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RESEARCH ARTICLE

The association between urban pollutants and preterm birth occurrences: a case study of Mashhad-Iran

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Abstract: Preterm birth and associated conditions are one of the biggest killers of children in the world-wide. In this regards, current study aimed at investigation of the relationship between air pollutants of Pm_{10}, CO, O_3, and SO_2 and preterm birth occurrences recorded in Imam Reza (PUH) Hospital of Mashhad for a five-year period from 2007 to 2011. The results of quantile regression showed that the amount of atmospheric pollutants have an important role in rising preterm births. In this way, the pollutants of Pm_{10} and CO have revealed the strongest effect on preterm birth occurrences especially for the last three months of pregnancy. Moreover, preterm births mostly have occurred in warm seasons of spring and summer, while the seasonal average of pollutants concentration, excepting O_3 pollutant, has shown rising in cold seasons of autumn and winter. However, reducing air pollution could also be effective in reducing preterm births across the world.

Keywords: urban pollutants, preterm birth, regression, Mashhad, Iran

1 Introduction

One of the key issues relating to urban climatology is air pollution, affecting all human activities and functions. Moreover, air pollution is responsible for increase in the rate of mortality, different kinds of diseases, especially respiratory ones, and affects pregnancy and fetal development, the length of convalescence, longevity, etc. In large cities all over the world, air pollution is a main factor contributing to preeclampsia during pregnancy, to fetal development disorders, to low birth weight, and finally to preterm births. Premature infants are one of the groups with the highest rate of mortality and neonatal complications. About two thirds of infant mortalities results from preterm births. According to the latest statistics released by the Ministry of Health and Medical Education (IRI) in 2003, 5.23% of babies in Iran were born prematurely[1] .

Preterm births occur before the 37th week of pregnancy and premature infants require intensive care, which needs spending a great deal of time and money, yet these infants face numerous problems during the first year of their life. The effects of being exposed to environmental pollutants on fetal development can be far-reaching. To mention one, the delay in fetal development can expose infants to the risk of heart diseases and diabetes in adulthood. The chance of surviving for 15 million babies born every year can differ depending on their birthplaces. Over 60% of premature infants in the world are born in Sub-Saharan Africa and South Asia, more than 80% of whom do not survive[2] .

Mashhad is one of the metropolitan cities in Iran, constantly beset with the problem of air pollution. Since the last three months of pregnancy are much more important than other months concerning the mother and fetus's health, the current study tries to investigate the relationship between air pollution and preterm births by considering the effect of air pollutants on the three last months of pregnancy (pregnancies lasting less than nine months).

A great deal of research on pregnancy and air pollution has been conducted in and out of Iran. Majority of these studies have been focused on the correlation between pollutants concentration and preterm births.[3–14] Generally, Most of these studies have shown the similar results. Many researchers selected a wide scope from among different countries for their studies.[15,16]

Although some studies found that public health can be affected by various air pollutions.[17–19] However, most

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previous studies have focused on the association between O_3 and low birth weight as well as the association between PM and preterm birth. In addition, a few studies have performed about the effect of air pollution on pregnancy[20] over the vast territory of Iran area. In a last research conducted by Janghorbani and Piraee[21] has been analyzed the relationship between air pollution and births of premature infants for 4758 cases of births in the city of Isfahan during 2010-2012. Results of this study showed that there is a significant relationship between two parameters of preterm births and low birth weight and the parameter of exposure of pregnant women to air pollution. Therefore, the objective of this study is to investigate the relationships between atmospheric pollutants and preterm birth in the megacity of Mashhad.

2 Materials and Methods

In order to conduct this research, first, the data on preterm births for a five-year period (2007-2011) were collected from Imam Reza (PUH) Hospital in Mashhad. The air pollution data for four main pollutants, consisting of Pm_{10}, CO, O_3 and SO for a five-year period (2007-2011) were collected from the Pollution Monitoring Center affiliated to Mashhad Municipality. Mashhad as selected study area of this research is a metropolitan located in the north east of Iran at 59.15 ° longitude and 36.20 ° latitude. In addition, the monthly, seasonal and yearly average of each of the four pollutants was calculated to find out the condition and the trend of pollution for this period of five years (2007-2011) in Mashhad. In order to investigate the relationship between urban pollutants and preterm births in Mashhad, first, the units of the four main pollutants (Pm_{10}, CO, O_3 & SO_2) were converted to the Pollutant Standard Index (PSI).

