of the probit model, which represents the effect of a one-unit change in the explanatory variable on the dependent variable. The first four columns of Table 2 present the estimation results of the baseline model. The first column includes no control variables and shows a significant negative correlation between urban NO2 concentration and the long-term settlement intentions of the floating population. Specifically, for every one-unit increase in NO2 concentration, the average probability of floating population wishing to reside long-term decreases by 1.28 percentage points. In the second column, personal characteristic control variables are added, and the coefficient of the explanatory variables does not change significantly, but it can be seen that the coefficient of income is significantly positive, that is, when the personal income in the inflow place increases by 1%, the probability of the floating population willing to stay for a long time increases by 3.64 percentage points on average. There is a surrogate relationship between individual income and the effect of air pollution on settlement intention. The third column adds the control variables of the city characteristics of the destination city, and the fourth column adds the control variables of the city characteristics of the domicile city. The results show that air pollution has a significant negative effect on the settlement intention of the floating population.

The degree of regional air pollution and the probability and severity of individual exposure to pollution are generally not random. Moreover, the settlement intentions of the floating population may reflect the economic development level of cities. In the current stage of China's economic development, economic growth and environmental pollution often show a positive correlation. Although the model controls for variables such as regional wage levels and per capita GDP, there may still be other variables related to economic development that are positively correlated with both air pollution and the settlement intentions of the floating population. This could lead to biased model estimation results. So the instrumental variable method is used. The virtual variable is set with whether the city implements the "no-coal area" policy as the instrumental variable of air pollution. From a correlation point of view, in 2016, the Beijing-Tianjin-Hebei and surrounding areas of air pollution prevention and control cooperation group proposed to build a national "no-coal area", the meeting clearly pointed out that the national "no-coal area" in addition to coal power, central heating and raw material coal enterprises, the rest of the enterprises must clean up the fuel coal. Jiang Chunhai et al. found that the implementation of "no-coal area" policy has led to relatively lower levels of air pollution[47]. From the perspective of exogeneity, the main purpose of proposing and implementing the "no-coal area" policy is to reduce emissions and control haze, and whether a region is planned as a no-coal area has nothing to do with the settlement intention of the floating population in the region. Therefore, in this paper, referring to the practice of Jiang Chunhai[47] and Luo Yonggen[48], Beijing, Tianjin, Hebei, Shandong and Henan are taken as "no-coal areas", and the rest are taken as structural tool variables of "non-no-coal areas". In the weak instrumental variable test, the corresponding p values of AR and

Variable Name	Variable Description	Sample Size	Mean	Standard Deviation	Minimum	Maximum
residence	settlement intention of floating population	59,275	0.55	0.49	0	1
pollution	Air pollution level (ug/m^3)	59,275	30.31	17. 11	0.61	70.17
age	Age	59,275	36.71	8.49	16	60
age_sq	Age squared	59,275	1419.88	652.23	256	3600
Income	Income (CNY/month)	59,275	4676.90	4119.98	1	120,000
gender	Gender	59,275	0.57	0.49	0	1
hukou	Hukou type	59,275	0.82	0.38	0	1
marriage	Marital status	59,275	0.94	0.23	0	1
eduyear	Years of education	59,275	10.35	3.19	0	19
pergdp	Per capita GDP (CNY)	59,275	78,858.69	34,406.95	10,987	207,163
wageave	Average wage of employees (CNY)	59,275	67,015.6	17,501.52	4958	114,582
popdensity	Population density (people/km^2)	59,275	685.16	515.87	5.77	2501. 14
teachers	Number of primary and secondary school teachers per 1,000 people	59,275	53.90	33.76	2.01	233.60
hospitals	Number of hospital beds per 1,000 people	59,275	44.17	33.80	1.52	164.36
houseprice	Average residential sales price (CNY/m^2)	59,275	8995.07	6064.05	2248. 14	33,942.16
hujipergdp	household registration location per capita GDP (CNY)	59,275	37,218.57	31,793.71	5762	787,770
hujiwageave	household registration location average employee wage (CNY)	59,275	59,299.63	107,920.5	987	2,112,150
hujipopdensity	household registration location population density (people/km^2)	59,275	505.27	772.71	0. 14	37,945.45
hujiteachers	household registration location number of primary and secondary school teachers per 1,000 people	59,275	4.97	2.62	0.16	22.91
hujihospitals	household registration location number of hospital beds per 1,000 people	59,275	2.54	1.59	0	18.01
hujihouseprice	household registration location average residential sales price (CNY/m^2)	59,275	4739.38	1644.83	2248. 14	14,612.34

Table 1. Definitions of main variables and descriptive statistics.

