A conversation with Jenna Forsyth, May 28, 2021

Participants

- Jenna Forsyth – Postdoctoral Fellow, Woods Institute for the Environment, Stanford University
- James Snowden – Program Officer, GiveWell

Note: These notes were compiled by GiveWell and give an overview of the major points made by Ms. Forsyth.

Summary

GiveWell spoke with Ms. Forsyth of Stanford University about her work to reduce lead adulteration in spices in Bangladesh. Conversation topics included a description of the intervention carried out by Ms. Forsyth's research team in Bangladesh, the estimated effect of the intervention on blood lead levels, lead isotope studies, risks of the before-and-after study model, and the contribution of paint to lead exposure.

The intervention

Background

- In Bangladesh, lead chromate is sometimes added to turmeric in order to brighten its color. This is added at the polishing stage, during which the turmeric roots are tumbled in a machine to remove their outer layers and lend the turmeric a brighter color.
- An initial study by Ms. Forsyth's research team at Stanford found that, of the nine major turmeric-producing districts in Bangladesh, one or two had especially high levels of lead chromate adulteration.

Geographic distribution

- Turmeric production and processing in Bangladesh is not centered in a single area. According to the country's Department of Agriculture, 50% of turmeric production takes place in nine districts.
- Much of the turmeric produced in these districts is shipped to Dhaka, the capital and largest city, then redistributed.
    - Turmeric-producing districts generally reserve some turmeric for local consumption and ship the rest to cities.
    - Rural populations are likely to consume turmeric locally produced in their district or a nearby district, while areas closer to Dhaka are more likely to consume turmeric from the capital wholesale markets.
    - A lot of turmeric is also shipped by boat to places like Barishal, a difficult-to-reach area in southwest Bangladesh.
- The Stanford research team visited both these nine districts and two non-turmeric-producing districts, including Dhaka and a neighboring district, Munshiganj. The non-turmeric-producing districts were included because consumer demand differs in these areas.

- Demand for the brighter turmeric resulting from lead adulteration tends to be higher in non-turmeric-producing areas. Residents of turmeric-producing districts tend to be more knowledgeable about genuine signifiers of turmeric quality, so lead adulteration is slightly less prevalent in these districts.
- Demand for brighter and more highly processed turmeric is also higher in major cities.

Components of the intervention

- The intervention took a three-pronged approach:
    - Nationwide, revisiting the major turmeric processors whose products had high levels of lead chromate and educating them on the dangers of lead. Most processors knew that lead was unsafe, but did not know the extent of the danger and continued to feed lead-adulterated spices to their children.
    - In Dhaka, working with the national Food Safety Authority on developing better monitoring and enforcement.
        - The Stanford researchers did some of the monitoring themselves at the major wholesale markets in Dhaka where turmeric shipments are aggregated.
        - The Food Safety Authority also issued warnings and large fines to wholesalers selling lead-adulterated turmeric roots.
    - In Dhaka, awareness-raising and promoting behavior change among wholesalers/distributors and consumers.
        - The research team worked with media on news stories that drew on the research team's findings, which emphasized both that lead in turmeric is widespread across the country and that lead in turmeric is linked to blood lead levels (as shown by an isotope study). Food adulteration currently gets a lot of attention in Bangladesh. The research team wanted the focus of the media to be on concrete evidence and solutions.
        - The research team also worked with the Food Safety Authority to distribute flyers to encourage consumers to buy either unpolished turmeric roots or packaged, branded turmeric (both of which tend to contain much less lead), and warn sellers of fines.

Monitoring

- The research team monitored the effectiveness of the intervention by returning to evaluate the turmeric at the main aggregator market in Dhaka and satellite markets, and revisiting turmeric polishers.
- There are three ways to tell whether lead chromate has been added to turmeric:

    - Measuring the lead and chromium concentrations in the soil, and identifying whether lead chromate has been used there based on the ratio of the two elements.
    - Looking for lead chromate dust inside the polishing machines.
    - Looking at the turmeric itself.
- Using these methods, the research team was able to tell the degree of lead adulteration in the turmeric at the markets and at the polishing mills.

Effect on blood lead levels

- The Stanford research team has access to blood samples from a cohort in the northern region of Bangladesh (Mymensingh, Kishoreganj, and Tangail districts), allowing them to do before-and-after testing of blood lead levels. In other regions, the researchers know there are high levels of lead adulteration, but do not have access to blood samples.
- How much this intervention could contribute to a reduction in blood lead levels is uncertain. Ms. Forsyth has modeled a reduction of roughly 2 micrograms/deciliter (µg/dl) from the intervention and guesses the real effect is between 1 and 3 µg/dl.
- There are a number of factors to consider in estimating the effect:
    - Bioaccessibility, meaning how much of the lead is absorbed by the body. Lead chromate is traditionally thought to be less bioaccessible than the lead oxides used in lead acid batteries. However, the Stanford research team has conducted lab experiments that show the lead chromate used in turmeric (which is often composed of other lead compounds like lead carbonates) is more bioaccessible than would generally be estimated.
    - How much turmeric is consumed.
    - How often the turmeric is replaced
    - General sourcing patterns (e.g., if a person always purchases turmeric from the same individual who sources from a polisher who always adulterates).
    - General nutritional status (e.g., a person deficient in iron or calcium might absorb more lead, so the contribution of the intervention to their blood lead levels might be greater).

