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Analysis of Influencing Factors of Pediatric Pneumonia based on Regression Analysis Method

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Abstact

Background: Pediatric pneumonia is a lung inflammation caused by infection of different pathogens. It is easy to occur in all seasons, and infants under 3 years old are more likely to suffer from pneumonia in winter and spring. Pediatric pneumonia is a global disease and has been reported in most parts of the world. According to the World Health Organization, pediatric pneumonia accounts for 1/4 to 1/3 of all deaths in children under 5 years of age. Therefore, this paper studies the factors for affecting children pneumonia, analyzes the influence of various factors on children pneumonia, and puts forward reasonable suggestions.

Method: The information of pediatric pneumonia cases from February 2018 to December 2019 are extracted from the medical information system of Anyang People's Hospital. After sorting out and excluding the data with incomplete information, 500 cases of pediatric pneumonia are finally regarded as the research object. For the influence degree of causes, regression analysis method and weight analysis are used to explore the relationship between the incidence of pediatric pneumonia and the main air pollutants (PM2.5, PM10, SO_2, NO_2, CO, O_3) and meteorological factors (average relative humidity, rainfall, sunshine duration, average minimum temperature).

Results: The influencing factors of pediatric pneumonia are the result of the interaction of meteorological factors and environmental pollutants. Among them, the incidence of pediatric pneumonia is positively correlated with PM2.5, SO_2, NO_2 and CO in the environmental pollutants, and negatively correlated with O_3. It is negatively correlated with rainfall, average relative humidity and average minimum temperature in meteorological factors. According to the weight analysis, the average minimum temperature has the greatest influence on the incidence of pediatric pneumonia, and CO has the least influence on it.

Conclusion: Pediatric pneumonia is affected by external factors and is closely to children's living environment. We should pay more attention to the air pollutants and meteorological factors that affect children's pneumonia, and the relevant departments and institutions should also pay close attention to them.

Keywords: pediatric pneumonia, multiple linear regression, weight analysis, air pollutants, meteorological factors

1. Introduction

The incidence of pediatric pneumonia is more in spring and winter. In recent years, China's environmental pollution situation is grim, with frequent smog and prominent pollution problems. Anyang is located in the plain area, the climate conditions cannot make the haze can be effectively settled and diffuse, resulting in the local air quality is not optimistic. All kinds of enterprise emissions and suspended matter in the air are increasing, increasing the level of air pollution. Children, whose respiratory systems are not well developed, are more sensitive to air pollutants than adults. Ambient air quality is poor, bacteria easy to enter the respiratory tract, thus causing pneumonia. According to the "Investigation report on the causes of death of children under 5 years old in China" published by The Lancet in 2010, pneumonia accounted for 46.8% of the deaths of infants aged 1-11 months; China's Ministry of Health's mortality monitoring data for children under 5 years old shows that pneumonia accounts for 15.4% of all deaths, with about 62,000 children dying from pneumonia each year. Chen also pointed out in a lecture at the hospital that from 1996 to 2000,

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pneumonia ranked first among children in the death rate, worldwide, pneumonia caused more deaths than the number of children who died from AIDS, malaria and tuberculosis combined. Therefore, it is of great theoretical significance and application value to study the influencing factors of pediatric pneumonia and put forward corresponding preventive suggestions.

In this paper, multiple linear regression, linear proportional transformation and range method are used to analyze the influence of environmental factors on the incidence of pediatric pneumonia, and the weight of each factor is given.

2. Literature review

In the last few years, pediatric pneumonia has been stuided by some authors (Kyu et al., 2016; Lawrence et al., 2017; Vijay et al., 2018; Ghafari and Tjortjis, 2019; Neuman et al., 2011; Laura et al., 2012; Claes et al., 2017; Hammitt et al., 2017; David and Heather, 2017; Liszewski et al., 2018). For example, Shaughnessy et al. (Shaughnessy et al., 2016) discussed the practical recommendations for the office-based practitioner in the evaluation and treatment of an infant or child with suspected CAP. Simon et al. (Simon et al., 2017) provided prevalence rates for the most common causes of hemoptysis in children. Ning et al. (Ning et al., 2017) analyzed the date of the factors contributing to CAP in children under 5y of age. Aimee et al. (Aimee et al., 2017) studied the antimicrobial stewardship efforts in the treatment of pneumonias in critically ill children. Sterling et al. (Sterling et al., 2018) compared pediatric emergency department time metrics between children who received point-of-care lung US versus chest radiography. Tribble et al. (Tribble et al., 2019) compared antibiotic prescribing for CAP between hospital types before and after guideline publication in 2011. Hassen et al. (Hassen et al., 2019) investigated that radiologic evidence of pneumonia was absent in half of the children with severe pneumonia. Cheng et al. (Cheng et al., 2019) derived that ambient air pollution is associated with pediatric pneumonia. Maya et al. (Maya et al., 2019) studied point-of-care lung ultrasonography versus chest radiography for pediatric pneumonia. Liang and Zheng (Liang and Zheng, 2020) derived a transfer learning method with deep residual network for pediatric pneumonia diagnosis. Zhang et al. (Zhang et al., 2020) discussed the inflammation injury in pediatric pneumonia through MyD88/NF-kB signaling pathway.