Explained variable: residence	(1)	(2)	Probit (3)	(4)	Ivprobit (5)
lnpollution	-0.0128*** (-7.84)	-0.0119*** (-7.52)	-0.00898*** (-5.43)	-0.00893*** (-5.40)	-0.171*** (- 14.76)
age		0.0235*** (11.56)	0.0244*** (12.06)	0.0241*** (11.92)	0.0206*** (8.96)
age_sq		-0.000268*** (- 10.32)	-0.000282*** (- 10.77)	-0.000277*** (- 10.62)	-0.00023*** (-7.81)
Income		0.0364*** (10.59)	0.0409*** (11.52)	0.0421***(11.83)	0.0403*** (10.07)
gender		-0.0145** (-3.42)	-0.0163*** (-3.84)	-0.0169*** (-3.99)	-0.0126** (-2.64)
hukou		-0.153*** (-27.08)	-0.147*** (-26.03)	-0. 144*** (-25.53)	-0.163*** (-25.75)
marriage		0.008 (0.93)	0.0125 (1.34)	0.0145 (1.55)	-0.00169 (-0. 16)
eduyear		0.0255*** (35.06)	0.0254*** (34.88)	0.0252*** (34.34)	0.0242*** (28. 18)
pergdp			-0.0345*** (-5.47)	-0.0386*** (-6.00)	0.0523*** (5.44)
wageave			0.149*** (9.94)	0.153*** (10. 12)	0.116*** (7.21)
popdensity			-0.00287 (-0.83)	0.00887** (2.42)	0.00017*** (15.35)
teachers			-0.0946*** (- 10.58)	-0.0969** (- 10.78)	0.00223 (0. 18)
Hospitals			0.0761*** (10.20)	0.0797*** (10.62)	0.0479*** (5.48)
houseprice			-0.0551*** (-7. 13)	-0.0619*** (-7.92)	-0.204*** (- 16.58)
hujipergdp				0.00656* (1.85)	0.002995 (0.75)
hujiwageave				0.0142** (3. 11)	0.004614 (0.9)
hujipopdensity				-0.0188978*** (-6.35)	-0.0149*** (-4.4)
hujiteachers				0.00305** (3. 16)	0.030824*** (4.9)
hujihospitals				-0.0105*** (-6.30)	-0.05414*** (- 10.2)
hujihouseprice				0.00221 (0.29)	-0.02363* (-2.68)
N	59,275	59,275	59,275	59,275	59,275
pseudo R^2	0.0008	0.0451	0.0489	0.0506	0.0537

Table 2. Baseline regression results. The first row in the table reports the marginal effects (dy/dx); values in parentheses are the heteroscedasticity-robust z-statistics. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The same applies to the following.

Wald are both significant at 1% level, indicating that the instrumental variables selected in this paper are not weak instrumental variables. The average marginal effect of the regression of instrumental variables is reported in this paper. As shown in column (5) of Table 2, the regression coefficient of air pollution on the settlement intention of floating population is significantly negative, and the estimated coefficient and significance under the method of instrumental variables are significantly increased. This suggests that the endogenous problem may cause the model to underestimate the effect of air pollution on the settlement intention of floating population. In summary, it can be concluded that air pollution affects the settlement intention of floating population, and the increase of pollution leads to the decrease of settlement intention. Hypothesis 1 is supported.

Robustness test

Replace the model

In order to make the empirical results more robust, OLS model was used to confirm each other with probit model in the baseline regression. At the same time, since probit or logit model is often used in the analysis of bivariate dependent variables in literature, logit model is also used for verification in column (2) of Table 3. The regression results show that air pollution has a significant negative impact on the settlement intention of floating population in both models. This shows that the OLS and logit models are basically consistent with the benchmark model in the direction and significance of parameter estimation, which preliminarily confirms the robustness of the estimation results of the benchmark model.

