The Intercept_

Poison Fruit

Dow Chemical Wants Farmers to Keep Using a Pesticide Linked to Autism and ADHD

Photo: David Paul Morris/Bloomberg News/Getty Images

Sharon Lerner
January 14 2017

ON MONDAYS, MAGDA and Amilcar Galindo take their daughter Eva to self-defense class. Eva is 12 but her trusting smile and arching pigtails make her look younger. Diagnosed with autism and attention deficit hyperactivity disorder, or ADHD, Eva doesn't learn or behave like the typical 12-year-old. She struggles to make change, and she needs help with reading and social situations.

Eva's classmates are sometimes unkind to her, and Magda worries for her daughter's feelings and her safety. So once a week, after they drive her from her middle school in Modesto, California, to her tutor in nearby Riverbank, the Galindos rush off to the gym where they cheer Eva on as she wrestles with a heavy bag and punches the air with her skinny arms.

The Galindos wish they could have protected their daughter from whatever originally caused her troubles, which began in infancy,

when she screamed incessantly. As she got older, Eva was slow to talk and make friends. Nine years ago, when her pediatrician diagnosed her with autism, he told the Galindos that nobody really knew why children developed such problems. And in some ways, that is still true; both the causes of these neurodevelopmental conditions and their increase among American children remain mysterious.

But a study the family participated in when Eva was 3 has pointed to one possible culprit: chlorpyrifos, a widely used pesticide that was sprayed near their home when Magda was pregnant. At the time, the family was living in Salida, a small town in central California surrounded by fields of almonds, corn, and peaches. The Galindos could see the planted fields just down the street from their stucco house. And Magda could smell them from the patio where she spent much of her pregnancy. Sometimes the distinct essence of cow manure filled the air. At other times she sniffed the must of fertilizer. And there was a third odor, too — "the smell of the chemical," said Galindo. "You can tell, it's different from mulch and manure. When they sprayed, the smell was different."

In 2014, the first and most comprehensive look at the environmental causes of autism and developmental delay, known as the CHARGE study, found that the nearby application of agricultural pesticides greatly increases the risk of autism. Women who lived less than a mile from fields where chlorpyrifos was sprayed during their second trimesters of pregnancy, as Magda did, had their chances of giving birth to an autistic child more than triple.

And it was just one of dozens of recent studies that have linked even small amounts of fetal chlorpyrifos exposure to neurodevelopmental problems, including ADHD, intelligence deficits, and learning difficulties.

On November 10, the U.S. Environmental Protection Agency issued a groundbreaking report laying out the serious dangers of chlorpyrifos. The "Chlorpyrifos Revised Human Health Risk Assessment," as it was called, laid out the evidence that the pesticide can cause intelligence deficits and attention, memory, and motor problems in children. According to the report, 1- and 2-year-old children risk exposures from food alone that are 14,000 percent above the level the agency now thinks is safe.

Dow, the giant chemical company that patented chlorpyrifos and still makes most of the products containing it, has consistently disputed the mounting scientific evidence that its blockbuster chemical harms children. But the government report made it clear that the EPA now accepts the independent science showing that the pesticide used to grow so much of our food is unsafe. The "pre-publication copy" of the report stated that "residues of chlorpyrifos on most individual food crops exceed the 'reasonable certainty of no harm' safety standard under the Federal Food, Drug and Cosmetic Act," which means, in simple terms, that any given sample of food may contain harmful levels of chlorpyrifos. In addition, estimated drinking water and non-drinking water exposures to the chemical also exceed safety standards. The next step was to finalize a chlorpyrifos ban.

Public health advocates have been calling on the EPA to ban the pesticide for years. Four months before the report came out, a group of 47 scientists and doctors with expertise in children's brain development, including the director of the National Institute of Environmental Health Sciences, issued a grave warning that toxic chemicals in the environment were increasing children's risks of developing behavioral, cognitive, and social disorders and contributing to the rise in cases of autism and ADHD. The TENDR statement, as it was called, included a list of the worst neurotoxins and amounted to a desperate plea for immediate action. Organophosphate pesticides, the class of chemical to which chlorpyrifos belongs, was at the top of the list.

Yet when the EPA's report was published indicating that the agency was finally taking action on chlorpyrifos, there was little rejoicing among the scientists and environmental advocates, because two days earlier, Donald Trump had won the presidential election.

Although the new risk assessment was the missing puzzle piece necessary to get chlorpyrifos out of the food chain and water supply, the law requires a 60-day comment period before such a decision can be finalized. Trump will be inaugurated three days after the comment period ends on January 17. The final deadline to incorporate the comments on the report is March 31, 2017, giving the new administration almost two months to derail the long-awaited regulation.

CHLORPYRIFOS IS THE "Coca-Cola of growers," as one former staffer of California's Office of Pesticides described it to me. "Everyone uses it out here."

Across the country, some 44,000 American farms collectively use between 6 million and 10 million pounds of chlorpyrifos each year on everything from corn, soybeans, asparagus, and peaches to strawberries, broccoli, cauliflower, onions, walnuts, and cranberries. Used on more than half of all apples and broccoli sold in the U.S., chlorpyrifos makes its way into the vast majority of American kitchens. The chemical has also been found in 15 percent of water samples taken around the country between 1991 and 2012 by the U.S. Geological Survey's National Water Quality Assessment Program.

