DOCTORAL THESIS

# Exploring the Associations between Temperature Extremes, Air Pollution, and Preterm Birth in China

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# Abstract

Preterm birth (PTB) is a multifactorial adverse birth outcome influenced by various factors, including genetic, behavioral, socioeconomic, and environmental factors. Both extreme climate events and ambient air pollution have been associated with increased risks of PTB. Weather and meteorology patterns have strong influences on the formation of air pollutants; thus air pollution might interact with extreme temperature in the context of climate change. While individual effects of these factors on adverse birth outcomes are well-documented, studies integrating their joint impacts remain sparse. This thesis addresses this gap by exploring the synergistic effects of extreme temperature and air pollution on preterm birth, focusing on critical exposure windows and vulnerable sub-populations during pregnancy. This comprehensive approach aims to enhance the precision of public health interventions and inform policy adaptations in the face of global climate change.

This thesis investigates the complex interactions between climate extremes, air pollution, and PTB through three main studies. The first study explores the spatial and temporal patterns of co-occurring heatwaves and air pollution extremes across China from 2013 to 2020, revealing an amplified upward trend in their joint occurrences, particularly in urban regions, such as Beijing-Tianjin-Hebei and Yangtze River Delta regions. The analysis suggests a higher compounded public health risk from simultaneous exposures than from individual factors. Using data from the China Birth Cohort Study, the second study focuses on individual-level exposure to air pollution and extreme temperatures during late pregnancy, demonstrating independent associations between these exposures and PTB risk. This study suggests that the third trimester may be critically vulnerable to combined exposures to high levels of $PM_{2.5}$, $NO_2$, $O_3$, and extreme temperatures. Significant risk ratios for preterm birth were observed at these exposure levels, with synergistic effects particularly evident between $PM_{2.5}$ and high temperatures. Given the

severity of climate change and air pollution in urban areas, which are densely populated, addressing these issues in such locales could potentially benefit a larger number of people through more effective health policies. With a specific focus under urban setting, the third study employs a novel individual-level approach to illustrate how localized increases in temperature in urban areas might further complicate the risks associated with preterm births, finding a significant association between UHI exposure and increased PTB risk. Higher risks were notably observed in older women, those with higher pre-pregnancy BMI, and residents in greener, higher socioeconomic status areas.

The findings highlight the compounded dangers of heat and air pollution extremes, which appear to significantly elevate preterm birth risks. Identifying critical exposure windows and particularly vulnerable populations could help tailor preventive strategies more effectively. These insights support for integrated public health policies and interventions that concurrently address the impacts of extreme weather and pollution, which may be essential for mitigating future public health crises stemming from climate change. The evidence from urban heat islands further emphasizes the need for urban planning reforms to enhance maternal health outcomes in increasingly dense urban settings. These findings contribute to our understanding of the complex interplay between environmental exposures and adverse birth outcomes and could have important implications for public health policies aimed at mitigating the impacts of climate change and air pollution on maternal and child health.

**Keywords:** Preterm Birth, Climate Change, Air Pollution, Urban Heat Islands, Extreme Temperatures, Public Health, Vulnerable Populations