Although the topic of pediatric pneumonia has been investiagted by some authors, only a simple correlation analysis has been used to find the main factors affecting the incidence of pediatric pneumonia.

3. Process and Methods

The flow chart is shown in figure 1.

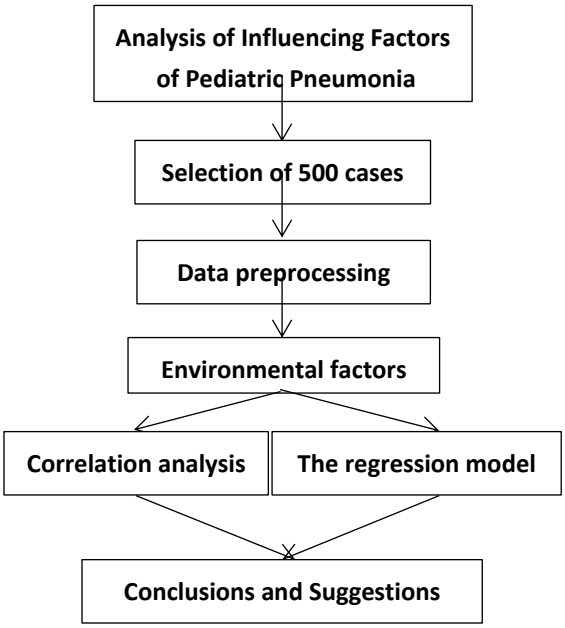

Figure 1: **Flow chart depicting the set-up of the study**

Data source

According to the information of pediatric pneumonia cases collected in Anyang People's Hospital, the original data are processed, and finally 500 cases are obtained by random sampling technique. Among the 500 pediatric pneumonia cases, there are 320 males and 180 females, with a male-to-female ratio of 1.78:1. According to the cases of infantile pneumonia in anyang people's hospital during February 2018 to December 2019, we use the crawler software to obtain air pollution index from the weather forecast, and calculate the monthly average. At the same time, the average relative humidity, rainfall, sunshine time and other meteorological factors index data of Anyang are obtained from China Meteorological Network. We investigate the association between pediatric pneumonia and air pollutants PM2.5, PM10, SO_2, NO_2, CO, O_3 and meteorological factors.

Methods

The confidence interval is set as 95%, and the P values of PM10 and sunshine time are both greater than 0.05 by using multiple linear regression. After deleting these two indexes, regression analysis is conducted. When the significance level is 0.05, eight indexes, PM2.5, SO_2, NO_2, CO, O_3, average minimum temperature, average relative humidity

and rainfall, are screened out. Therefore, a multiple linear regression model is established:

$$y = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \alpha_5 X_5 + \alpha_6 X_6 + \alpha_7 X_7 + \alpha_8 X_8$$

where y represents the number of cases, X_1 represents PM2.5, X_2 represents SO_2, X_3 represents NO_2, X_4 represents CO, X_5 represents O_3, X_6 represents the average minimum temperature, X_7 represents the average relative humidity and X_8 represents the rainfall (mm).

In order to further clear the risk degree of eight indicators: PM2.5, SO_2, NO_2, CO, O_3, mean minimum temperature, the average relative humidity, and the influence of rainfall (mm) for pediatric pneumonia, we use the method of linear proportion transformation to standardize the index data. We get the evaluation matrix R.

4. Results

Parameter estimation

In Table 1, the coefficients of constant and eight indicators are as follows: α_0 =-59.254, α_1 =-0.255, α_2 =-2.068, α_3 =1.604, α_4 =50.624, α_5 =0.295, α_6 =-1.859, α_7 =-0.292, α_8 =0.162. It is observed that the P values of PM2.5, SO_2, NO_2, CO, O_3, mean minimum temperature, the average relative humidity, and the influence of rainfall (mm) are all less than the significance level α =0.05.

