A conversation with Professor David Bellinger, September 13, 2017

Participants

- Professor David Bellinger – Professor, Department of Neurology, Harvard Medical School, Department of Environmental Health, Harvard T.H. Chan School of Public Health
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Note: These notes were compiled by GiveWell and give an overview of the major points made by Professor David Bellinger.

Summary

GiveWell spoke with Professor David Bellinger of Harvard T.H. Chan School of Public Health (HSPH) as part of its investigation into lead exposure. Conversation topics included the scope of lead issues, sources of lead exposure, effects of exposure, impacts of interventions, strategies to address lead, and organizations and people working on lead reduction.

Scope of lead issues

The World Health Organization (WHO) has estimated that 10% of children globally have a blood lead level (BLL) above 20 micrograms of lead per deciliter of blood (µg/dL)—which exceeds safe levels. 99% of these children are located in developing countries.

More specific data on the average BLLs of children across Africa—for example—is not readily available. Significant lead exposure data is available from South Africa and to a lesser extent Egypt and Tanzania. However, during Professor Bellinger's work with the WHO, he has found it difficult to determine the scope of lead exposure in many African nations. This may make it difficult to estimate the potential impact of various lead reduction interventions in Africa.

Sources of exposure to lead

Lead poses a significant risk because it is pervasive in the environment—a result of unrestricted use over thousands of years. Children may be exposed to lead through a variety of pathways, including:

- **Air**
- **Water**
- **Soil**
- **Paint**
- **Consumer products**
- **Food** – Professor Bellinger was on a WHO committee that analyzed the health impacts of lead in food—although little data was available for most countries.

- **Gold** – In Nigeria, the mining of gold that incidentally contained lead resulted in over 400 child deaths.
- **Dust –** Much academic literature emphasizes lead in dust as the main pathway responsible for increasing children's BLLs—except in clinical cases of lead poisoning. However, lead is not inherent to dust. It is incorporated through other pathways.

Relative importance of different pathways

Although the types of pathways are well understood, the relative importance of pathways varies from site to site. Epidemiological studies, rather than studies of specific interventions, have helped demonstrate each pathway's contribution to increased BLLs. For a given site, studies have been able to roughly estimate what percentage of lead in blood is attributable to different pathways.

It is difficult, however, to estimate which pathways are most important. Targeting specific pathways only addresses a portion of the problem. For example, even though soil lead levels correlate strongly with BLLs, reducing lead in soil may not always significantly reduce BLLs. The impact of reducing lead in soil, paint, or any other source of exposure would depend on the different pathways a child is subjected to as well as each pathway's relative importance. For this reason, interpreting the results and determining the potential benefits of lead reduction interventions can be difficult.

Effects of lead exposure

Health issues that cannot demonstrate strong short-term impacts—such as lead exposure—may not receive the attention they merit. However, lead can have serious effects on children over longer periods of time.

Reduction in IQ

When the available evidence is pooled, it indicates a clear loss of IQ points in young children as a result of increased BLLs. A team led by Bruce Lanphear—a scientist at Simon Fraser University—developed one of the most reliable estimates of the IQ–BLL relationship by pooling data from seven prospective studies across the world. The studies collected data on children's BLLs, beginning in some studies during gestation, and IQ between the ages of four and ten. The pooled data suggested a curvilinear relationship between BLL and IQ. The highest loss of IQ points for each additional μg/dL occurred at the 0-10 μg/dL range—with marginally lower IQ loss as BLLs increased above 10 μg/dL. Children with BLLs of 30 μg/dL experienced an average loss in IQ of six points.

The effect that lead exposure has on IQ may vary across different countries, but IQ loss appears to be the outcome that is most consistently observed. In terms of IQ points lost within the US child population, lead may be more important than a variety of other health issues—including congenital heart disease, traumatic brain injury, attention deficit hyperactivity disorder (ADHD), and iron deficiency. Various economists have monetized IQ points, which can help determine the economic impact of lead exposure. The WHO's Global Burden of Disease analysis, however, only registers the impact of lead exposure when increased BLLs cause IQ to reduce below 70.

Other cognitive impacts

Focusing solely on IQ may ignore other significant consequences that lead exposure has for the brain. For example, high BLLs can negatively impact executive brain functioning—including the ability to anticipate consequences, inhibit impulses, delay gratification, and make long-term plans. Lead exposure can also increase a child's risk of developing ADHD. These various effects that lead has on the brain may be as important as IQ to a child's life outcome, but they are also more difficult to express in monetary units.

Increased risk of developing social pathologies

Environmental economist Rick Nevin modeled the relationship between production of lead and the rates of various social pathologies over time at the population level, finding a significant association. These models are intriguing but should be interpreted cautiously, as a variety of confounding variables could be influencing the relationship. There is, however, substantial evidence suggesting that lead exposure to individuals in childhood can increase the risk of committing crimes in early adulthood.