Explained variable: residence	OLS	logit
lnpollution	-0.0129*** (-7.64)	-0.0127*** (-7.52)
Personal characteristics control variable	YES	YES
Inflow city characteristics control variable	YES	YES
Household registration location characteristics control variable	YES	YES
N	59,275	59,275
R^2 o r pseudo R^2	0.064	0.0489

Table 3. Regression results of OLS and logit models.

Explained variable: juliu	Probit	lvprobit
lnpollution	-0.00592*** (-3.62)	-0.138*** (- 12.00)
Personal characteristics control variable	YES	YES
Inflow city characteristics control variable	YES	YES
Household registration location characteristics control variable	YES	YES
N	59,275	59,275
pseudo R^2	0.070	0.0731

Table 4. Changing settlement intention indicator.

Change the settlement intention index

In terms of the measurement of settlement intention, the main source of the current research data on the settlement intention of the floating population is the questionnaire of dynamic monitoring of the floating population organized by the National Health Commission. The question "Do you plan to live in the local area for a long time (more than 5 years)?" in the questionnaire is used to define settlement intention[37,49]. However, some scholars believe that the intention to stay includes many aspects. Referring to the practice of Lin Liyue and Zhu Yu, this paper superimposed the results of the two indicators of "long-term settlement intention" and "household registration intention" in the questionnaire to build a comprehensive score index of settlement intention[10].

Specifically, the question "Do you plan to live in the city for a long time (more than 5 years)?" will be asked. "And" If you meet the requirements for local settlement, are you willing to move your hukou to here?" In the two questions, the value of "intend" or "willing" is 1, otherwise it is 0. Then, these two indicators are added with equal weights to form an order variable with a value range of (0,1,2). The values from small to large represent "no settlement intention", "low settlement intention" and "high settlement intention" respectively. Finally, it is transformed into a binary variable representing settlement intention, in which the value of "no settlement intention" is assigned to 0, and the other variables are unified as "have settlement intention" and assigned to 1. The regression results show that the negative effect of air pollution on the settlement intention of the floating population is still significant after the change of settlement intention index(see Table 4).

Heterogeneity analysis

It is of great theoretical and practical significance to investigate the impact of air pollution on the settlement intention of floating population in terms of individual characteristics and regional characteristics, which is helpful for the government to design differentiated population policies and measures. In this paper, multi-dimensional grouping regression is carried out on the sample of floating population, and then the heterogeneous effect of air pollution on the settlement intention of floating population is investigated. The regression model has the same setting as column (4) of Table 2.

Years of residence

The floating population is grouped according to the years of residence. Due to the time lag of environmental factors, the floating population with an inflow period of less than one year was excluded in the data clearing. Therefore, the floating population was divided into two groups, those who had flowed into the current region for less than two years and those who had flowed into the current region for more than two years. The regression results show that air pollution has a significant negative effect on the settlement intention of the floating population with an inflow period of more than two years(see Table 5). For every 1 unit increase in air pollution concentration, the willingness of migrants who have been in the inflow for more than two years to stay in the inflow area will decrease by 1.37 percentage points. However, the effect on the floating population within two years is not significant. It may be because the longer the inflow years of floating population, the greater the impact of air pollution on their health level, so the change of air pollution will lead to a greater decline in their settlement intention.

years of residence		
Explained variable: residence		
	Within two years	**More than two years**
lnpollution	-0.00334 (-0.79)	-0.0137*** (-7.61)
Personal characteristics control variable	YES	YES
Inflow city characteristics control variable	YES	YES
Household registration location characteristics control variable	YES	YES
N	7619	51,656
pseudo R^2	0.0566	0.0491
Coefficient group difference test P-value	0.018**	

Table 5. Heterogeneity analysis—years of residence. Between-group difference test p-values are calculated using Fisher's combination test (sampled 1000 times), as shown in the subsequent tables.

Education Level		
Explained variable: residence		
	High School and Below	**Junior College and Above**
lnpollution	-0.0108*** (-5.67)	-0.0189*** (-5.24)
Personal characteristics control variable	YES	YES
Inflow city characteristics control variable	YES	YES
Household registration location characteristics control variable	YES	YES
N	48,470	10,805
pseudo R^2	0.0246	0.0416
Coefficient group difference test P-value	0.008***	

Table 6. Heterogeneity analysis—Education level.

