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Title

The Intrauterine Inflammation and Maternal Exposure to Ambient $PM_{2.5}$ during Preconception and Specific Periods of Pregnancy: The Boston Birth Cohort Study

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Abstract

Background

Preterm birth and low birth weight can cause breathing problems, feeding difficulties, vision problems, and developmental delays in affected children. Globally, the impacts of preterm birth are the leading cause of death of children under 5 years[1]. According to the Centers for Disease Control and Prevention, the number of preterm births in the United States (US) was 381,321 in 2014, and the number of infants of low birth weight was 318,847[2]. Of particular note are marked racial and ethnic disparities; non-Hispanic black infants have significantly higher preterm birth rates and percentages of low birth weight compared to non-Hispanic white and Hispanic infants.

Particulate matter (PM) or particle pollution, is a complex mixture of small particles and liquid droplets suspended in the air, and is considered a hazardous air pollutant. This mixture includes acids (such as nitrates and sulfates), organic chemicals, metals, and dust and soil particles. This type of pollution can be released into the air through activities such as construction, wood burning, or other combustion processes, and can also be formed in the atmosphere from industry and automobile emissions. Particulate matter designated specifically as $PM_{2.5}$ refers to particles so small (2.5 micrometers in diameter or smaller) that, individually, they cannot be seen by the naked eye. These fine particles can be drawn deep into our lungs, and may even enter the bloodstream[3].

Maternal exposure to air pollution during pregnancy has been associated with preterm birth and low birth weight in children in previous studies, but the biological mechanism (how the pollution may contribute to these adverse outcomes) is not yet well understood. Animal studies suggest that $PM_{2.5}$ exposure, specifically, may be associated with intrauterine inflammation (IUI), which is known to increase the chances of preterm birth and low birth weight[4]. However, not many studies among humans have investigated the link between air pollution, and specifically $PM_{2.5}$ exposure, and IUI.

Objective

This study was designed to investigate the association of maternal exposure to $PM_{2.5}$ (both before and during pregnancy) and IUI, as IUI may be the mechanism for how air pollution can affect birth outcomes (preterm birth, low birth weight), and ultimately, infant health.

Methods

A cohort of over 5,000 mother-infant pairs in an at-risk urban predominantly minority population were recruited from the Boston Medical Center between 1999 and 2012. The mothers were given an interview-questionnaire to establish data on education, income, residency, and smoking status.

[1] Preterm Birth. (November 2015). Retrieved May 31, 2016, from http://www.who.int/mediacentre/factsheets/fs363/en/
[2] Hamilton, B., Martin, J., Osterman, M., Curtin, S., and Mathews, T.J., (2015). Births: Final Data for 2014. *National Vital Statistics Reports*, 64 (12), 1-64. Retrieved from http://www.cdc.gov/nchs/data/nvsr/nvsr64/nvsr64_12.pdf
[3] Particulate Matter Basic Information. (n.d.). Retrieved May 31, 2016, from https://www3.epa.gov/pm/basic.html

$PM_{2.5}$ exposures were estimated for each mother based on her residential address using data from air quality monitors from the U.S. Environmental Protection Agency's (EPA) Air Quality System. Estimates were obtained from pre-conception, each trimester of pregnancy, and the final month of pregnancy. These estimates were categorized into quartiles (4 levels of exposure) in order to assess the association with IUI.

IUI was assessed based on whether a mother experienced a fever during labor and by evaluating the placenta. Data was gathered from both maternal and infant records, as well as the interview-questionnaires administered at recruitment.

The statistical analysis used to determine the significance of the association of maternal $PM_{2.5}$ exposure with IUI adjusted for potential confounding factors such as including maternal age at delivery, education level, smoking status, body mass index, and race/ethnicity.

Results

Comparing the highest to the lowest $PM_{2.5}$ exposure quartiles, the association was significant for all exposure periods considered: 3 months prior to conception, first trimester, second trimester, third trimester and whole pregnancy. The strongest association was observed for the first trimester and for the entire pregnancy.

Conclusion

Even with low exposures, these study findings suggest a positive association between $PM_{2.5}$ exposure during preconception and pregnancy and IUI. Early pregnancy may be a particularly vulnerable time for pregnant women and developing fetus to be affected by $PM_{2.5}$ pollution and IUI/related health outcomes.

Policy Implications

EPA sets federal standards for several air pollutants--the National Air Ambient Quality Standards (NAAQs). Currently, the primary NAAQ standard for $PM_{2.5}$ is 12μg/m^3, which is an annual mean averaged over 3 years. This standard was designed to provide public health protection, including protections for sensitive populations[4].

During this study in Boston, the annual mean daily ambient $PM_{2.5}$ level at the start of the study was 16.3 μg/m^3, which then decreased to an annual mean of 9.5 μg/m^3 later in the study period. Almost 69% of the study participants had estimated exposures during the period of the entire pregnancy that were below the federal standard. These study findings should be considered when EPA next reviews the scientific literature to either reaffirm or modify the $PM_{2.5}$ standard in order to fully protect sensitive populations, especially pregnant women and their unborn children.

Despite the existence of a national standard, there are many US cities that experience pollution levels above this standard. Some have significantly higher annual mean levels of $PM_{2.5}$, such as Fresno, CA (44.6 μg/m^3 in 2012). In fact over half of the US population live in counties where ozone levels or PM levels make the air unhealthy to breathe[5].

Moreover, air pollutants ($PM_{2.5}$ and other harmful chemicals) often affect certain communities more than others. Research has shown that communities of color are more likely to live in places with higher levels of air pollution, as well as communities of low socioeconomic status[6]. In a 2003 study, Hispanic, African-American, and Asian/Pacific Islander mothers experienced higher mean levels of air pollution and were more than twice as likely to live in highly

[4] NAAQS Table. (2016). Retrieved May 31, 2016, from https://www.epa.gov/criteria-air-pollutants/naaqs-table
[5] Key Findings: State of the Air 2016. (2016). Retrieved May 31, 2016, from http://www.lung.org/our-initiatives/healthy-air/sota/key-findings/
[6] Disparities in the Impact of Air Pollution. Retrieved May 31, 2016, from http://www.lung.org/our-initiatives/healthy-air/outdoor/air-pollution/disparities.html

polluted counties when compared to white mothers[7]. The health effects of air pollution can also be further worsened by lack of access to health care, and lack of environmentally healthy jobs.[8]

Reducing $PM_{2.5}$ pollution, especially for communities that are disproportionately exposed, is crucial to protect pregnant women and the developing fetus from the potential negative health effects of $PM_{2.5}$ pollution. Ensuring that regulatory standards like the NAAQs are truly protecting the health of sensitive populations, and that there is attention on improving the air quality in areas that do not meet the NAAQs is necessary to safeguard the health of future generations.

Reference

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Keyword(s)

Particulate pollution, preterm birth, low birth weight, developing fetus, intrauterine inflammation, pollution exposure

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