Several farmers I spoke with at a Dow-sponsored citrus growers convention in Exeter, California, explained that they used Lorsban, one of Dow's chlorpyrifos-containing products, because it is one of the most reliable and affordable products available to kill ants. The growers were also clearly hoping the pesticide, which kills some 400 different species, would help combat the Asian citrus psyllid, a sap-sucking bug that has been killing fruit trees around the country.

It's a testament to both the deference the government has shown large companies and the lack of foresight about the consequences of spraying our food with toxic chemicals that the pesticide could become such a widely used tool. After all, there has never been much doubt that organophosphates harm people. German chemist Gerhard Schrader first documented the effects of the chemicals on the human nervous system while trying to develop pesticides to protect food for the Nazi war effort.

As Schrader noted in 1936 after he and a colleague were severely sickened by a mere drop of organophosphate that landed on a lab bench near them, people who were exposed choked, shook, vomited, and sweated. Because exposure sometimes led to seizures, comas, and death, the discovery spawned the use of organophosphates as weapons and Schrader spent much of the war producing one of these first nerve agents, Tabun, at a secret Nazi lab.

More than two decades later, the environmental writer Rachel Carson described the effects of organophosphate pesticides, or organic phosphorus insecticides, as she called them, in terms eerily similar to Schrader's in her 1962 bestseller, "Silent Spring": "Their target is the nervous system, whether the victim is an insect or a warm-blooded animal. … The movements of the whole body become uncoordinated: tremors, muscular spasms, convulsions, and death quickly result."

Even back then, the organophosphate pesticides that were supposed to focus their lethal power on cockroaches, ticks, ants, and termites were clearly triggering some of the same reactions in humans.

Chlorpyrifos — and for that matter the nerve agents Sarin and Tabun — work by blocking cholinesterase, an enzyme that breaks down the neurotransmitter acetylcholine. When cholinesterase doesn't function correctly, the nervous system can go into overdrive, as nerves fire repeatedly without being shut off. Thus, between being sprayed with organophosphates and dying, cockroaches become hyperactive, hyperexcitable, and convulse. And, as Carson delicately described back in 1962, "honeybees become wildly agitated and bellicose."

Though it was introduced to the market in 1965, the use of chlorpyrifos in farming only began to take off in the 1980s after another group of chemicals was phased out because of the health problems they caused. Carson, who died of cancer at age 56, just 18 months after the publication of "Silent Spring," would no doubt have been dismayed to know that the banning of DDT, for which she is often credited, gave rise to the widespread use of organophosphates, such as chlorpyrifos. Back in 1962, she already saw the folly of swapping one neurotoxic chemical for another and noted that DDT was itself a replacement for the pesticide lead arsenate, which was abandoned because it too had caused health problems.

As the use of the pesticide rose, so did concerns about it. In 1988, Congress asked the National Academy of Sciences to look into whether pesticides in children's diets might be dangerous. The resulting report described a range of harms that pesticides can cause and noted that organophosphates have "subtle and long-lasting neurobehavioral impairments" in animals. When he was presenting the report to Congress in 1993, epidemiologist Philip Landrigan, who led the committee, warned that children were particularly vulnerable and called on Congress to apply more stringent pesticide standards.

THE SHORTER-TERM DANGERS of the chemical were already apparent by 1996, when the annual number of chlorpyrifos poisonings, which can cause twitching, tremors, slurred speech, and even paralysis and death, reported to Poison Control Centers in the U.S. reached 7,000.

It was also becoming clear that children were particularly sensitive to the pesticide, which was available in many household products used to kill cockroaches, termites, fleas, and other bugs.

Vicki Herb learned that soon after she brought her infant son, Joshua, to her West Virginia home from the hospital. Joshua Herb had been born healthy in 1990. But days later an exterminator came for a regularly scheduled visit and, not noticing Joshua asleep in his crib, sprayed chlorpyrifos on a nearby windowsill while the baby was napping. Within days, Joshua became partially paralyzed. Though the doctors who first saw him were dismissive of the idea, Vicki Herb believed her son had been poisoned by pesticides and in 1992 hired attorney Stuart Calwell to sue Dow. Since then the evidence of its dangers — particularly to children — have been mounting.

The Herbs' case, along with several others that Calwell brought against Dow, did more than reveal how powerfully chlorpyrifos could affect children. It also brought to light how hard the company would work to protect its lucrative pesticide. It soon became clear that Dow's strategy was to protect the public image of chlorpyrifos, heavily promoting the most positive view of its chemical and attacking research to the contrary.

During the discovery process of the Herb case, Calwell asked Dow's lawyers to provide reports of adverse incidents tied to the chemical, which companies are required by law to file with the Environmental Protection Agency. Dow's attorneys told him to get the reports directly from the EPA, according to Calwell.

But a judge backed Calwell's request, and Dow was forced to hand over 220 reports of adverse incidents, including poisonings, that it hadn't filed with the agency. Calwell, who went on to litigate several cases of people exposed to chlorpyrifos, still remembers the day the Dow attorneys showed up in court holding the brown envelope full of the reports.