Education level

The education level of the floating population is measured based on the number of years of education they have received. The years of education are assigned as follows:

Individuals who have never attended school are assigned 0 years of education.
Those with primary school education are assigned 6 years.
Those with junior high school education are assigned 9 years.
Those with high school education are assigned 12 years.
Those with junior college (associate's degree) education are assigned 15 years.
Those with a bachelor's degree are assigned 16 years.
Those with a master's degree are assigned 19 years.

Higher values of years of education indicate a higher level of education. The sample is divided into two groups based on the years of education:

(1) High School and Below: This group includes individuals with high school education or below.
(2) Junior College and Above: This group includes individuals with junior college education or above.

The regression results reveal that the impact of air pollution on the settlement intention of the floating population is positively correlated with their education level(see Table 6). Specifically, for individuals with a high school education or below, an increase of 1 unit in air pollution concentration leads to a decrease of 1.08 percentage points in their willingness to reside in the current area for the long term. On the other hand, for individuals with junior college education or above, the impact is even more significant, leading to a decrease of 1.89 percentage points in their settlement intention. It appears that individuals with higher education levels are more capable of assessing the impact of air pollution on their health accurately, and, as a result, the effect of air pollution on their settlement intention is more pronounced.

Household registration location air quality

The impact of air pollution on the willingness of floating populations to settle down may vary depending on the air quality in their household registration location. Southern China generally has a more humid and rainy climate, resulting in better air quality. Individuals who grew up in the south may have lower adaptability to air pollution, while northern regions tend to be drier, experience less rainfall, and rely on coal heating during the winter. This might make northern residents more adaptable to air pollution. In this study, we categorized regions using the Qinling Mountains and the Huai River as dividers, distinguishing between northern and southern origins. Specifically, we classified Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Anhui, Shandong, Henan, Heilongjiang, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang as northern regions, and Jiangsu, Zhejiang, Shanghai, Hubei, Hunan, Sichuan, Chongqing, Guizhou, Yunnan, Guangxi, Jiangxi,

household registration Location Air Quality		
Explained variable: residence		
	Southern Origin	**Northern Origin**
lnpollution	-0.0126*** (-5.38)	-0.00730*** (-2.91)
Personal characteristics control variable	YES	YES
Inflow city characteristics control variable	YES	YES
Household registration location Characteristics control variable	YES	YES
N	39,570	19,705
pseudo R^2	0.0512	0.0438
Coefficient group difference test P-value	0.07*	

Table 7. Heterogeneity analysis — Household registration location air quality.

Explained variable: Physical health	Health A	Health B
lnpollution	-0.00626*** (-3.66)	-0.0143*** (-8.27)
Personal characteristics control variable	YES	YES
Inflow city characteristics control variable	YES	YES
Household registration location characteristics control variable	YES	YES
N	59,275	59,275
R^2	0.0008	0.0181

Table 8. Mechanism test — The impact of air pollution on physical health.

Fujian, Guangdong, Hainan, and Tibet as southern regions. Regression results show that for every one-unit increase in air pollution concentration, the willingness of floating populations from southern regions to settle in their destination city decreases by 1.26 percentage points(see Table 7). On the other hand, the impact on floating populations from northern regions is less pronounced, with their willingness to stay decreasing by 0.73 percentage points for each unit increase in urban air pollution. This suggests that the influence of air pollution on the willingness of floating populations to settle down is affected by their adaptability to air pollution. Those who originally lived in areas with less severe air pollution may be more sensitive to the impact of air quality on their health, resulting in a greater negative effect on their settlement intentions.

