November Article of the Month

Acute Impact of Hourly Ambient Air Pollution on Preterm Birth

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Background:

A preterm birth, commonly referred to as a premature birth, is a birth that occurs before the 37th week of pregnancy. According to the Centers for Disease Control and Prevention (CDC), one in ten babies were born preterm in the United States (U.S.) in 2014. Preterm births pose a great threat to the health of the infant as it is the greatest contributor to infant death. Preterm birth can also cause long-term neurological disabilities including cerebral palsy, breathing problems, developmental delay, and feeding difficulties.[1] The causes of preterm birth are not fully understood; however, there is mounting evidence that air pollution may be a factor.

The Clean Air Act (CAA) of 1970 was the first federal legislation that controlled air pollutants.[2] CCA mandated that the U.S. Environmental Protection Agency (EPA) protect human and environmental health via the establishment of National Ambient Air Quality Standards (NAAQS). These standards regulate the following six common and harmful air pollutants throughout the U.S.: carbon monoxide (CO); sulfur oxides via indicator sulfur dioxide (SO_2); nitrogen oxides via indicator nitrogen dioxide (NO_2); lead; particle pollution (also referred to as particulate matter or PM); and ground-level ozone (O_3).[3]

These six pollutants are emitted into the air through the burning of fossil fuels—primarily by power plants, vehicles, and locomotives. Research indicates that when pregnant women inhale these pollutants in high concentrations, it causes oxidative stress and intrauterine inflammation. These conditions can lead to the development of preeclampsia (pregnancy hypertension) and preterm premature rupture of membranes (PPROM) respectively, which together cause preterm birth.[4]

Prior studies have examined the relationship between exposure to air pollutants and risk of preterm births over the course of the entire pregnancy or during specific trimesters. However, there are no known studies that focus on the impact of maternal air pollutant exposure in the hours before onset of preterm labor.

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[1] Preterm Birth. Retrieved October 20, 2016 from http://www.cdc.gov/reproductivehealth/maternalinfanthealth/pretermbirth.htm

[2] Clean Air Act History and Requirements. Retrieved October 20, 2016 from https://www.epa.gov/clean-air-act-overview/clean-air-act-requirements-and-history#common

[3] Criteria Air Pollutants. Retrieved October 20, 2016 from https://www.epa.gov/criteria-air-pollutants.

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Objective:

The objective of this study was to identify the relationship, if any, between short term increases in ambient air pollutants a few hours before onset of labor and preterm birth.

Method:

Data for births that occurred in the Brisbane (Australia) Metropolitan Area between January 1, 2009 and December 31, 2013 was collected from the Queensland Health Perinatal Data Collection Unit. The data included births from all public hospital, private hospital, and self-reported homebirths. Only births that had a gestation period of less than 37 weeks were included in the study. The date and time of birth, length of labor, number of births, infant sex, maternal smoking status, and index of maternal socioeconomic status (SES) during the pregnancy was also collected. A total of 6,949 preterm births were used in this study.

Air pollution data was collected from the Queensland Government Department of Environment and Heritage Protection. Hourly data on coarse PM which is less than 10 micrometers in diameter (PM_{10}), fine PM which is less than 2.5 micrometers in diameter ($PM_{2.5}$), NO_2, SO_2, O_3, CO, ambient temperature, and relative humidity was collected.

Using the data, the mean values of each air pollutant for the time intervals 0-24hr, 24-48hr, 48-72hr, 0-48hr, and 0-72hr before each preterm birth were calculated. These mean values were compared to control mean values of each pollutant. The control mean values were calculated by using pollutant data from the same hour and same day of the week within the calendar month of each preterm birth. These comparisons were then analyzed to determine if there was an association between short term increases in concentration of air pollutant and risk of preterm birth.

Results:

The study results indicated a positive relationship between risk of preterm birth and short term increases in concentration of NO_2, SO_2, and CO, and no significant relationship between preterm births and short term increases in concentration of $PM_{2.5}$, PM_{10}, or O_3. The results implied that each pollutant's effect on risk of preterm birth was independent from the other pollutants. The results also indicated that there was a threshold, a minimum increase in concentration of air pollutant, that resulted in increased risk of preterm birth for NO_2, SO_2, and CO. The threshold increase of concentrations were: 7.6 parts per billion (ppb) NO_2 during the time interval 0-24 hours before birth; 3.8 ppb SO_2 during the time interval 24-48 hours before birth; and 162.5ppb CO during the time interval 24-48 hours before birth. If the mother was exposed to a short term increase in concentration of pollutant above the threshold, there was increased risk of preterm labor. In addition, as the exposure concentration increased past the threshold, the risk of preterm labor also increased.

The study also indicated the possible influence of socioeconomic status (SES), previous birth history, and maternal smoking status on a mother's susceptibility to air pollutants and subsequent risk of preterm labor. The association between concentration of NO_2 and CO and risk of preterm birth was slightly stronger for mothers who had been pregnant before, had multiple births, and had female babies. It is proposed that the experience of having a previous pregnancy or multiple births aggravates the body's response to future air pollution and induces preterm labor. There was also a significant increase in risk of preterm birth in mothers who smoked during pregnancy and mothers who had families living in lower-SES areas.

