On the Causal Link between Lead Exposure and Cognitive Capacities

by Carlos Rubio, on February 28th, 2025.

The medical community has professed that any non-zero degree of lead exposure at early ages will cause a decrease in brain volume as well as intellectual and cognitive capacities. Because of the nature of the topic, there are no randomized studies on the impact of lead on cognitive capacities, which makes it hard to determine the validity of such claim. Even so, literature of observational studies on the topic is large and varied, which makes it a good candidate to test Rosembaun's causal inference model of multiple strands.

Study in Cincinnati

One of the studies I've analyzed, published on May 27, 2008 and titled "Decreased Brain Volume in Adults with Childhood Lead Exposure" (Cecil et al.), recruited a sample of children $n = 157$ through the Cincinnati Lead Study, "an urban, inner-city cohort with detailed prenatal and postnatal histories of low to moderate lead exposure and behavioral outcomes monitored over 25 y[ears]." The histories included childhood lead blood concentrations[1], MRI brain scans to asses gray and white matter, demographics[2], maternal data[3], as well as other neuropsychological markers.[4]

The study observed

1. a positive linear association between gray matter volume and neuropsychological factor scores for both sex,
2. a significant, negative linear relationship in males between gray matter volume development in prefrontal cortex and other wares, and childhood lead exposure,
3. no significant results in females.

While the study collected and aggregated over an impressive amount of data, the cohort nature (everyone lived near Cincinnati), as well as the unknown nature of the assigment mechanism (how exactly were the kids exposed to lead) supposes the main barriers to conclude about the causal relationship between lead and congition.

Study in Boston

If we were to follow Rosenbaum's counsel of looking for complementary strands of evidence in order to infer causality, we must look into other cohort studies performed in other geographical locations. Such is the case with a study performed in Boston published on 2011 titled "Low-level environmental lead exposure in childhood and adult intellectual function: a follow-up study". Similar to the Cincinnati study, a cohort of 249 children born in Boston between 1979 and 1981. From that cohort, only $n = 43$ adults were neuropsychologicaly tested. Data collected includes blood lead concentration[5], IQ measurements[6], demographics, personal and materal history.

The results were similarly to those of Cincinnati: high blood lead concentrations at different stages negatively linearly associated with all IQ markers. The study didn't find (or failed to note, which is

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[1] Measured every 5 months until age of 5, and less frequently for older ages.
[2] Includes age, sex and socioeconomic status
[3] Includes maternal IQ, gestational age and substaces use.
[4] Includes motor control, IQ, learning, memory, attention and visuoconstruction skills.
[5] measured at birth, 6 months, 1, 2, 4 and 10 years.
[6] including Full-Scale, Verbal an Performance.

unlikely) any variation of significance across sex, a piece of evidence that complements the Cincinnati study. The study also has it's deficiencies: it was noted that both the coefficient of the relation as well as its significance changed. The study concluded that while most of the results were significant, the magnitude of the sample size, as well as the unpredicted variations of the coefficient when conditioned upon maternal IQ could deem the results inconclusive. But the fact that this results matched closely with those of Cincinnati give us a hint that the causality might be more sound than apparent by the individual results. Even so, one might find the results of this combination unsatisfactory to determine causality. A third, more robust study, would prove to be the answer.

One study to bind them all

The last study to consider, published on March, 2005 with the title "Low-Level Environmental Lead Exposure and Children's Intellctual Function: An International Pooled Analysis", was undergone by a consortium of different organizations and researchers across the globe, which included and pooled data from Boston, Cincinnati, Cleveland, Ohio, Mexico City, Australia, Rochester and Yugoslavia. The variables collected in these location were similar to the ones in studies described before.

The study return similar results: negative association between different IQ measures and blood lead concentrations during childhood. It was also found that the covariates (including those extracted from maternal history) "contributed very little to the overall fit of the model of the model, and their inclussion in the model resulted in virtually no change to the coefficient for blood lead", with none of them being statistically significant. The sensitivity of the study was assesed by comparing both random-effects and fixed-effects versions of the models, which had similar results. Even more, the models were fitted in 7-combinations and compared, still yielding similar results.

Conclusion

The results across this three different studies, performed with slightly different sets, yielded very similar results. Which lead us to believe that there is an effective negative linear cause and effect between the blood lead concentration during childhood and IQ, as well as other markers for cognitive capabilities.