Diversity & Equality in Health and Care
ISSN: 2049-5471

Open access Research Article

Effects of Air Pollution on Incidence and Mortality of Breast Cancer: A Nationwide Analysis of China

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ABSTRACT

Background: Although more and more evidence shows that air pollution will increase the risk of breast cancer, the evidence is still insufficient. We aim to use national cancer registration data and air quality data to assess the association between air pollution exposure and female breast cancer incidence and mortality in China.

Methods: The study is a comparative study using open source data. The data of incidence and mortality of female breast cancer were released by China National Cancer Centre, grouped by region. The data of air pollutants (PM10, PM2.5, NO_2, SO_2) were published by the Ministry of Ecology and Environment of China. By establishing single-factor and multi-factor linear regression models of air pollutants and female breast cancer incidence and mortality, the relationship of them was quantitatively analysed.

Results: In China, the incidence and mortality of female breast cancer in urban are higher than rural, east and central are slightly higher than west. Single-factor and multi-factor linear regression analysis showed that there was a linear correlation between air pollutants (PM10, PM2.5, SO_2, NO_2) and the incidence of female breast cancer, and a linear correlation between air pollutants (SO_2, PM10) and the mortality of female breast cancer. PM10 (PM2.5) has a greater impact on female breast cancer incidence than SO_2 and NO_2. SO_2 has a greater impact on female breast cancer mortality than PM10 (PM2.5) and NO_2.

Conclusion: The increased risk of female breast cancer and death is related to air pollutants (PM10, PM2.5, SO_2, NO_2). The control measures to reduce air pollution may reduce the incidence and mortality of female breast cancer in the future.

Keywords: Air pollution; Breast cancer; Incidence; Mortality; Regression; Models; Fine particles (PM2.5); Coarse particles (PM10); Sulfur dioxide (SO_2); Nitrogen dioxide (NO_2)

INTRODUCTION

Breast cancer is one of the major female health problems in the world. According to the data from China National Cancer Center, the first cancer among women is breast cancer. In 2016, the number of new cases of female breast cancer in China was 79,450, accounting for 16.09% of all female cancers [1]. The identified risk factors for breast cancer include genetic variation, age, family, history, alcohol consumption, smoking, reproductive history and post-menopausal hormone therapy [2]. In addition, more and more evidence shows that air pollution is related to breast cancer [3-10]. Researchers observed that the incidence of breast cancer in urban areas is higher than that in rural areas and the incidence of breast cancer increases with

Received:	28-November-2022	**Manuscript No:**	IPDEHC-22-15220
Editor assigned:	30-November-2022	**PreQC No:**	IPDEHC-22-15220 (PQ)
Reviewed:	14-December-2022	**QC No:**	IPDEHC-22-15220
Revised:	19-December-2022	**Manuscript No:**	IPDEHC-22-15220 (R)
Published:	26-December-2022	**DOI:**	10.21767/2049-5471.22.19.57

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Citation Chen H, Dai J (2022) Effects of Air Pollution on Incidence and Mortality of Breast Cancer: A Nationwide Analysis of China. Divers Equal Health Care. 19:57.

the increase of traffic emissions [3,5,9]. Air pollution contains carcinogens and endocrine disrupting substances, which are risk factors for breast cancer. The mechanism of air pollution affecting breast cancer may be:

- Air pollutants directly lead to gene mutation, because they are carcinogenic [11,12].
- Air pollution increases female breast density. High breast density is one of the risk factors for breast cancer [13]. Studies have reported that nitrogen oxides (NO_2) [3,4], fine particles (PM10 and PM2.5) [14-17] and polycyclic aromatic hydrocarbons (PAHs) are related to the incidence of breast cancer [18]. A cohort study from 9 European countries found that there was an association between air pollution (PM2.5, PM10, NO_2) and the incidence of breast cancer [19]. Studies from the United States found that the high incidence of breast cancer was associated with PM2.5, PM10 and NO_2 [20,21]. The results from South Korea show that the concentration of air pollutants (CO, NO_2, SO_2, PM10) is significantly positively correlated with the incidence of breast cancer, and the concentration of PM10 is directly proportional to the mortality risk of breast cancer [22].

However, the research on air pollution and breast cancer has never been conducted at the national level in China. In this study, we used the data of incidence and mortality of female breast cancer released by China National Cancer Center, and the data of air pollution indicators in urban air quality report released by China Ministry of Ecology and Environment. By establishing single-factor and multi-factor linear regression models of air pollutants and female breast cancer incidence and mortality, the relationship of them was quantitatively analysed.

METHODS

Source of Female Breast Cancer Data

The national cancer registration and follow-up monitoring system has been established in China. China National Cancer Centre is responsible for collecting, evaluating and publishing cancer statistics from the cancer registry every year. According to the completeness and quality of female breast cancer data, this study extracted the national female breast cancer cases in 31 major cities in 2016. ICD10 (International Classification of Tumour Diseases, 10th Edition) is used to classify female breast cancer cases.

Source of Air Quality Data

The Ministry of Ecology and Environment of China has provided official authoritative ground monitoring data of air quality. This data comes from the "National Ambient Air Quality Testing Network" built by China National Environmental Monitoring Center.