While Dow was keeping some of the disturbing information about its chemical from the public, its own research was showing chlorpyrifos to be much safer. While they were reassuring, the company's studies were also "scientifically worthless," according to neuroscientist and Stanford professor Robert Sapolsky. Calwell hired Sapolsky, an expert in the degeneration of nerve cells and a recipient of a MacArthur Fellowship, to review Dow's own studies on the pesticide. After reading them, Sapolsky wrote to me in an email, he was "simply stunned at how bad the work was, how utterly awful every aspect of them was, from the scholarship to how the studies were conducted to how data were analyzed, to how everything was then interpreted."

Eventually, Sapolsky enlisted a dozen postdoctoral neuroscientists at Stanford to systematically review as much of the company's research on the pesticide as he could find. According to an unpublished report they produced in 2008-2009, all the Dow studies on chlorpyrifos they reviewed had some errors and 89 percent had errors that broke the basic rules of science. And these weren't randomly distributed mistakes, according to Sapolsky. "Every one of the errors in the papers worked in Dow's favor." Thus tailored, the company's studies "were all sterling testimonies to [the] utter safety of the stuff," according to the neuroscientist.

Dow heavily promoted this rosy vision of chlorpyrifos. Even as it was spinning the science, collecting reports of poisoning incidents, and fending off legal responsibility for them, Dow — or Dowelanco, as it was called at the time — was also boasting about the safety of its pesticide. "The 20-plus years of chlorpyrifos use involving millions of applications confirm that there is not a single documented incident of significant adverse health effect resulting from proper use of Dursban insecticides," announced one 1991 brochure under a picture of a woman with a small child on her lap. "Does Dursban have any long-term effects?" the brochure asked before supplying the answer: "No."

Such assertions were, even back then, patently untrue, as the New York attorney general argued in a 1993 suit charging the company with false advertising. Citing the dangers of pesticides and the particular risks they posed to children, the settlement of the case required Dowelanco to immediately stop using such language to promote its chlorpyrifos-containing products, Dursban and Lorsban.

But Dow stuck to its claims of safety, even when they put the company at odds with the truth — and the law. Almost immediately after striking an agreement over the first suit from the New York attorney general, Dow went on to violate it with more falsely reassuring claims about chlorpyrifos, according to another suit from the AG's office. Dow paid $2 million to settle that suit in 2003. For the AG's office, this was a record fine. For Dow, it was perhaps a small price to pay for a decade's worth of reassuring messaging.

The legal challenges cost the company only modestly. Dow settled several of the poisoning cases and reportedly paid Joshua Herb's family $10 million, which helped cover Joshua's round-the-clock care. And Calwell's discovery that Dow had withheld critical information about its chemical led to the EPA fining the company $876,000 in 1995. But the company never admitted any wrongdoing, even in the case of Joshua Herb, who died as a teenager.

BY THE LATE 1990s, when Dow was negotiating with the EPA over chlorpyrifos, more than 10 million pounds of the pesticide were used on crops each year. In 2000, advocacy groups including Beyond Pesticides and Californians for Pesticide Reform asked the EPA to ban the chemical altogether, including its use in agriculture. But Dow threatened to sue the agency if it tried for a full ban, according to a retired EPA toxicologist named Jeremy Blondell.

"They negotiated with us and said, fine, we won't take you to court," Blondell explained in an interview. The prospect of a long, expensive legal battle apparently deterred the agency from moving forward. "If we had gone to court, it would have taken four or five years," said Blondell. Instead, in 2000 the agency struck an agreement with Dow that phased out most household uses of chlorpyrifos but preserved the growing agricultural market from serious restrictions.

A few years earlier, Dow had managed an even bigger threat to its pesticides. As the biggest spender in a coalition of companies, Dow actively fought the implementation of a clause in a 1958 law that had strictly forbidden the use of food additives that caused any cancer in humans or animals.

Dozens of pesticides could have been outlawed if it were enforced. Instead, by 1996, Dow led a coalition that helped water down the strict "zero risk" standard set by the law to one designed to minimize the risk to health.

It fell to the EPA to calculate how much risk to health was acceptable based on the risk of cancer and other diseases. As it does with most pesticides, the agency used the company's own studies to determine safety for humans, including some of those Sapolsky had judged as flawed and biased. In 1996, when the agency re-registered chlorpyrifos, the EPA set a safety limit that allowed the chemical to be used in amounts that caused just a small reduction in the activity of the enzyme cholinesterase. For kids, it soon became clear, this wasn't enough.

IT'S STANDARD PRACTICE for companies to rely on animal studies to prove the safety of their chemical products. Conducted in research labs, such experiments allow scientists to closely control and monitor their conditions, pinpoint the exact doses associated with outcomes, and replicate entire studies. But different species don't always respond to chemicals the same way. And, while scientists have traditionally tested the safety of pesticides by exposing lab animals to relatively high doses, such studies don't necessarily capture the risks posed by the lower amounts people breathe and eat.