Severe lead poisoning and death through lead-based paint

Lead can sometimes cause clinical toxicity or death—most frequently (in the US) through exposure to lead-based paint. Since the concentration of lead in paint can be very high—sometimes reaching 50% by weight—a child eating lead paint chips could be subject to extremely unsafe levels of lead in a short period of time.

Determining more definitively what percentage of lead poisoning is due to lead-based paint may be a challenge. Potentially, researchers could conduct a nationally representative survey of how many homes have lead paint and then compare the BLLs of children living in homes with and without lead paint. However, lead paint tends to be concentrated in inner city homes, where various sociodemographic factors may also have an influence on BLLs. The study would have to ensure that children in treatment and control groups are both exposed to the same non-paint sources of lead.

Addressing lead-based paint

Many countries rarely used lead paint in homes due to the high cost. Numerous others banned lead in paint after the White Lead (Painting) Convention in 1921. The most pertinent need now is to address the lead-based paint that currently exists in homes. In the US, an estimated 20 million homes still have some lead paint—although it would be costly, at least in the short term, to completely remove this paint.

Impacts of lead reduction interventions

The trends of population BLLs over time provide evidence that lead reduction interventions have been effective at reducing BLLs. In the late 1970s, a nationally representative survey of the US population indicated an average BLL of 15 μg/dL. 90% of preschool children in the US had a BLL above 10 μg/dL. Since that time, lead exposure has been addressed in many ways—including but not limited to banning lead from gasoline, prohibiting the use of lead solder in cans, reducing lead in the air by regulating industrial emissions, and restricting the use of lead in consumer products. After more than 30 years, the average BLL in the US is now below 1 μg/dL. The WHO estimates that eliminating lead from fuel alone can reduce a country's average BLL by 5-7% per year for the first five years.

Various researchers have tried to estimate the increase in IQ related to the lead reduction interventions from the past four decades—with one recently published paper suggesting an IQ increase of three to five points in adult IQ.

Long-term vs. short-term impacts

The potential long-term impacts of lead reduction interventions are particularly compelling. For example, although removing lead-based paint from homes can be beneficial for current children living there, there may be a much stronger cumulative impact for all the future generations of inhabitants.

Complications with lead in tissue

One aspect of lead exposure that complicates interventions is that lead is mostly stored in hard and soft tissues rather than blood. Even though interventions may reduce BLLs in the short-term, the accumulated lead that has been stored in tissues will eventually reincorporate back into the blood. This can make the results of intervention research very difficult to interpret, as an intervention might appear to be ineffective in reducing BLL if the participants consist of individuals with substantial past exposure, or an immediate reduction in BLLs might not be sustained due to the requilibration of lead in the different body pools.

Around 20 years ago, the US Environmental Protection Agency (EPA) funded intervention research to determine whether or not removing lead-contaminated soil near the homes of children at risk of lead poisoning would reduce their BLLs. The results found little impact because children had already accumulated so much lead in their tissues.

A similar study identified children with high BLLs (20-30 μg/dL) and placed them into a case management program where they received education on lead exposure and the importance of handwashing. Parents were also informed about different sources of exposure inside the home. Due to the storage of lead in tissues, it took around two to three years before most children's BLLs reduced below 10 μg/dL—even though the half-life of lead in blood is around one month. In many cases where children had a starting BLL of 30 μg/dL, it took four years to reduce below 10.

Strategies to address lead exposure

Comprehensive and long-term interventions

Interventions that comprehensively address the entire array of lead exposure pathways may be more effective. Expectations or goals for interventions should also be long-term, as any potential impacts may take years to manifest.

Research to expand knowledge on lead issues

The first step in addressing lead exposure is for a country to know the scale and sources of its lead issues. This could be achieved through nationally representative or targeted sampling. From this information, solutions specific to the local context can be created.

The dangers of a lack of knowledge are made clear by the Nigerian lead poisoning incident. In that case, local pediatricians did not have the expertise to determine that the illness and deaths among their children were related to the lead present in gold that was being mined. Children were not diagnosed and treated until a team from Médecins Sans Frontières (MSF) discovered the village and was told about the child deaths. Workers from the WHO and the Centers for Disease Control and Prevention (CDC) later came to the village to train local doctors on lead exposure.

Organizations and people working on lead reduction

Organizations

The WHO leads a partnership called the Global Alliance to Eliminate Lead Paint. GiveWell may find it useful to examine the partnership's initiatives, which may include systematic reviews of evidence on lead exposure and reduction.

Pure Earth, formerly known as the Blacksmith Institute, works in developing countries on environmental issues including lead.

Professor Bellinger knows of various informal groups comprised of public health professionals that are concerned with lead exposure.

People to talk to

- **David Jacobs** is one of the foremost experts on lead in paint.
- **Joanna Tempowski** is coordinating a WHO group (on which Professor Bellinger is a chairman) that is developing guidelines for the prevention and treatment of lead poisoning. She likely has extensive knowledge on the global context for lead, as the group has conducted systematic reviews of various lead interventions.
- **Bruce Lanphear**, as mentioned previously, is a scientist and policy advocate from Simon Fraser University. He has conducted several RCTs that examine the impact of dust control.

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