Statistical Analysis

The model of four single factors of air pollutants (PM10, PM2.5, SO_2 and NO_2) on the incidence and mortality of female breast cancer was established by single-factor linear regression, and the standardized partial regression coefficients. Beta of them were calculated respectively. In order to minimize the multicollinearity in the multi-factor linear regression model, the variables with correlation coefficient higher than 0.7 were determined. SPSS statistics 27 software was used for statistical analysis.

RESULTS

Incidence and Mortality of Female Cancer Grouped by Region in 2016

In 2016, new cases of female breast cancer was 79,450 cases, accounting for 16.09% of all female cancers, including 47,378 cases in urban areas and 32,072 cases in rural areas. **Figure 1** shows the incidence and mortality of female breast cancer grouped by region. The incidence rate of female breast cancer in China is 27.97/100,000, including 31.83/100,000 in urban areas, 23.77/100,000 in rural areas, 32.62/100,000 in Eastern areas, 26.14/100,000 in Central areas, 20.61/100,000 in Western areas. The incidence rate in urban is 1.34 times that in rural. The mortality rate of female breast cancer ranks fifth in the female cancer death spectrum. 19,049 women died of breast cancer, accounting for 7.76% of all female cancer deaths, including 11,357 cases in urban areas and 7,692 cases in rural areas. The mortality rate of female cancer in China is 6.22/100,000, including 6.96/100,000 in urban areas, 5.38/100,000 in rural areas, 6.43/100,000 in Eastern areas, 6.47/100,000 in Central areas, 5.46/100,000 in Western areas.

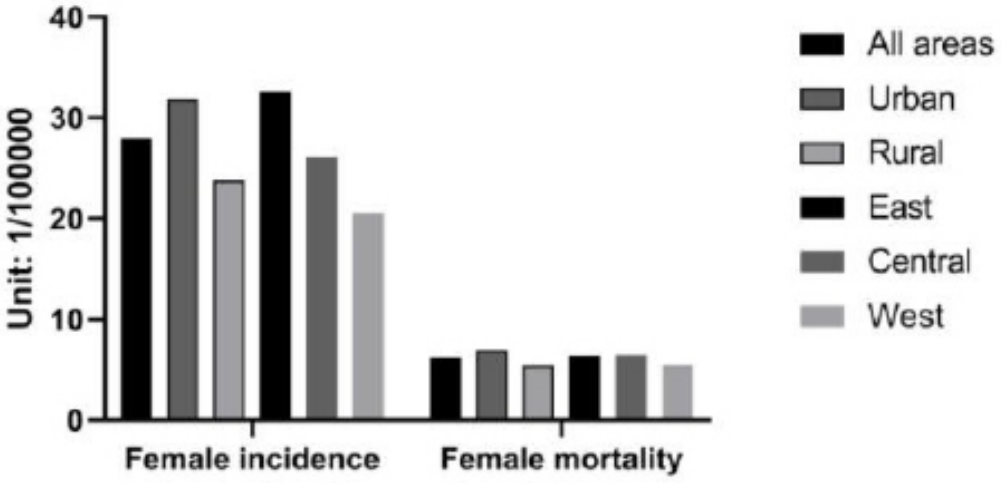

Figure 1: The incidence and mortality of female breast cancer grouped by region in 2016

Correlation Analysis between Air Pollutants and Incidence and Mortality of Female Breast Cancer

In order to study the impact of air quality indicators on the incidence rate and mortality of female breast cancer, we selected 31 major cities as research objects, mainly considering the reliability of air quality monitoring in major cities and the data of incidence and mortality of breast cancer, as shown in **Table 1**. The correlation between air pollutants (PM10, PM2.5, SO_2, NO_2) and the incidence and mortality of breast cancer was analysed by single-factor and multi-factor linear regression analysis using SPSS statistics 27 software. **Table 1** shows the average incidence rate and mortality of female breast cancer in 31 major cities in 2016, as well as the average values of air pollutants (PM10, PM2.5, SO_2, NO_2). **Table 2** shows the results of single factor linear regression analysis. For the incidence of female breast cancer, the P values of air pollutants (PM10, PM2.5, SO_2, NO_2) are all less than 0.05. The standardized partial regression coefficient Beta from high to low is PM10 (0.656), PM2.5 (0.629), NO_2 (0.395), and SO_2 (0.362), respectively, indicating that there is a linear correlation between the four air pollutants and the incidence of breast cancer. PM10 has the greatest impact, followed by PM2.5, followed by NO_2, SO_2. For female breast cancer mortality, the P values of air pollutants (PM10, SO_2) are less than 0.05, and the standardized partial regression coefficients Beta are SO_2 (0.584) and PM10 (0.554), respectively, indicating that there is a linear correlation between the two and female breast cancer mortality. The P values of PM2.5 and NO_2 were both greater than 0.05, and the standardized partial regression co-efficient Beta were PM2.5 (0.354) and NO_2 (0.085), respectively, indicating that there was no linear correlation between the two air pollutants and female breast cancer mortality. This shows that air pollution has a greater impact on the incidence of female breast cancer than the mortality. In conclusion, the results of single factor analysis show that air pollutants (PM10, PM2.5, NO_2, SO_2) have an impact on the incidence of female breast cancer, and air pollutants (PM10, SO_2) have an impact on the mortality of female breast cancer. Multivariate analysis showed that there was a multiple collinearity relationship between PM10 and PM2.5. Therefore, PM2.5 is excluded from the multi-factor analysis, and only PM10, SO_2 and NO_2 are considered. The results show in **Table 3**. PM10 (PM2.5) is linearly related to the incidence of female breast cancer, while SO_2 and NO_2 are not. The standardized partial regression coefficient Beta of PM10 (PM2.5) and female breast cancer incidence rate is 0.474. There is a linear correlation between SO_2 and female breast cancer mortality, while PM10 (PM2.5) and NO_2 are not. The standardized partial regression coefficient Beta of SO_2 and female breast cancer mortality is 0.430. In conclusion, the results of multivariate analysis showed that PM10 (PM2.5) had a greater impact on the incidence of female breast cancer than SO_2 and NO_2, and SO_2 had a greater impact on the mortality of female breast cancer than PM10 (PM2.5) and NO_2.