Mechanism test

This study further examines whether health is the mediating mechanism through which air pollution affects the willingness of floating population to settle. Following the approach of Sun Weizeng, a linear probability model is used to estimate the impact of air pollution on the health status of the floating population. In this model, the coefficient of the air pollution variable reflects the effect of air pollution changes (relative to the household registration location) on the health status of the floating population[24]. The specific model is set as follows:

$$health_{ij} = \varphi_1.\ln pollution_{ij} + \varphi_2.X_i + \varphi_3.Z_j + \varphi_4.C_h + \varepsilon_{ij}$$

$$residence_{ij} = \gamma_1 health_{ij} + \gamma_2 X_i + \gamma_3 Z_j + \gamma_4 C_h + \varepsilon_{ij}$$

The variable $health_{ij}$ reflects the health status of the floating population i living in city j, $^{\ln}$ *pollution*$_{ij}$ is the core explanatory variable representing air pollution concentration. $residence_{ij}$ represents the settlement intention of individual i in city j, indicating their willingness to reside there. X_i represents individual characteristics control variables, Z_j represents the inflow characteristic control variables, and C_h represents the characteristic control variable of the household registration location. The selection of control variables is the same as in the baseline model. ε_{ij} is the unobservable random disturbance term.

Two questions from the 2017 Floating Population Dynamic Monitoring Questionnaire were selected to construct two variables, health A and health B, reflecting the health status of the floating population. For question 1, "Have you experienced symptoms such as diarrhea, fever, conjunctivitis, or a cold in the past year?" health A is set to 1 if the answer is "no," and 0 otherwise. For question 2, "Have you suffered from illness (injury) or discomfort in the past year?" health B is set to 1 if the answer is "no," and 0 otherwise. Table 8 shows that air pollution significantly negatively affects the physical health of the floating population. The results in Table 9 also indicate that migrants with better health status demonstrate stronger settlement intentions. In conclusion, Hypothesis 2 is confirmed.

In the theoretical research on the relationship between health and labor force mobility, there are mainly three effects: health selection effect, health loss effect, and the "salmon bias" effect[50,51]. Among them, the "salmon bias" effect mainly explains that individuals with relatively poor health conditions may return to the place they migrated from or nearby areas. This is because individuals with health problems, considering factors like the

Explained variable: residence	
Health A	0.5563*** (5.27)
Health B	0.5368*** (5.13)
Personal characteristics control variable	YES
Inflow city characteristics control variable	YES
Household registration location characteristics control variable	YES
N	61,292

Table 9. Mechanism test — The impact of physical health on residence intention.

Explained variable: residence	Health A	Health B
lnpollution	-0.0663*** (-3.88)	-0.0995*** (-5.87)
Healthcare*lnpollution	0.0534*** (3.05)	0.0663*** (3.81)
Healthcare	-0.0385 (-0.66)	-0.0619 (-1.08)
Personal characteristics control variable	YES	YES
Inflow city characteristics control variable	YES	YES
Household registration location characteristics control variable	YES	YES
N	59,275	59,275
pseudo R^2	0.0062	0.0136

Table 10. The Impact of Social Health Insurance on Residents' Health.

cost of living, are more likely to return to their household registration location. As a result, the willingness of individuals with relatively poor health conditions to settle in the city is lower. Foreign studies suggest that individuals with relatively good health conditions are more likely to stay in the city and have a stronger intention to settle[52]. Domestic research shows that the overall health status of the floating population is relatively good, and they are more inclined to settle in the city in the long term[53]. Therefore, considering that the intention to settle is an important antecedent to labor migration, health conditions should also have a significant impact. In conclusion, Hypothesis 2 is confirmed.

Furthermore, this paper explores the impact of the healthcare insurance system on health and examines the role of government-provided healthcare services in mitigating the effects of air pollution on residents' health. The healthcare insurance system established by the Chinese government primarily includes the Basic Medical Insurance for Urban Employees, the Basic Medical Insurance for Urban Residents, and the New Rural Cooperative Medical Scheme. These systems cover the majority of the population, particularly rural residents and economically disadvantaged groups, enabling more people to access basic medical services through insurance policies.

The healthcare insurance system reduces the financial burden on individuals by reimbursing a portion of medical expenses, thereby alleviating the economic pressure on residents when facing illnesses. Residents enrolled in social health insurance are defined as receiving government healthcare services, with a value of 1 assigned to participants and 0 to non-participants. An interaction term between participation in social health insurance and air pollution is constructed, and the specific model is as follows:

$$health_{ij} = \eta_1 lnpollution_{ij} + \eta_2 healthcare_{ij} * lnpollution_{ij} + \eta_3 healthcare_{ij} + \eta_4 X_i + \eta_5 Z_j + \eta_6 C_h + \varepsilon_{ij}$$

The results, as shown in Table 10, indicate that in the empirical analysis with health A and health B as dependent variables, the coefficients of the interaction terms are both significantly positive. This means that when residents participate in social health insurance, the probability of being in good health increases with each unit rise in urban air pollution. This demonstrates the moderating role of social health insurance in the chain of influence between air pollution and residents' health.