Then, the ordinary least-squares regression and the quantile regression model are used for the conditional quantiles. In this regards, the type of the quantile regression model has a number of applications such as examining the relationship between explanatory variables. However, the most important use of a quantile regression might be to identify the distribution shape of a dependent variable of the model at various levels of an explanatory variable. Finally, the parameters of the quantile regression model are estimated by using of the least absolute deviation (LAD) method. In the LAD method, the regression curve is fitted in such a way that on the whole, and the distance of points from it, is minimized. In this way, solving the relationship and finding the parameters of estimation would be possible through the linear programming method including Simplex Algorithm, Internal Points Algorithm, and Finite Smoothing Algorithm. The simplex algorithm in spite of having a low speed in the mode of numerous observations is much more stable than the other two algorithms, and for different types of data, in particular data that have a large number of outliers, can find a solution.

3 Results

3.1 Frequency of preterm births

The following monthly and seasonal distribution was achieved by investigating 1678 cases of preterm deliveries having occurred between the years 2007 and 2011 in Mashhad. Investigating the five-year trend showed that the most preterm births have occurred in 2008 and fewest ones in 2011. In general, the occurrence of the preterm births from 2007 to 2011 has had a downward trend (Figure 1). The preterm births monthly percentage in Mashhad shows that most preterm births have occurred in May and the lowest frequency percentage of the preterm births has been recorded in February (Figure 2). The figure indicates that in the investigated five-year period (2007-2011), the highest frequency of the preterm births is observed in warm months and the lowest frequency of them is observed in cold months. The seasonal frequency percentage of the preterm births shows that the preterm births have been most frequent in spring and summer (Figure 3).

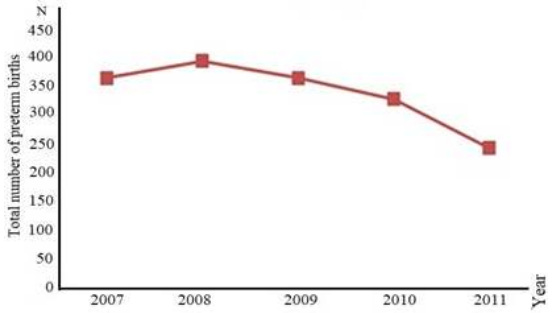

Figure 1. Annual frequency of preterm births in Mashhad

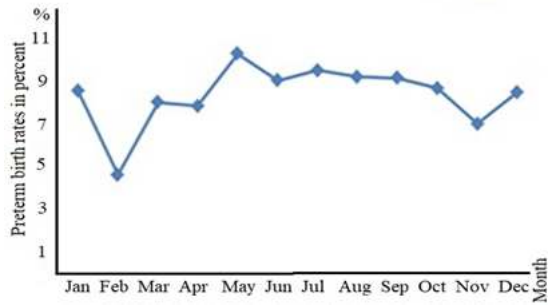

Figure 2. Monthly frequency of preterm births in Mashhad

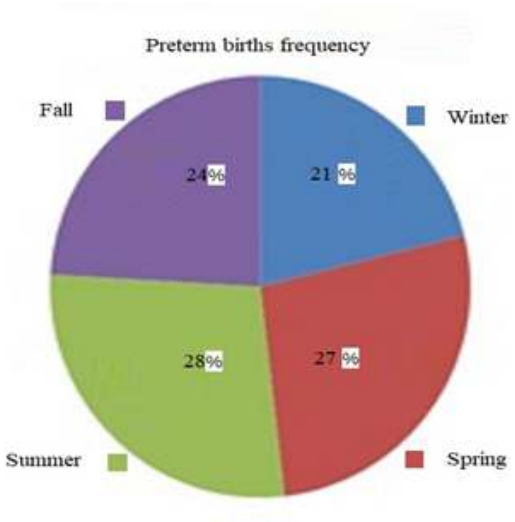

Figure 3. Seasonal frequency of preterm births in Mashhad

3.2 Concentration of urban pollutants

The main pollutants frequency was compared on time scales of monthly, seasonally, and yearly. This comparison has revealed the concentration of each of urban pollutants for the studied years (2007-2011). Average concentration of $Pm_{10}$and CO from 2007 to 2011 has had a downward trend (Figure 4). The pollutant of O_3 has had the highest average concentration in 2008. The average concentration of SO_2 showed that this pollutant's concentration from 2007 to 2011 has had an upward trend (Figure 5).