In 1998, when Dow was still facing off with victims in court, three teams of scientists began to tackle the questions of how these real-world exposures affect actual people.

At the University of California, Berkeley and Mt. Sinai Hospital and Columbia University in New York City, the researchers embarked on a series of government-funded studies to see how young children were affected by environmental chemicals.

Virginia Rauh, an epidemiologist leading the neurodevelopment team at the Columbia Center for Children's Environmental Health, chose to investigate chlorpyrifos because she and her colleagues were aware that organophosphate pesticides had potentially irreversible neurological effects on lab animals. She also knew that the chlorpyrifos could cross the human placenta and enter the fetal blood before birth. Plus, as she explained to me recently in her office overlooking the Hudson River, "these are chemicals that were specifically designed to attack the mammalian nervous system."

Rauh and her colleagues, who ultimately enrolled 725 African-American and Dominican mothers and their children in New York City, were aware, too, that like most New Yorkers, the women in the Columbia study used the stuff to kill fleas, ants, and cockroaches in their homes.

As she expected, the research team soon found ample evidence of chlorpyrifos exposure. Ninety-nine percent of the air sampled from the subjects' apartments tested positive for chlorpyrifos, as did 70 percent of the blood samples taken from the mothers and their children. What Rauh hadn't expected was that the EPA's ban on in-home use of chlorpyrifos would go into effect in 2001, even as the team was enrolling women in the study, almost immediately causing the amounts of the chemical in their bodies to drop.

"We have this beautiful slide that shows the concentration levels going down right after the ban, and by 2006, almost all the levels were nondetectable," Rauh told me.

This accident of timing divided her study population into two: children who were born before the ban, and had relatively high levels of exposure, and those born afterward, whose levels were much lower. When the Columbia researchers compared the otherwise indistinguishable groups, they found clear differences. The babies who were exposed to more of the chemical tended to be smaller, have poorer reflexes, and weigh less. In fact, the babies with the highest level of chlorpyrifos were a half-pound lighter on average than those with the lowest levels.

What's more, even though the exposures happened before birth, their effects seemed to last for years. Rauh and her colleagues kept following the children enrolled in the study and found that, at age 3, those who had higher chlorpyrifos levels were more likely to lag in terms of both motor and mental development. The differences weren't subtle. The children in the higher exposure group were more than twice as likely to be mentally delayed; more than five times as likely to have symptoms of pervasive developmental disorder, a diagnosis that was later folded into autism spectrum disorder; more than six times as likely to have ADHD-type symptoms; and more than 11 times as likely to have symptoms of other attention disorders.

Meanwhile, the team out in Berkeley was also tying chlorpyrifos exposure to a number of neurodevelopmental effects, as the researchers from both teams discovered when they met up at a conference.

The Berkeley study, known as CHAMACOS (for the Center for the Health Assessment of Mothers and Children of Salinas), was studying women and children in California's rural farming communities. Their findings were strikingly similar to what Rauh had found in an urban setting. When compared to the children with the lowest prenatal exposures, the CHAMACOS kids who had been most highly exposed also tended to have lower IQs, poorer cognitive function, abnormal reflexes, and an increased risk of attention problems.

And when they followed the kids in their study as they aged, both teams found that the effects persisted. At age 7, the highly exposed children in Rauh's sample had lower IQs and deficits in working memory. The team in Berkeley also found that exposure to organophosphates had significant lasting effects. In their group, 7-year-olds who had the highest level of exposure to organophosphate pesticides, including chlorpyrifos, had IQ scores that were seven points lower than those with the lowest exposure.

The researchers at Mt. Sinai had similar findings. In fact, all three groups of scientists studying chlorpyrifos were so similar that they decided to publish them together. Each one had independently found that chlorpyrifos had neurodevelopmental effects on children. Perhaps most startlingly, the researchers were seeing effects at levels of chlorpyrifos lower than the ones that interfered with cholinesterase. In Rauh's study, the pesticide had lasting effects on kids' brains at levels 20 times below the EPA's safety level.

Dow, which often refers to Rauh's work as "controversial," has taken issue with her findings precisely because they show that small amounts of the chemical can have effects. Chlorpyrifos.com, a website created by the company, cites the fact that the Columbia study's thresholds are lower than those of other studies as one of the reasons the effects "are not likely to have been caused by chlorpyrifos."

The company's own studies, which the site describes as "40 years of high-quality animal research," were not looking for the changes Rauh observed and couldn't have detected them because they were done on animals. Nor would it have been ethical to deliberately expose humans to brain-altering levels of chlorpyrifos. Yet just by using the pesticide in their homes, people were exposed to the chemicals at these levels. The epidemiologists were observing changes that took place as people encountered the pesticides in their daily lives.

"These were relatively modest exposure levels," Rauh said. "A lot of people in the country are still having these exposures.

ZENAIDA MUÑOZ LIKELY had even higher exposures to chlorpyrifos when she was pregnant with her 8-year-old son, Alan. At the time, Muñoz was living directly across the street from an orange grove in the central California town of Woodlake. Her one-story house was about 30 feet from the trees. And when the groves were sprayed, the fumes drifted in through the windows. Plus, one of her favorite ways to relax was to walk through the orange groves.