Conclusion and implications

This study, using data on air pollution in 287 prefecture-level cities and data from the 2017 Dynamic Monitoring Survey of the Floating Population, examined the impact of air pollution on the settlement intention of the floating population. It also investigated the mechanisms through which air pollution affects this population and the variations in these effects among different groups. The main findings and implications are as follows: (1) Air pollution reduces the settlement intention of the floating population. Empirical results demonstrate that air pollution has a significant negative effect on the settlement intention of the floating population. With each unit increase in air pollution concentration, the probability of the floating population desiring long-term residency

significantly decreases by 0.89 percentage points. (2) The impact of air pollution on the settlement intention of the floating population varies based on individual characteristics and regional differences. Specifically, those with higher levels of education, longer periods of residence in the destination city, and better air quality in their hometowns experience a more significant negative impact on their settlement intention due to air pollution. (3) The mechanism through which air pollution affects the settlement intention of the floating population is primarily related to changes in their physical health. Air pollution leads to a decline in the physical health of the floating population, which, in turn, reduces their desire to reside in the destination city. (4) Further research finds that better healthcare services provided by the government can enhance the willingness of migrant populations to settle in areas with environmental pollution.

This paper has several implications. Firstly, environmental quality is one of the core factors in regional talent competition**.** In the current context of urban competition for talent, superior environmental quality is a critical factor in attracting and retaining migrant populations. Developing a sustainable ecological environment is essential for improving urban livability. Policymakers should implement long-term air pollution control strategies, enhance green infrastructure, enforce stricter regulations on industrial emissions and vehicular exhaust, and transition from coal-based to cleaner energy sources through initiatives like "coal-free zones."Secondly, cities should consider the tailored talent policies in different regions. Cities should design differentiated population policies that address the diverse needs of migrant workers, particularly regarding environmental quality and urban livability. This could involve offering targeted incentives such as housing subsidies and preferential access to education services, thereby establishing an environmental compensation mechanism. Furthermore, talent policies should be integrated with environmental policies, emphasizing ecological competitiveness, for instance, through urban greening projects and constructing air purification parks. Thirdly, the government should provide health interventions address pollution impact. Air pollution negatively affects the health of migrant populations, thereby reducing their willingness to settle. Alongside pollution control efforts, governments must improve healthcare services to ensure a healthy living environment for migrants. Specific strategies include offering exclusive health check-ups and treatments for migrants, increasing the availability of healthcare services, and implementing targeted interventions for high-risk groups, such as children and the elderly, to mitigate the health risks posed by pollution.

Data availability

The datasets generated and/or analyzed during this study, including city-level NO_2 data, the 2017 national floating population dynamic monitoring survey data, and associated urban data, are all based on data from China. These datasets are available from the corresponding author, Ce Guo, upon reasonable request. Requests to access the data should be directed to guoce@zuel.edu.cn.

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Author contributions

Dongmei Cao conceived the research idea and design. Dongmei Cao and Yujia Liao collected and analyzed the data. Ce Guo and Xiaofan Xu contributed to the interpretation of results. Dongmei Cao, Yujia Liao, Ce Guo, and Xiaofan Xu wrote and revised the manuscript. All authors reviewed and approved the final version of the manuscript.

Declarations

Competing interests

The authors declare no competing interests.

Ethical approval

This study does not involve experiments on humans, human tissue samples, or the collection of primary human data. Instead, the analysis is based on publicly available secondary data sources. Specifically, this paper utilizes the 2017 Dynamic Monitoring Survey of China's Floating Population and matches it with air pollution

data from 287 prefecture-level cities to construct a Probit model. As the data used in this research is publicly accessible and anonymized, there are no ethical concerns or requirements for institutional approval, informed consent, or compliance with experimental protocols.

Additional information

Correspondence and requests for materials should be addressed to C.G.