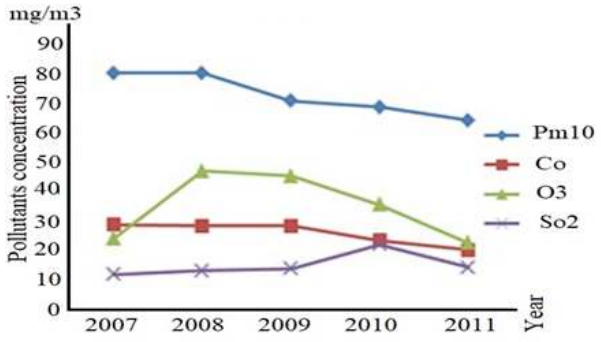

Figure 4. Annual average of urban pollutants concentration in Mashhad

Average concentration of the urban pollutants in Mashhad on a monthly basis shows that Pm_{10} and CO have had the highest concentration in November (Figure 6). The seasonal average concentration of the urban pollutants indicated that Pm_{10} and CO have had the highest concentration in fall and winter. The monthly average concentration of O_3 showed that this pollutant has had the highest concentration in February. Moreover, the seasonal average concentration of O_3 indicated that it has had the highest concentration in spring and the seasonal average concentration of SO_2 shows that this pollutant has had the highest concentration in fall season (Figure 7).

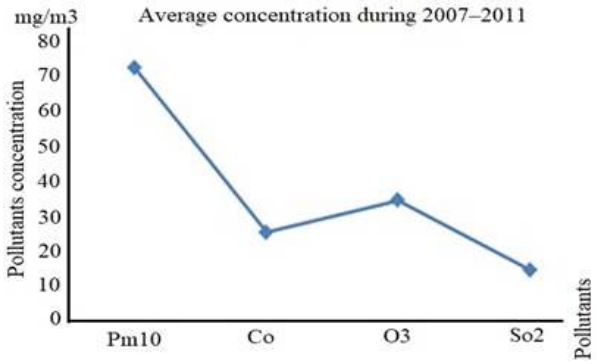

Figure 5. Average concentration of urban pollutants in Mashhad during the five-year period

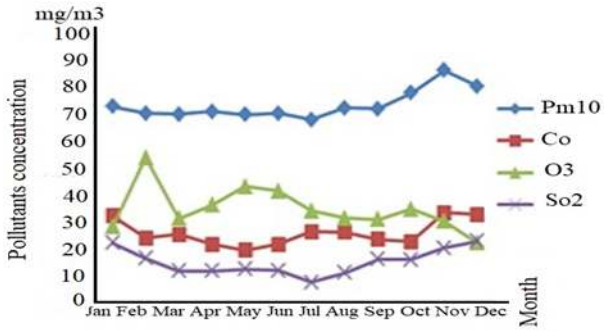

Figure 6. Average concentration of urban pollutants in Mashhad on a monthly basis

3.3 The relationship between air pollutants and preterm births

In this part, the correlation and relationship between air pollution and preterm births were analyzed by using of the quantile regression. In Figure 8, the eight fitness lines correspond with the quantile regression lines include; 0.996, 0.99, 0.95, 0.9, 0.7, 0.5, and 0.01. Also, one line is related to the ordinary least-squares regression, which has been drawn as a dotted line in red. In this figure, the median regression line has coincided with the quantile regression line 0.01. The quantiles 0.9 and 0.95 have also coincided with each other. As the figure shows, the lower lines are closer to each other than the upper lines. This means that the shape of the probability distribution is inclined towards the right hand side. In details, the curve is skewed to the right. Please note

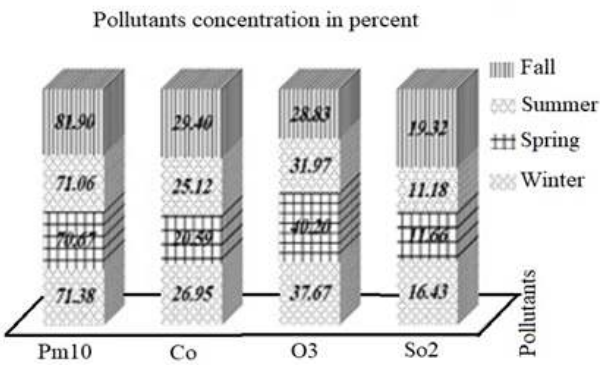

Figure 7. Seasonal average concentration of urban pollutants in Mashhad

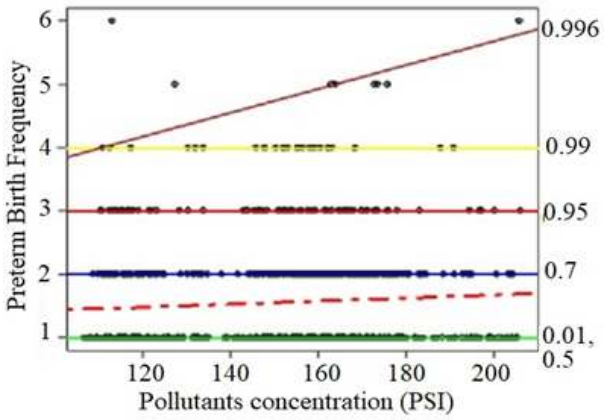

Figure 8. The correlation between air pollution concentrations and preterm births

that ordinary regression cannot indicate the susceptibility rate of an explanatory variable at different levels of distribution, while quantile regression can show the state of data distribution. The susceptibility rate of the Pollutant Standards Index is higher in upper percentiles of this index.