She spent much of her free time during her pregnancy this way, wandering past the rows of perfectly spaced trees.
Sometimes on her walks, the smell of the chemicals was strong enough to make Muñoz nauseous. But at the time, it didn't occur to her that she — or the baby growing inside of her — might suffer any lasting effects. "Pesticides are a part of life here, they're normal," she told me through a translator. And, indeed, it is residents of agricultural communities like Woodlake who tend to have the highest exposure. A documentary filmmaker who recently analyzed hair samples from six children in farming communities in California found that each tested positive for at least 50 different pesticides, including chlorpyrifos. In addition to being exposed to the residues on fruits and vegetables, as people throughout the country are, they are more likely to inhale chlorpyrifos that drifts in the air after spraying and drink the small amounts of it that sometimes seep into drinking water. Like everyone else living around the grids of farmland that make up much of central California, Muñoz was used to seeing workers spray the chemicals. And she assumed that if a chemical were truly dangerous, farmers wouldn't be allowed to use it.

In the four years since Alan was diagnosed with autism and ADHD, Muñoz has thought about those walks often. She knew her son was struggling long before then. Alan is her second child and at just 8 months of age, he already seemed far more restless and difficult than her first. He would run at every opportunity and never seemed to settle down.

By the time he was 4, he was clearly far less able to speak than his peers. He also had a hard time making friends. His many frustrations led to sudden outbursts.

Muñoz, who moved to the nearby town of Cutler four years ago, knows other mothers whose children have health effects they believe are related to pesticides. She belongs to a group of 20 women who get together regularly to work on local issues. Four of them have children with neurodevelopmental problems, two have kids with ADHD, and one mom described her 3-year-old daughter as having "mental retardation and other cognitive problems."

Now pregnant with a third child, Muñoz tries to avoid exposure to pesticides. It's not easy. She stays indoors as much as possible and has stopped taking her walks through the orchards. But Muñoz still passes them every day as she takes Alan to school. And even as he struggles, he continues to risk exposure to the pesticide. Alan's school, Cutler Elementary, is a short distance from the fields — as everything is in Cutler. California's careful tracking of the locations and quantities of pesticide applications has shown that Alan is one of some 500,000 children in California who attend a school within a quarter mile of fields where "pesticides of public health concern," such as chlorpyrifos, are applied.

THE SCIENCE DOCUMENTING that chlorpyrifos has long-term effects on children's brains had reached a critical mass by 2007. That year, Earthjustice sued the EPA on behalf of the Pesticide Action Network, the Natural Resources Defense Council, and farm worker groups, asking that it consider the long-term effects of chlorpyrifos and ban the chemical. That suit turned out to be the first of many. The EPA failed to take action, however, so the environmental groups sued the agency again in 2010, urging it to stop all uses of chlorpyrifos. In 2012, when the EPA still hadn't banned the pesticide, the groups sued yet again, to no avail. And in September 2014, seven years after they first filed their request, the advocates sued the EPA for a fourth time, again demanding that the agency revoke its approval of chlorpyrifos.

Such delays are unfortunately typical of the process of getting dangerous pesticides off the market, according to Patti Goldman, an Earthjustice attorney who has been working on the chlorpyrifos suit. Part of the reason for the glacial pace, according to Goldman, is the influence of pesticide manufacturers.

"Industry spends a lot of time walking the halls of EPA and urging the agency not to do anything until it's absolutely sure," said Goldman, who has noted an increased presence from Dow in recent years. Indeed, Dow, a multinational corporation that had more than $48 billion in revenue in 2015, has a far bigger budget for lobbying and scientific research than the nonprofit organizations representing the health interests of kids and farmworkers. "They can spend a lot of money on all of that," said Goldman. "We just don't have the resources."

Nevertheless, three months after the groups' last suit, in December 2014, the EPA did what the smaller groups had been urging for years, acknowledging the serious risks chlorpyrifos posed to the developing brain.

In a draft version of the risk assessment finalized in November, the agency highlighted Rauh's work showing an increased chance of developmental disorders, attention problems, working memory loss, and intelligence deficits in children who had been exposed to the pesticide prenatally. Still, the EPA did not move to take chlorpyrifos off the market.

By August 2015, after the EPA requested yet another delay before issuing a final decision, the court that had been hearing the chlorpyrifos case reached the limit of its patience. Calling the delay in responding to the advocates' 2007 petition "egregious," three judges in the 9th Circuit Court gave the EPA a hard-and-fast deadline for finalizing its rule: October 31, 2015.

In an emailed response to questions from The Intercept, a spokesperson for the EPA said the delay in responding to the groups' request was due to the fact that the suit "raised numerous complex, novel scientific issues," which required several scientific reviews. Those reviews, the agency representative wrote, "required years to complete, which is not unusual for cutting-edge scientific issues."

Yet even with a clear timeline set, the EPA requested another extension. And, once it was granted, the agricultural lobby moved to prolong the process still further. In July 2016, 15 groups, including the American Sugarbeet Growers Association, the National Potato Council, the National Corn Growers Association, the American Soybean Association, the Almond Alliance of California, the National Cotton Council, the U.S. Apple Association, and CropLife America, an agribusiness trade association whose members include Dow, wrote to the court.