Geographic differences in effect

- Ms. Forsyth believes the intervention had a national impact, because follow-up visits to polishers revealed reductions in lead adulteration at all polishers.
- However, Ms. Forsyth would expect a greater effect in Dhaka, because the research team found higher levels of lead in turmeric there, and a lower effect in rural turmeric-producing districts in the north, such as Mymensingh, Tangail, and Kishoreganj. Again, this is because there is more demand for highly processed, adulterated turmeric in non-turmeric-producing districts.

- Because of this disparity, the before-and-after estimates of blood lead levels might slightly underestimate the intervention's effect in these three rural districts, and overestimate the effect in Dhaka. However, the research team did not collect baseline blood lead levels in Dhaka, and does not have a cohort there from which it can access blood samples, so currently there is no way to quantify the effect in Dhaka.

Incorporating Munshiganj data into effect estimate

- Adding data on blood lead levels in the Munshiganj district, which is the non-turmeric-producing district close to Dhaka, might allow for a better estimate of the overall impact.
    - The Stanford team did not collect baseline blood samples in Munshiganj, but another team from Harvard collected blood samples there in 2014. That team found that the prevalence of elevated blood lead levels in children in Munshiganj was about double what it was in the three northern districts.
    - Ms. Forsyth believes that the intervention's impact would thus be slightly overestimated in Munshiganj, as in Dhaka; this could counterbalance an underestimated impact in the northern districts.
    - The cohort in Munshiganj is 180 children. Its relatively small size and proximity to Dhaka mean that adding analysis of these blood samples would add about $75,000-$100,000 to a potential grant budget.
    - If there isn't room in the budget, the Kathgora site could be swapped in instead.

Risks of before-and-after study

- Because the intervention was implemented nationwide, it was not feasible to use a control group, so the study was structured as a before-and-after, in which blood lead levels and presence of lead chromate in turmeric are measured before and after the intervention.
- If the source of lead exposure did not remain consistent between measurements, this leaves open the possibility of confounders, potentially including:
    - Seasonality. In Bangladesh, the amount of lead chromate added to turmeric varies by season. It will be important to keep the season of measurement consistent before and after the intervention, if possible.
        - The research team measured the addition of lead chromate a few months after the intervention and then one year later, and found large decreases that lasted over the course of two harvest years, so this should not be a great concern.
        - Season matters particularly if the primary path of exposure is through soil. During times of year when children are more likely to play outside, or when it's dustier, children are more

likely to ingest soil and its contaminants. If the primary exposure is through food, seasonality is less likely to be a factor.

- Changes in nutritional status. Recruiting participants of similar age and socioeconomic status can help to reduce variation from changing nutritional status in the area. Data on nutrition indicators, e.g., how anemia rates have changed between baseline (2014) and today, can also be obtained from UNICEF and other organizations.
- Changes in industry, especially in areas where lead acid battery recycling is common. There is little such industry in the northern region, but there is lead acid battery recycling in Munshiganj, and the evolution of that activity could be a factor.

Lead isotope study

- The Stanford research team conducted a study that correlated the lead isotopes in blood samples in some of the districts they visited with lead isotopes in the turmeric. This supported the conclusion that lead-adulterated turmeric was a significant contributor to blood lead levels.
- However, isotope studies on their own may not provide enough information to draw conclusions.
    - Lead chromate is also added to yellow craft and artistic paint, so it is possible that the matching lead isotopes in the blood samples resulted from paint exposure instead of turmeric.
    - The lead isotope should not vary much within the body and should remain similar to the isotopes in the source of the lead, but the origins of the sources are the same for lead in paint and lead in turmeric.
- The research team felt more confident in the results of the isotope study because it was paired with a case-control study and environmental sampling effort.
    - The cohort responded to a questionnaire to identify potential sources of lead exposure, out of a list of sources drawn from the literature. Exposure modeling implicated several sources, from food to agrochemicals. Upon further environmental sampling and lead concentration analyses, Ms. Forsyth and colleagues were able to eliminate agrochemicals and rice as ongoing sources of human exposure because physical sampling demonstrated that they did not contain detectable lead.
    - The research team also got to know the communities well enough to understand that they were likely not using lead paint.
    - Of all the potential sources of exposure for the cohort, turmeric had high lead levels and was the only one that they were eating on a daily basis.