Table 1: The average value of female breast cancer incidence mortality and air quality in 2016

	Mean	SD
Female incidence (1/100000)	30.52	8.57
Female mortality (1/100000)	6.44	2.28
PM10 (μg/m³)	81.94	13.74
PM2.5 (μg/m³)	50.13	10.89
SO_2 (μg/m³)	22.1	9.58
NO_2 (μg/m³)	37.68	8.92

Table 2: The results of single factor linear regression analysis between air pollutants and female breast cancer incidence and mortality

Single-factor		Beta	Sig	B	95% CI	Adjusted R^2
Incidence	PM10	0.656	<0.001	0.409	0.23-0.588	0.411
	PM 2.5	0.629	<0.001	0.495	0.263-0.727	0.375
	SO_2	0.362	0.045	0.324	0.007-0.64	0.131
	NO_2	0.395	0.028	0.379	0.044-0.715	0.127
Mortality	PM10	0.554	<0.001	0.092	0.039-0.144	0.283
	PM 2.5	0.354	0.051	0.074	0-0.148	0.095
	SO_2	0.584	<0.001	0.139	0.066-0.212	0.319
	NO_2	0.085	0.65	0.022	-0.193	-0.027

Table 3: The results of multi-factor linear regression analysis between air pollutant and female breast cancer incidence and mortality

Multi-factor		Beta	Sig	B	95.0% CI	Adjusted R^2
Incidence	PM10	0.474	0.015	0.295	0.062-0.529	0.419
	SO_2	0.201	0.244	0.18	-0.622	
	NO_2	0.237	0.17	0.227	-0.661	
Mortality	PM10	0.367	0.059	0.061	-0.126	0.395
	SO_2	0.43	0.019	0.102	0.018-0.186	
	NO_2	0.009	0.957	0.002	-0.179	

DISCUSSION

This study reveals the correlation between air pollution and the incidence and mortality of female breast cancer in China. The result of multiple comparisons is that air pollutants (PM10, PM2.5, SO_2, NO_2) are linearly related to the incidence of female breast cancer. Air pollutants (SO_2, PM10) have an impact on the mortality of female breast cancer. This result is consistent with the previously reported study on the incidence risk of female breast cancer [19-22]. Our study adds evidence of significant positive correlation to the above studies. Our advantage lies in the use of a national database. The cancer registration of China National Cancer Center covers a wide range of people and the quality of registration data is high. Such data based on National Censuses can eliminate possible confounding factors, including data collection methods and any other unknown factors. This is different from previous control or cohort studies, adding new evidence related to air pollution and incidence and mortality of female breast cancer. The above research shows that heavily polluted areas will increase the incidence and mortality of female breast cancer. This study also has some limitations. Although our incidence and mortality statistics of female breast cancer are based on the verified database of the National Cancer Center of China, covering most of the population in China, some cities still lack sufficient high-quality data, and the statistical research lags behind. We also ignore the social and economic differences between these cities, human activity patterns and other factors. Our findings aim to strengthen air pollution supervision and reduce the incidence of female breast cancer caused by air pollution.

DECLARATIONS

Ethics Approval and Consent to Participate

Not applicable.

Consent for Publication

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Cancer data is from the annual report of China National Cancer Center, please refer to the link: https://doi.org/10.1016/j.jncc.2022.02.002. The data of air pollutants in major cities is from The Ministry of Ecology and Environment of China. All data used during this study available from the corresponding author (chenhui2001@126.com) on reasonable request.

COMPETING INTERESTS

We declare that there is no financial or non-financial conflict of interest in relation to this article.

AUTHOR'S CONTRIBUTIONS

Hui Chen conceptualized the hypothesis for this paper and wrote the manuscript. Jing Dai prepared and analysed the data. Hui Chen prepared the figure. All authors read and approved the final version of the manuscript.

ACKNOWLEDGEMENT

Not applicable.

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