Table 1. **Coefficients**

Model	B	Std. Error	Standardized	t	Sig.
Constant	-59.254	33.656		-1.761	.049
PM2.5	-.255	.236	-.511	-1.081	.029
SO_2	-2.068	.543	-1.064	-3.812	.012
NO_2	1.604	.584	1.019	2.746	.014
CO	50.624	26.861	.919	1.885	.048
O_3	.295	.192	.580	1.536	.014
mean minimum temperature	-1.859	1.196	-1.035	-1.554	.013
the average relative humidity	-.292	.245	-.180	-1.192	.028
rainfall	.162	.124	.473	1.303	.011

Remark 1: The P value means significance probability value. If the P value is less than the significance level α, the regression coefficient passes the hypothesis test. The symbol Sig. represents the P value.

Model test

We use regression analysis to test the fit degree of the model. The results of Table 2 and Table 3 show that the model pass the hypothesis test. In Table 2, the value of R square is 0.848>0.515. In Table 3, F=6.195, at the significance level of 0.05, $F_{0.95}$ (8,16) =3.20, and F>3.20. It indicates that the fitting degree of the model is high.

Table 1. **Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.921[a]	.848	.813	3.2582

a. Predictors: (Constant), PM2.5, SO_2, NO_2, CO, O_3, mean minimum temperature, the average relative humidity, rainfall.

b. Dependent Variable：Number of Cases

Table 3. **ANOVA[a]**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6281.794	8	785.224	6.195	.001b
	Residual	2027.966	16	126.748		
	Total	8309.760	24			

a. Dependent Variable：Number of Cases

b. Predictors: (Constant), PM2.5, SO_2, NO_2, CO, O_3, mean minimum temperature, the average relative humidity, rainfall.

Remark 2: R Square means goodness of fit. It is used to test how well the regression equation fits the sample observations. If the value of R Square is close to 1, the effect of regression fitting is better.

Through the observation of cases, we found that the incidence of pediatric pneumonia cases has obvious seasonal changes. The number of children with pneumonia from November, December to January of each year is quite large, accounting for

67% of the number of patients, and the incidence rate from February to October is stable, maintaining at about 3%. This phenomenon from the side shows that winter is the incidence of children with pneumonia. In winter, the temperature of Anyang is the lowest, and the concentration of pollutants is high. Children's immunity is low, and they are prone to respiratory infections.

The relationship test

In Table 4 and Table 5, the number of cases is positively correlated with PM2.5, SO_2, NO_2 and CO, and negatively correlated with O_3, rainfall, average relative humidity and average minimum temperature. The correlation between the mean minimum temperature and the other seven factors is strong. It can be seen that the average minimum temperature has a greater impact on the incidence of pneumonia in children. The weight of each index is obtained by using range method:

$\boldsymbol{w}$ = [0.1264 0.1267 0.0999 0.0807 0.1361 0.1898 0.0848 0.1554]

It is obviously that the average minimum temperature has the greatest influence on the incidence of pneumonia in children, while CO has the least influence on it. (influence: the average minimum temperature > rainfall > > SO_2>O_3 > PM2.5 > NO_2 > average relative humidity > CO).

Table 4. **Correlations**

		Number of Cases	PM2.5	SO_2	NO_2	CO	O_3
Number of Cases	Pearson	1	.586**	.261	.670**	.617**	-.615**
PM2.5	Pearson	.586**	1	.586**	.661**	.878**	-.697**
SO_2	Pearson	.261	.586**	1	.693**	.801**	-.498*
NO_2	Pearson	.670**	.661**	.693**	1	.763**	-.808**
CO	Pearson	.617**	.878**	.801**	.763**	1	-.702**
O_3	Pearson	-.615**	-.697**	-.498*	-.808**	-.702**	1
mean minimum temperature	Pearson	-.617**	-.908**	-.672**	-.809**	-.850**	.845**
the average relative humidity	Pearson	-.015	-.163	-.328	-.057	-.202	.000
rainfall	Pearson	-.426*	-.689**	-.601**	-.748**	-.606**	.556**

Table 5. **Correlations**

		mean minimum temperature	the average relative humidity	rainfall
Number of Cases	Pearson	-.617	-.015**	-.426
PM2.5	Pearson	-.908**	-.163	-.689**
SO_2	Pearson	-.672	-.328**	-.601
NO_2	Pearson	-.809**	-.057**	-.748**
CO	Pearson	-.850**	-.202**	-.606**
O_3	Pearson	.845**	.000**	.556*
mean minimum temperature	Pearson	1**	.167**	.809**
the average relative humidity	Pearson	.167	1	.314
rainfall	Pearson	.809*	.314**	1**

** $\alpha = 0.01$.
* $\alpha = 0.05$.

5. Discussion

Effects of air pollutants on pediatric pneumonia

In recent years, the air pollution index in Anyang has been high. Anyang is located in central China; the level of economic development needs to be improved. Anyang Iron and Steel Co., Ltd., Anyang Bosheng Iron and Steel Company and other enterprises are the main contributors to the economy of Anyang. But, at the same time, these enterprises also emit a lot of air pollutants. PM2.5, SO_2, NO_2, CO and O_3 are all major air pollutants. From the correlation tables, we can observe that the number of cases is positively correlated with PM2.5, SO_2, NO_2 and CO, and negatively correlated

with O_3. The peak of pediatric pneumonia is in winter. The haze weather in Anyang is mostly in winter, PM2.5, SO2, NO2, CO content is high, the incidence of pediatric pneumonia increased.