Considering the estimates obtained in the Figure 8, it observed that the mortality rate of infants in preterm births is on the rise in line with air pollution increase. Given that there are too many outliers in these data, the least-squares regression would not be able to interpret the relations precisely. Therefore, it can be concluded that in some years a particular quantile is useful in order to be able to interpret the data appropriately. As we see, the least-squares regression has a larger y-intercept in the lower and central bounds than the quartile regression patterns and this shows the existence of outliers in this model. Little space between the quantile regression lines revealed that data compaction is high and large space between the data quantiles showed that the data compaction is lower; in other words, there are fewer data in this part. As seen in the Figure 8, in most quantiles, the estimated error is close to zero or zero and this showed that the model fitted to the data has sufficient reliability.

To discover effects of each of pollutants on preterm births, we examined the data again using the above-mentioned quantile regression model. In this regards, as it has already examined, an ordinary regression model is not well suited for fitting models to data at each of the pollutant levels for CO. Therefore, the quantile regression model, which prevents errors, is used for fitting models to data (Figure 9). The results obviously revealed that the effect of Pm_{10} on the number of preterm births is more than the other pollutants due to its steep and positive gradient in the upper bounds. Therefore, either the level of air pollution should be reduced in these places or pregnant women should be kept away from these environments (Figure 10). The CO pollution level in quantiles of 0.9, 0.95, 0.7, 0.5 and 0.01 is rising almost in the same direction. This indicated that the level of pollution in the atmosphere shows no typical trend at these levels (Figure 11). Regarding the negative slope of the upper quantiles (0.99 and 0.996) in SO_2. It can be concluded that this pollutant has had the least effect on preterm births (Figure 12).

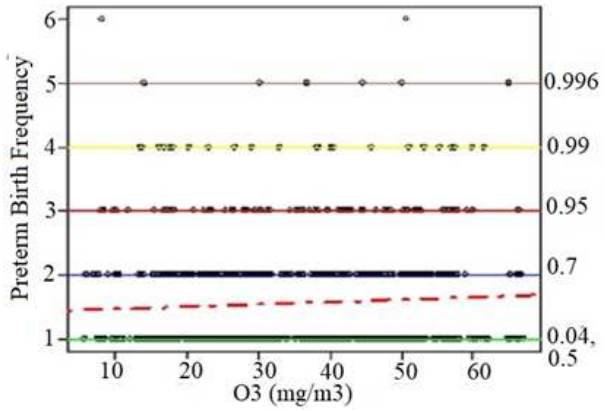

Figure 9. The relation between O_3 and preterm births

4 Discussion and Conclusion

Pollutants, by creating respiratory problems and increasing the risk of heart attacks, have a major effect on activities of the human body. In this regards, to determine the relationship between air pollution and preterm births, previous studies mostly have used logistic regression. In logistic regression, emphasis falls on only occurrence or non-occurrence of preterm births (dependent variable), as well as the effect of an independent variable on preterm births is indicated. However, quantile