Though the EPA had been considering banning chlorpyrifos for at least nine years, the groups insisted that they had been given "not nearly enough time" to respond. The industry brief described the EPA as being "forced to rush to judgment" and argued that the agency needed at least another year beyond the court's current deadline to conduct its science work.

By this point, Dow had enlisted Exponent, a science-for-hire group, to publish articles disputing the accumulating science on chlorpyrifos and arguing that there is no scientific reason to change the safety standards. Yet when those publications were excluded, the scientific literature overwhelmingly agreed about the harms of organophosphate pesticides, including chlorpyrifos. Of 27 studies published by 2012, all but one showed that organophosphate pesticides caused "negative effects" in children's brains. And since then, several others, including the CHARGE study, have added to the findings. Yet because the EPA cited Rauh's work most often in its decision to move forward on chlorpyrifos, the industry focused its attentions on the Columbia epidemiologist, dissecting her papers and criticizing the researcher herself.

In addition to taking issue with its focus on humans, Dow has complained that the Columbia team has refused to make their data public. Rauh's "raw data have not been made available for independent scrutiny by EPA and other stakeholders, despite multiple requests from the agency to the study authors on previous occasions to provide it," the company claimed on chlorpyrifos.com.

Dow has also made that charge in public comments to the EPA and in legal briefs submitted to the court. The industry talking point even surfaced in a February hearing on "the impacts of the Environmental Protection Agency's actions on the rural economy," when committee chair K. Michael Conaway said that he "heard" that Rauh's "research data may not be reliable" and that Columbia had "refused to provide the raw data to EPA even though EPA provided funding for the study," according to his prepared comments.

"We do the science, we publish the work, we release data when we're asked. Everything has been done appropriately."

In response to questions from The Intercept for this article, Dow AgroSciences said in a statement that the company "strongly disagrees with EPA's proposal to revoke chlorpyrifos tolerances." Dow also said that the "EPA's proposal to revoke all tolerances appears to be based on a non-replicated epidemiology study for which no raw data has been provided to the agency. Dow AgroSciences is confident that authorized uses of chlorpyrifos products offer wide margins of protection for human health and safety, when used as directed."

But when I asked the Rauh herself whether she had shared her data with the EPA, she seemed familiar with and perplexed by the accusation. "It is hard to take seriously because it's not true," Rauh said with a sigh. "We do the science, we publish the work, we release data when we're asked. Everything has been done appropriately."

Rauh said she and other researchers on her team have had several meetings with EPA officials. "EPA has been invited to have our data. They don't even want it. There is no contentiousness about it. They've seen it, it's been represented to them many, many times." When asked whether Rauh had refused to provide data, the EPA referred to a note the agency inserted into the public record in 2014 saying that while the agency had initially requested the raw data from the Columbia Center for Children's Environmental Health, and the center "did not agree to provide" them, subsequently "the researchers met with EPA and discussed the agency's questions about the data to help determine whether further review of the raw data might assist EPA in resolving uncertainties. As a result of new information gathered through an on-site meeting and other sources, EPA is no longer pursuing the request for the original analytic data file from CCCEH researchers."

The Columbia epidemiologist knows her work has drawn the ire of industry. "They have an army," Rauh said of the many scientists Dow has hired to focus on her work. She gets questioning emails from them every time she publishes a paper, and she has seen them at meetings, when "Dow had booked most of the day with their rebuttals trying to poke holes." But Rauh chooses not to engage directly with her detractors. Instead, she pointed to the dozens of studies beyond her own showing links between early chlorpyrifos exposure and neurodevelopmental problems, noting, "The evidence is mounting and it is largely consistent."

The EPA's new report backs her up, finding that with the exception of two negative studies in 2015, "all other study authors have identified significant associations with neurodevelopmental outcomes."

PERHAPS THE MOST impressive recent addition to the science on chlorpyrifos is the CHARGE study, in which Eva Galindo participated. Directed by epidemiologist Irva Hertz-Picciotto, CHARGE looks at both genetic and environmental factors in the development of autism and has helped establish links between autism and insufficient folic acid intake as well as the presence of metabolic conditions, such as diabetes, obesity, and hypertension, in mothers.

In 2014, the CHARGE researchers added pesticides to their list of environmental factors linked to the disease with a study of nearly 1,000 children, including 486 with autism spectrum disorder. Published in Environmental Health Perspectives in 2014, the paper showed that the children born to women who lived near agricultural fields where pesticides were applied during their pregnancies have significantly higher rates of autism.

Several organophosphates besides chlorpyrifos were associated with increased autism rates, as were another group of pesticides called pyrethroids. And other kinds of developmental delay were also associated with the pesticides. But the link between autism and chlorpyrifos was the strongest. While the nationwide autism rate is now one in 68, for women who lived near fields where chlorpyrifos was sprayed during their second trimester, the chance of having a child with autism was closer to one in 21.