Effects of rainfall on pediatric pneumonia

Rainfall is one of the disease factors affecting pediatric pneumonia. Anyang is located in the northern warm temperate zone and belongs to the continental monsoon climate. Under the influence of monsoon climate, Anyang has the majority of summer rainfall weather. Rainfall may affect the distribution of biological communities, which is not conducive to virus transmission and reduces the chance of virus infection. From the correlation tables, we can observe that the number of cases is negatively correlated with rainfall, and the number of cases is less due to high humidity in summer. In addition, some studies have proved that rainfall can have a scouring effect on the pollutants in the air and reduce the dust suspended in the air, thus reducing the occurrence probability of air pollutants and reducing the probability of disease.

Effects of the average relative humidity on pediatric pneumonia

In winter, the climate is exceptionally dry, the environmental relative humidity is too low which can make the human respiratory system resistance decline, induce and aggravate the respiratory system diseases. At the same time, the low environmental relative humidity makes all kinds of viruses and pathogenic allergens multiply faster, and with the spread of dust, cause the epidemic of disease. From the correlation tables, it is obviously that the number of cases is negatively correlated with the average relative humidity. Therefore, maintain indoor relative humidity can not only inhibit the breeding and transmission of bacteria, but also improve immunity, reduce the incidence of pediatric pneumonia.

Effects of mean minimum temperature on pediatric pneumonia

The mean minimum temperature is also a factor affecting the incidence of pediatric pneumonia. From the correlation tables, we can observe that the number of cases is negatively correlated with the mean minimum temperature. According to researchs, winter weather is colder than body's ability to resist, so cold air can hurt lungs and cause disease in children. Winter, the majority of people moves indoors, air circulation is more likely to cause the occurrence of pediatric pneumonia.

6. Conclusions

In the study of the external causes of pediatric pneumonia, through parameter estimation and regression analysis, it is found that PM2.5, SO_2, NO_2, CO, O_3, average minimum temperature, average relative humidity and rainfall are the main factors affecting the incidence of pediatric pneumonia. The number of cases is positively correlated with PM2.5, SO_2, NO_2 and CO, and negatively correlated with O_3, rainfall, average relative humidity and average minimum temperature. The correlation between the mean minimum temperature and the other seven factors is strong. In the analysis of the impact of eight indicators on the incidence of pediatric pneumonia, it is concluded that the average minimum temperature has the greatest impact on the incidence of pediatric pneumonia, and CO has the least impact. We have discussed the external causes of pediatric pneumonia. However, due to the limitation of statistical techniques, we cannot analyze the internal factors of pediatric pneumonia well. Therefore, the future research topics will include the internal factors of pediatric pneumonia.

7. Suggestions

In recent years, the emission of various enterprises and suspended matter in the air are increasing in Anyang, which constantly aggravates the degree of air pollution. The government should increase the means of environmental governance, pay close attention to the environmental situation, control the emission of pollutants from enterprises, and create a good living environment. meteorological bureau should be all-weather monitoring of meteorological conditions, timely release of disease early warning, which is conducive to parents to strengthen prevention and reduce the occurrence of disease.

In general treatment, keep the air circulation in the ward, the room temperature is maintained at 20 ℃, the humidity is about 60%. It is recommended to strengthen exercise, strengthen physical fitness, reduce passive smoking, and maintain indoor air circulation. Actively prevent and treat diseases such as rickets, anemia, and malnutrition. Pay attention to personal hygiene, especially hands. Children should avoid crowded places with poor air circulation to avoid cross-infection. Children should be vaccinated to reduce the incidence of pneumonia.

The majority of medical staff should strengthen the study of the pathogens that cause pediatric pneumonia, seek better treatment, strengthen the control of the disease, and reduce the occurrence of pediatric pneumonia. Hospitals can strengthen parents' awareness and prevention of children's

diseases by holding lectures on safety knowledge and handing out leaflets on health knowledge.

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Conflict of Interest

There are no conflicts of interest in this study.

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