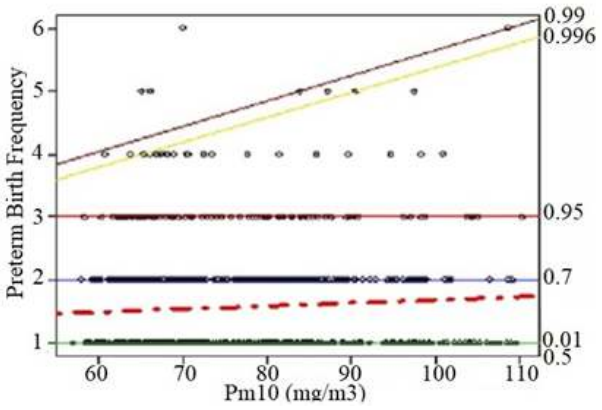

Figure 10. The relation between Pm_{10} and preterm births

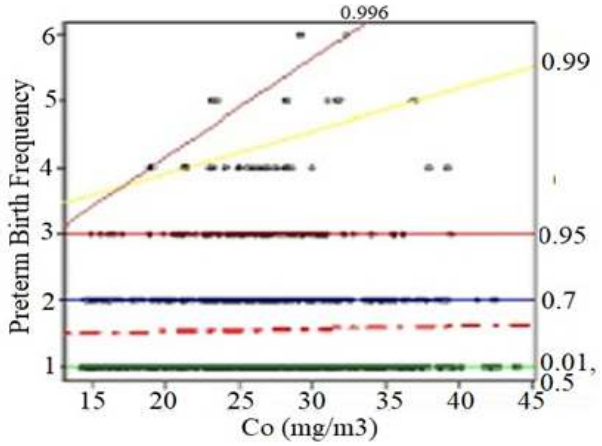

Figure 11. The correlation between CO and preterm births

regression also considers the number of preterm births. Therefore, quantile regression can not only be a suitable substitute for median regression, but also in some cases it can provide researchers with more information than median regression, so that they can present better findings about high dispersion of response variable at some levels.

Previous studies on preterm births have emphasized on first three months of pregnancy as the initial three months of fetal development, but this study found that the last three months of pregnancy are very important as well. This finding is significant because the risk of preterm births increases in the last months of pregnancy, and external factors are contributory to occurrence of preterm births. In the first year of life, air pollution strongly affects the child's respiratory system, so that 1 to 3 month-old infants who breathe large amounts of carbon monoxide gas (CO) and 4 to 12 month-old infants exposed to high levels of particulate matter (Pm_{10}) less than ten microns, face the serious risk of death due to respiratory diseases. Those mothers who are exposed to

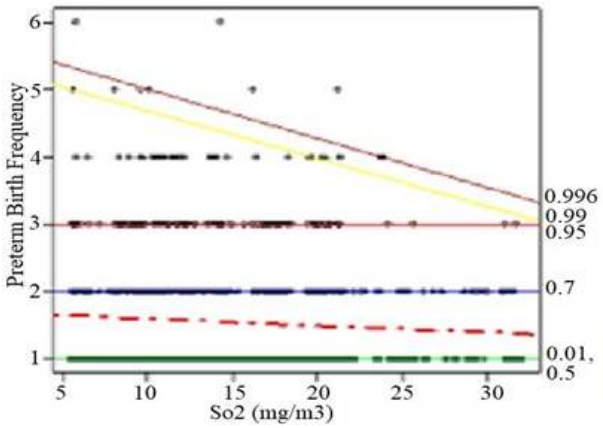

Figure 12. The correlation between SO_2 and preterm births

high amounts of carbon monoxide and particulates during pregnancy raise the risk of having a miscarriage, a preterm birth, pre-eclampsia and giving birth to babies with low weight or congenital heart defects. Studies conducted elsewhere in the world indicate similar effects of air pollutants (especially carbon monoxide, sulfur dioxide and particulates) on fetuses as well.

Preterm births and low birth weight have a relationship with being exposed to high amounts of carbon monoxide and particulates during the first three months and the last three months of pregnancy. Exposure to air pollution at the beginning of pregnancy is a matter of great importance because of its interference with fetal development through placenta and its reducing oxygenation and nutrients to the fetus, and in the last three months for its effect on the weight of the fetus. Exposure to air pollution during certain periods of pregnancy is a stimulant of inflammation and as a result, preterm births. Some heart damages related to high amounts of carbon monoxide and probably ozone have been observed during the second month of pregnancy, because the second month is the most important period for the development of the fetus heart. Not only do the last three months of pregnancy control the weight of the fetus, but also they are more susceptible to preterm births comparing with other months of pregnancy.

Overall, the results revealed that the most preterm births occur in spring and summer. The pollutants of Pm_{10} and CO have shown the strongest effect on the number of preterm births with the highest possible coefficients. Therefore, increase of Pm_{10} and CO concentration increases the number of preterm births. Since concentration of Pm_{10} and CO increases remarkably in winter due to occurrence of temperature inversion phenomenon. While, rising the preterm birth frequency during spring and summer is natural. It means that the ef-

fects of air pollutants in winter when winter covers the last three months of pregnancy or three medial months of preterm births in spring and summer, are much more importance. Based on these discussions, it can be concluded that the amount of atmospheric pollutants have an important role in rising preterm births. Thus, by using effective methods, we should reduce the amounts of pollutants and prevent increase of them. Also as a recommendation, pregnant women should not be exposed to air pollution.

5 Conflict of Interest and Funding

Authors have no conflict of interest or any funding to declare.

6 Acknowledgments

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