Contribution of lead paint to blood lead levels

- Ms. Forsyth has had some experience investigating lead paint in Bangladesh. She believes there is not enough evidence to draw a clear conclusion about how much lead paint contributes to exposure in low- and middle-income countries (LMICs); however, it likely contributes less than it used to.
- It is important to sample the kind of paint most commonly used by that population. E.g., looking only at packaged products is of limited use, especially if consumers are buying loose pigments in informal markets and mixing them.
- The Stanford research team initially believed lead paint would be one of the focal sources in Bangladesh (along with battery recycling and turmeric), but concluded it was likely not a major contributor.
    - The house paint most likely to contribute to lead exposure is paint on hinges of windows and doors, which chips off more frequently. It seems unlikely that people would be accidentally consuming enough of this paint for it to have a large effect.
    - Rural populations do sometimes use decorative paints, and leaded decorative paint is used around the world; however, the lead exposure from these paints is probably limited because it's most often used on items that aren't frequently touched.

Extrapolating from US history of lead paint

- It has been suggested that lead paint was frequently used to paint walls in the United States in the 1940s, and that present-day LMICs might have comparable levels of exposure from leaded wall paint. Some evidence from a meta-analysis indicates that living in a lead-painted house could contribute 1 to 3 μg/dl to blood lead levels.
- Ms. Forsyth's team tested a narrow sample of wall paint on the market in Bangladesh, and the Bangladeshi government's Environmental and Social Development Organization has also produced a report on this. It is not clear that the effect of leaded wall paint in Bangladesh today can be compared to the use of leaded wall paint in 1940s US.
    - Ms. Forsyth's impression is that wall paint in Bangladesh today contains less lead than paint in 1940s US, although there may not be enough evidence on the latter.
    - In Bangladesh, and possibly other LMICs, the fraction of dwellings that are painted in a way that is likely to result in lots of chipped paint may also be lower.
    - Rural populations in Bangladesh do not paint their homes much. In urban settings homes are more often painted, but the fraction of paints that contain lead seems to be lower than in 1940s US.
    - Both the prevalence of lead exposure from paint and the total maximum lead exposure are thus probably lower in present-day Bangladesh.

- However, blood lead levels are higher in urban places than in rural, which could indicate some impact from lead paint, in addition to exposure from industry and other sources.

Upcoming Stanford study in Dhaka

- The Stanford team has funding to conduct a cohort-based study to better understand prevalence of elevated blood lead levels and the major sources of exposure in Dhaka.
- The team has proposed isotope studies to help them understand the attributable fraction of each different source. Combined with wall paint samples from multiple sites and an exposure questionnaire, this could help answer the question of how much exposure comes from wall paint, especially because the lead in these pigments is likely not lead chromate (yellow-painted walls are not common).

Durability of intervention's effect and how to improve it

- The intervention was relatively easy, requiring minimal financial and human-resource inputs.
- Public awareness of a toxic substance being added to food can be a powerful force, though its impact may vary by location.
    - Ms. Forsyth believes increased awareness among consumers, wholesalers, and polishers had an effect on blood lead levels. The research team measured blood lead levels at a polishing mill that had been using a lot of lead chromate, and found a decrease after the intervention. Among polishers, the effect is slightly different because the lead at the mills is inhaled instead of eaten.
    - One challenge in LMICs is frequent turnover in government roles and loss of institutional knowledge. E.g., in Bangladesh, a woman at the Food Safety Authority who had helped spearhead the research team's consumer awareness efforts is no longer in that position.
    - Frequent, inexpensive repetition of consumer awareness campaigns in some form may be necessary.
- Occasional monitoring and levying of fines by the Food Safety Authority could also be effective.
- The research team has also done some work with the government agricultural institute to look at the origins of lower-quality turmeric roots and improve the drying and polishing processes.
- However, the rapid decrease in blood lead levels, plus the fact that lead chromate is still on the market, poses a risk that blood lead levels will increase again.

Other uses for lead chromate

- In Bangladesh, lead chromate is also used for furniture glazing and in the plastics industry. The risk from furniture glazed with lead chromate is likely

more of an occupational hazard to the worker and less of a risk to the consumer. The risk of exposure from plastics is likely low.
- The Stanford research team explored the possibility that lead chromate was also used in colored rice chips, but eventually ruled this out.

Potential for bans

- Lead chromate is difficult to make and is generally imported into Bangladesh from India and China.
- A ban on lead chromate would be helpful, but might require a stronger regulatory state than Bangladesh.
    - The prime minister's office has said that it will restrict the use of lead chromate, but currently it's possible to buy lead chromate and other toxic pigments at a market next door to a food market.
    - In higher-income countries, these substances are restricted, but lead chromate is hard to restrict in LMICs because it's very inexpensive.
    - Pursuing better regulation in China or India might make more sense than trying to regulate lead chromate in a small country like Bangladesh. China may be a more feasible target for regulation than India.

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