

The Effects of Short-Term, Prenatal and Postnatal Lead Exposure on Early Educational Outcomes: Quasi-Experimental Evidence from NASCAR's Deleading Policy

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Abstract

Lead (Pb), is a naturally occurring element, which can be toxic when absorbed by the body through breathing, eating, or drinking. Exposure to any pollutant can have larger negative effects on children than adults, because their bodies are still growing and developing, which puts them at increased risk. Moreover, children have higher exposures to certain pathways due to behavioral patterns (e.g., hand-to-mouth). Lead poisoning can affect nearly every body system; in particular, it can damage a child's central nervous system, kidneys, and reproductive system.

There is a rich and still-growing literature on the effects of early childhood lead exposure on educational outcomes. There is consensus that early childhood lead exposure leads to deficits in cognitive development (Miranda et al. (2007); Reyes (2015)), even at low levels of exposure (Bellinger et al. (1992); Lanphear et al. (2005); Miranda et al. (2007,2011); and Aizer et al. (2018)). Adverse effects from low-level lead exposure on cognitive development have even been shown to persist into later adolescence (Shadbegian et al. (2019)).

The link between early childhood lead exposure and cognitive development is well established, however the *causal* relationship between short-term, prenatal exposure to lead and cognitive development is less well understood. Various longitudinal cohort studies have established a link between prenatal lead exposure and early cognitive development (Bellinger et al. (1987), Schnaas et al. (2006)), though these studies often rely on relatively small cohorts of children.

It has been nearly 30 years since the U.S. EPA required the complete phaseout of leaded fuels in automobile gasoline (1996). The National Association for Stock Car Racing (NASCAR), however, was granted an exemption for the use of leaded racing fuel under the 1990 Clean Air Act Amendments. How much lead emissions does a typical NASCAR race cause? For a single race, 10,000 gallons are consumed during a race which includes practice and qualifying laps (Finney 2006). Leaded gasoline content in racing fuels range from 2 – 6 grams/gallon. At 4 grams/gallon, that suggests that if all of the lead is released, a single race could account for as much as 40kg of lead being emitted. NASCAR events usually involve several races of varying types (stock cars, trucks, etc.) and distances during the same weekend. As a point of comparison, in 2005, the second largest emitter of lead emissions in the United States was a Missouri lead recycling facility, which released an average of 30.82 kg of lead per day.

Our study extends Bui et al. (2022), who exploit NASCAR's voluntary switch to unleaded racing fuel in 2007, by linking individual births around the Charlotte Motor Speedway (CMS) in North Carolina from 2004 to 2010 to their respective 3rd through 8th grade standardized math and reading exam scores. Our research design compares test scores of children born close to (e.g., within 4 km) and far from (e.g., beyond 10 km) the CMS before and after the deleading of NASCAR fuel, which allows us to *causally* estimate the relationship between short-term, prenatal and postnatal exposure to lead and educational outcomes. To minimize the likelihood that other potentially confounding factors will bias our estimates (i.e., our estimated effect of prenatal lead exposure on educational outcomes is systematically incorrect), we include a set of variables that can affect the educational outcomes (e.g., mother's age, education, race; child's gender). To further minimize the likelihood that our estimates are biased, we pre-process our data using a coarsened exact matching (CEM) algorithm prior to undertaking our statistical analyses (Iacus, King & Porro, (2012)). In our context, CEM is designed to match each child in the treatment group (i.e., those living near the CMS) with a child in the control group (i.e., those living far from the CMS), who has the same observable characteristic that could affect educational outcomes. The variables we matched on were: child's race; National Lunch Program Participant; mother's marital status, smoking behavior, and education level during pregnancy; as well as grade-year indicators.

Our research is the first to exclusively investigate the effects of both prenatal and post-natal exposure to lead on school performance. We find that prenatal exposure to lead has an insignificant negative effect on both end-of-grade math and reading scores, whereas post-natal exposure to lead has a significant negative effect on both end-of-grade math and reading scores. Importantly our previous research [Shadbegian et al. (2019)] showed that the negative impact of lead exposure in early childhood on test scores persists through a child's progression from 3rd to 8th grade. This result indicates that physical maturation and additional schooling are not sufficient to offset the damage caused by early childhood exposure to lead. Thus, our results highlight the need to develop effective public health interventions to continue to reduce early childhood exposure to lead.