Hertz-Picciotto, who came to the MIND (Medical Investigations of Neurodevelopmental Disorders) Institute at the University of California–Davis from North Carolina in 2001, was able to zero in on the connection because of California's records on both pesticide use and autism cases, which are both the most detailed in the nation. After identifying the children with autism, she interviewed mothers about where they were living during their pregnancies and combined that information with the data on where pesticide spraying took place.

Her efforts came at a delicate time. Since the idea that vaccines cause autism was first hotly debated and then discredited over the last decade, the public has come to distrust experts who focus on environmental causes of the developmental disorder. "There's this culture in science that favors the most technologically advanced approach over anything else," said Hertz-Picciotto. "Because of this molecular revolution, genetics has taken center stage in a huge way. If you look at NIH funding [for research on the causes of autism], comparing genetics versus environmental factors, the ratio is 20 to 1."

But Hertz-Picciotto, whose previous work focused on the impact of lead on children, feels it's pointless to pit genetic and environmental factors against one another. Both contribute to the development of the disease roughly equally, she said, and even interact. Several studies have shown particular genetic variations increase the susceptibility of both children and adults to chlorpyrifos, for instance. And several different genetic and environmental occurrences may contribute to any one case of the disease.

“I suspect that there are multiple factors,” said Hertz-Picciotto. “Maybe not taking your prenatal vitamin doesn’t push you over the edge, it just creates the susceptibility. Maybe then the mom got an illness. Maybe she had a little flu. And that also had some impact on the migration of cells getting to the right place in the brain. … Of course, the body, even before birth, has some resilience. However, pesticides like many other chemicals, cross the placenta, and the fetus has fewer enzymes to detoxify chemicals than a child or adult has; and finally after a certain point, the insults pile up and you’ve gone past the ability — the biologic capacity — to adapt.”

Chlorpyrifos exposure is just one of several chance occurrences that may combine to cause autism. But unlike an individual’s genetic makeup, it’s one that could be easily changed. That, according to Hertz-Picciotto, is the appeal of exploring the environmental causes of autism. While genetic research may, in the long term, help to develop treatments for autism, exploring the environmental triggers for the disease can help prevent future cases.

JENNIFER AND PATRICK Coleman took part in the CHARGE study for that very reason — because they hoped it might prevent other kids from developing autism and spare other parents some of the difficulties their family has endured. “It’s too late for us, we already have it,” Jennifer Coleman told me recently. By “we” Coleman meant her two sons, Jackson, who is 12, and his little brother, Drake, who is 7.

Caring for her children is clearly more time-consuming and labor-intensive than it would be if they didn’t have autism. Drake also has ADHD, and the boys’ behavior can be unpredictable and grating, their meltdowns frequent and loud.

“Everything about parenting is harder,” Jennifer told me as we sat in their leafy backyard in Modesto, California. Both boys were actually playing quietly at the time, but “other parents can tell their kids, ‘Don’t do that,’ and they won’t do that. My kids are like, ‘What?’ When you say, ‘Don’t do it,’ my kids will do it 12,000 more times.”

Parenting can also be more emotionally wrenching in ways that are impossible to measure. There is Patrick Coleman’s sadness that Jackson will never be an Eagle Scout, for instance, or his fear that Drake’s wildness will ultimately land him in prison. Even the prospect of telling Jackson the truth about Santa has thrown his parents into a terror most parents of neurotypical children will never know. He still believes “lock, stock, and barrel,” as his mother put it, and they fear he will see their years of misinformation as an unforgivable betrayal.

Indeed, while he is a literal-minded child, Jackson is also an exquisitely sensitive one. After he was recently bullied at school by kids who find him odd, Jackson told his mother in a matter-of-fact tone that he wanted to die. Jennifer Coleman was able to get her son transferred to another class and he now seems happier.

But she knows both her sons will continue to struggle — and that there is little she can do besides being as loving and patient a parent as she can be — and participating in research that might spare other kids and parents the same fate.

THE EPA, ON the other hand, has the power to ban chlorpyrifos. By law, the agency is required to regularly re-evaluate pesticides to make sure they continue to meet the safety standard of causing "no adverse effects." And in its infuriatingly slow way, the agency was doing what it was supposed to do. The EPA's November 10 report showed that despite the intense pressures of the industry, the agency has come to see the dangers of chlorpyrifos as settled science. It was taking action, and had the election gone differently — or had the EPA not requested its final extension of its deadline — the policy may have been settled, too.

Instead, the chemical industry has renewed its efforts to derail the proposed regulation. On November 29, CropLife America launched a Hail Mary effort to stop the ban. The business group petitioned the head of the office of pesticide programs to "cease regulatory decision making" on chlorpyrifos until it has developed standards "for acceptance of epidemiologic studies in human health risk assessment," a process that could easily take several years.

Donald Trump's scorn for science and his embrace of widely discredited ideas, including the theory that vaccines cause autism, has long terrified the scientific community. For those working on chlorpyrifos, that terror is sometimes accompanied by a feeling of destabilization.

"We're all wondering what will happen next," said Nathan Donley, a senior scientist at the Center for Biological Diversity, who has studied chlorpyrifos. "That's what keeps me awake at night."