Conclusion:

The results from this study indicate that maternal exposure to CO, NO_2, and SO_2 above a threshold concentration may lead to preterm labor in a matter of hours.

Policy Implications:

Since the enactment of the Clean Air Act and establishment of the NAAQS, there has been tremendous progress in reducing the concentration of pollutants in the air. From 1970 to 2014, there has been an 85% decrease in national concentration of CO, an 80% decrease in national concentration of SO_2, a 60% decrease in national concentration of NO_2, and a 33% decrease in national concentration of ground-level O_3 in air. From 2000 to 2014, there has been a 36% decrease in concentration of $PM_{2.5}$ and a 30% decrease in concentration of PM_{10} in air.[5]

EPA continues to propose rules that reduce air pollutants and enable states to meet standards. The Agency finalized the Mercury and Air Toxic Standards (MATS) in 2011, and the Court of Appeals for the District of Columbia Circuit issued a ruling in December 2015 that allows EPA to enforce MATS despite the Supreme Court rejection of the rule in June 2015. MATS established strict standards on coal and oil-fired power plants, and is predicted to reduce SO_2 emissions from power plants by 41%.[6] In an effort to reduce emissions from diesel locomotives, EPA introduced a three-part program that will result in locomotive engines built in 2015 or later to have high-efficiency catalytic aftertreatment technology.[7] In addition, EPA introduced the Tier 3 Vehicle Emission and Fuel Standards Program, which will begin in early 2017. This program is setting new standards to reduce both tailpipe and evaporative emissions from cars and light trucks as well as reduce sulfur in gasoline.

However, despite these regulations, more than half of the US population lives in counties where ozone or PM pollution exceeds NAAQS. In addition, air pollution disproportionately affects certain states and communities, placing citizens of these areas at potentially greater

[5] Progress Cleaning the Air and Improving People's Health. Retrieved October 20, 2016 from https://www.epa.gov/clean-air-act-overview/progress-cleaning-air-and-improving-peoples-health#pollution
[6] Cleaner Power Plants. Retrieved October 20, 2016 from https://www.epa.gov/mats/cleaner-power-plants
[7] Locomotives. Retrieved October 20, 2016 from https://www3.epa.gov/otaq/locomotives.htm#info

risk of health effects than others. For example, primarily in the eastern, central, and southern U.S., air pollution produced from one state may drift to a "downwind" state causing pollution levels in the latter to exceed certain NAAQS. In an effort to address this, EPA introduced the Cross-State Air Pollution Rule (CSAPR) in 2011. This rule requires 28 states to reduce their annual SO_2, NO_2, and O_3 emissions so that states "downwind" of these states can be NAAQS compliant.[8]

Communities of lower socioeconomic status and communities of color tend to be disproportionately affected by high levels of air pollution, as many are in highly urban areas near industry or high traffic-density roads. This risk is often compounded by lack of access to adequate health care, poorer job opportunities, and workplaces with potentially higher hazardous exposures, in addition to the prevalence of existing health conditions, behaviors, or traits.[9] As indicated in the study, mothers who had families living in lower SES areas had a significantly greater risk of preterm birth. More needs to be done to address these "hot spots" of elevated pollution levels throughout the country.

Recently, EPA announced the Clean Power Plan (CPP), which plans to cut significant amounts of carbon pollution and pollutants that are emitted from power plants. Although CPP does not target "hot spots", reducing air pollution across the country will help to alleviate the burden on communities that face greater exposure. It is projected that by 2030, sulfur dioxide emissions from power plants will be reduced by 90% and nitrogen dioxide emissions from power plants will be reduced by 72%.[10] The Clean Power Plan will reduce our dependence on fossil fuels and help to advance clean energy innovation; steps necessary to reducing air pollution. Currently, the Clean Power Plan is under review by the U.S. Court of Appeals for the District of Columbia Circuit. A decision will most likely not be reached until the fall of 2017; however, a ruling in favor of upholding the Clean Power Plan would be monumental in curbing air pollution and addressing the negative impacts it has on our health.

Despite the substantial decreases in air pollutant levels achieved since 1970, there is still opportunity to significantly reduce harmful pollutants, and to improve monitoring and equitable enforcement throughout the country. By investing in regulations that reduce pollutants now, we will realize known monetary and health benefits especially with regard to respiratory-related health care costs, and as this study indicates the potential to improve birth outcomes as well. Continued vigilance in protecting and improving our air quality is important in safeguarding children's health.

Article is from Environmental Health Perspectives.

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[8] Cross- State Air Pollution Rule. Retrieved October 20, 2016 from https://www3.epa.gov/airtransport/CSAPR/index.html

[9] http://www.lung.org/assets/documents/healthy-air/state-of-the-air/sota-2016-full.pdf

[10] Clean Power Plan. Retrieved October 20, 2016 from https://www.epa.gov/cleanpowerplan/fact-sheet-overview-clean-power-plan