Donley told me he thought the industry might have been emboldened by Trump. And it's easy to see why they might be. In the first months since the election, Trump has reinforced his allegiance to industry in general and Dow in particular. Mike McKenna, a Dow lobbyist, was one of the first to serve on his transition team and Myron Ebell, a foe of chemical regulation who has received money from Dow, has overseen staffing of the new EPA. In December, Trump named Dow's CEO Andrew Liveris to head the American Manufacturing Council, a private sector committee that advises the secretary of commerce. Meanwhile, Scott Pruitt, Trump's pick to run the EPA, is an avowed foe of environment regulation.

Dow has already managed to slow the process of regulating chlorpyrifos to a virtual crawl over the past decades. Could a process that's been thwarted by at least two previous administrations finally succeed under Trump?

Some longtime advocates are clinging to the hope that the pending regulation is too far along for the new administration to stop. Disregarding the mountain of scientific evidence would be too egregious a move even for Trump, according to Patti Goldman, the Earthjustice attorney who has worked to protect the public from the effects of chlorpyrifos for more than 20 years.

Though he is an unabashed friend of the chemical industry, the president-elect doesn't necessarily want to be an enemy of children, said Goldman. And choosing to ignore widely accepted research showing that a chemical hurts children's brains would make him just that. "Going up against brain damage in kids," she predicted, would be "a public relations disaster."

And then there's the matter of the law. The court's clear instruction to the EPA to issue its final rule on chlorpyrifos would be extremely difficult to defy, said Kristin Schafer, policy director of the Pesticide Action Network. "This is a legal deadline."

But the company has several potential ways it could circumvent the regulation without technically defying the law. Dow recently previewed one in a press release issued on the day the EPA announced the proposed ban. "The court ordered EPA to make a final decision on the petition by March 31, 2017, but did not specify what that decision should be," Dow explained. "The EPA can deny the petition and retain all tolerances, which would be consistent with the science and allow the agency to complete its registration review and address their remaining concerns in an orderly manner." In other words, the EPA could issue a rule that, despite the evidence, declares chlorpyrifos safe to use rather than moving forward with the ban. Or Congress could even draft legislation that somehow gives Dow's neurotoxic product a reprieve.

Dow has been working on end-runs around the EPA since at least 2014, when the company hired lobbyist James Callan to work on "federal regulatory actions to maintain tolerances for the insecticide chlorpyrifos." The company has paid Callan $140,000 in the past two years, according to lobbying records.

Just two years ago, when Callan first started working on chlorpyrifos, these strategies must have seemed like pipe dreams. At the time, the company's best option — its only option, really — was delay. Though a favored strategy of the chemical industry, it was unclear that stalling action on chlorpyrifos would do anything more than extend the period in which the company could benefit from its product before an inevitable ban.

After the whiplashing election, however, it's clear that Dow's bid for additional time may deliver much more, not just temporarily putting off a ban of chlorpyrifos but potentially setting the science-driven process back by years.

DOW HAS DONE its best to quantify the benefits of its product, which, along with other pesticides, helps "U.S. farmers produce 144 billion pounds of additional food, feed and fiber and reap $22.9 billion in farm income increases," according to chlorprifos.com. But the cost of continuing to use the toxin on our food can be measured, too. Every day chlorpyrifos is in use, more kids will be exposed — and more brains altered by the chemical. The oldest of the children in Rauh's study are now 18. And, as they age, she is learning more about how their brains are different. She recently scanned the brains of 20 of the children in her study and found structural differences in those who were most highly exposed. These kids also tend to have tremors and Rauh is now exploring whether they're more likely to develop parkinsonian-type symptoms as they enter late adolescence and adulthood.

Several scientists have attempted to estimate the cost of the "silent pandemic of neurotoxicity" that's resulted from this and other toxic exposures. The TENDR scientists noted that chemicals, including chlorpyrifos, have already contributed to an "alarming increase in learning and behavioral problems in children." An estimated 10 percent of American children are now diagnosed with ADHD, and one in 68 American children is diagnosed with autism spectrum disorder, amounting to a 17 percent increase over the last decade.

David Bellinger, a researcher at Harvard Medical School, sliced the burden another way, estimating that exposure to organophosphate pesticides, including chlorpyrifos, has collectively cost American children almost 17 million IQ points. In Europe, researchers have even tried to put a price tag on the neurodevelopmental problems caused by chlorpyrifos and other pesticides each year: 120 billion euros, or $126 billion.

While children in farming communities get the biggest doses of chlorpyrifos, people across the country are exposed to potentially dangerous amounts of the chemical through their food. Though it's unclear exactly how much pesticide residue can alter brain development, all of the researchers I spoke with told me they advise pregnant women and young children to eat organic fruits and vegetables.

It's not unlike the strategy of Zenaida Muñoz, who has cloistered herself in her two-bedroom house in Cutler, California, during her pregnancy.

After reckoning with the shock that chlorpyrifos could be used even though it's known to harm kids' brains, Muñoz has done what she can to protect her growing family. They can't afford to buy organic. So, she's hoping her drawn curtains and closed doors will protect her — and waiting for the government to do something about the pesticide that is all around her.

This article was reported in partnership with The Investigative Fund at The Nation Institute.