TROUBLE AT HOME

BU RESEARCHERS TRACK THE PATH OF A CHEMICAL THREAT FROM OUR LIVING ROOMS TO OUR HORMONES

BY ART JAHNKE

A COLLECTIVE GASP RUSHED THROUGH THE STOCKHOLM conference room when environmental health experts saw the data flashed on a screen. It was 1998, and an analysis of breast milk from Swedish women was showing that concentrations of PBDEs, a close chemical cousin of long-ago-banned PCBs, were doubling every five years. PBDEs have been used for twenty years as a fire retardant in items from furniture to televisions to children's pajamas; now, the researchers reported, they were in us.

The findings were so alarming that they were the talk of environmental conferences for years, says Thomas Webster, a School of Public Health associate professor and associate chair of the environmental health department, who heard about the report from a colleague who had attended the Stockholm meeting. "For those of us who follow these things," Webster says, "it was stunning."

PERSISTENT POLLUTANTS

Within a short time, hundreds of scientists in labs all over the world had resolved to figure out exactly what kind of trouble we were in. Animal studies showed that PBDEs (polybrominated diphenyl ethers) can wreak hormonal havoc, damage reproductive systems, and cause serious learning problems. Other research looked at how quickly the toxic compounds were piling up in our bodies. Using data from the National Health and Nutrition Examination Survey, statisticians in the United States learned that PBDEs were present in virtually all of the several thousand people surveyed. Epidemiological surveys suggested that PBDE levels in typical U.S. citizens are about ten times higher than those found in most Europeans and that Americans between the ages of twelve and nineteen — the youngest group tested — had the highest concentrations in their blood. "The evidence showed that they are in all of us," says Webster. "And they are in some of us at levels approaching those that harm rats."

Environmental scientists are particularly worried about three aspects of PBDEs. They reside where we reside, having been used for decades in couches, mattresses, carpet padding, televisions, computers, car stereos, car seats, and padded dashboards. They are fat-seeking, meaning they aggregate in the body's adipose tissue. And, like PCBs, most PBDEs do not quickly biodegrade. In science lingo, they are POPs — persistent organic pollutants — and instead of breaking down, they bioaccumulate, piling up as they move up the food chain from plants to animals to humans. What that means, says Webster, is that if your body has PBDEs now, it will have them until you die, and if you have children, they will have them too.

"The thing to consider," says Michael McClean, an SPH assistant professor of environmental health and Webster's longtime collaborator, "is that just because you are not experiencing symptoms does not mean that there is no risk of harm. Chemicals like these could be contributing to problems down the road or even to problems for your kids."

Webster and McClean decided to pursue a piece of the PBDE puzzle that had, at the time, attracted scant attention: tracking the path of the chemicals from products to people, or, as the scientists say, from source to "body burden."

Now, ten years later, their research, conducted with grad students and researchers from other institutions, has positioned the two at the head of the class of PBDE experts. In June, Webster and McClean were awarded

ILLUSTRATION BY DAVID BRINLEY

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a grant of approximately $1 million from the National Institute for Environmental Health Sciences (NIEHS), a branch of the National Institutes of Health, for a four-year study of exposure pathways of PBDEs. It is one of the largest PBDE research projects to be funded by a federal or state agency.

THE PIGPEN EFFECT

In the years since Webster focused his attention on PBDEs, some regulatory agencies and manufacturers have taken action. In 2004, the European Union banned two of the three forms (penta and octa) of PBDEs. In the United States, manufacturers of those two forms of PBDEs voluntarily ceased production. The third form, deca-BDE, escaped restriction because there was less evidence that it was accumulating in humans or animals. More recent research has revealed, however, that when exposed to sunlight, deca breaks down into other brominated and potentially harmful substances. That concern convinced European regulators to ban deca from all electronics in April of this year. It also persuaded Philips, Electrolux, Sony, Dell, Intel, Apple, and Hewlett-Packard to commit to eliminating deca-BDE from their product lines.

In fall 2006, Webster sent his first proposal to the NIEHS. At the time, he had already begun a series of more modest research projects, funded by the New York Community Trust and BU. "We wanted to know how this gets into people," he recalls. "We knew that, with PCBs, the main source was diet, but this was different since PBDEs are used in consumer products. We wanted to know if exposure occurred primarily via diet or indoor exposure."

In one project, SPH doctoral student Nerissa Wu took samples of breast milk from forty-six first-time mothers and compared the PBDE concentrations to that from house dust collected from their Boston-area homes. "We found strong correlation levels in breast milk and in dust," says Wu. "There had been a lot of speculation about diet, but our work showed that dust is a huge reservoir for this stuff."

Next, Webster's team tried to correlate the number of furnishings — televisions and couches — likely to contain PBDEs with the amount of PBDEs in house dust. Initially, says Webster, the effort failed.

"The problem," says Joseph G. Allen (SPH'08), who earned a Ph.D. working with Webster and McClean, "is that manufacturers didn't say which products contained PBDEs, so we didn't know where they were. We knew they were in some couches, but not all couches, so counting the number of couches didn't help."

Webster and Allen found the tool they needed: a portable technology called X-ray fluorescence (XRF) that had been used for years to reveal the presence of lead in some environments. After lab tests proved to Allen that X-ray fluorescence could identify bromines, which are reliable indicators of PBDEs, he took his technology into nineteen homes in the Boston area. This time, Allen says, things went better than they had expected.

"The XRF didn't just tell us how many bromines were in couches," he says. "We were able to narrow it down to televisions as a source of deca, which was important, because that had never been documented."

While the results of Allen's tests were, in his words, intuitive, they were also profound. In finding the first scientific proof that the chemicals were escaping from furniture and electronics and winding up in house dust, he had disproved the contention of some manufacturers that PBDEs were incapable of escaping from products.

In another project that pushed the boundaries of PBDE research, Webster's group found a new way to measure the amount of deca-BDE in a home environment. They set up air sampling pumps in bedrooms and living rooms of Boston-area homes. A third pump, called a personal pump, was strapped to the hips of residents and worn for seven days.

"We did that," Allen says, "because we knew that as you walk, you kick up dust. We all end up walking around in a kind of personal dust cloud that has a higher concentration of particulates than the rest of the room. Tom calls it 'the Pigpen effect.'"

As it turned out, the magnitude of the Pigpen effect (named for the character in the *Peanuts* comic strip) surprised even Webster.

Concentrations of PBDEs in the personal pumps were significantly higher than in the stationary pumps, leading the researchers to revise their assumptions about the importance of inhalation as a pathway.

"Previous estimations thought inhalation accounted for about 3 percent of exposure to deca," says Allen. "Our research showed that it can account for as much as 22 percent."

Heather Stapleton, an assistant professor of environmental science and policy at Duke University, who helped analyze the samples, credits Webster's team with the first scientific proof that our living environments were a major source of PBDE exposure.

"Tom's research is very important," says Stapleton. "It's leading us in new directions in

trying to understand children's exposure to this stuff. Children crawl around on the floor and put their hands in their mouths. We don't know what that means for their health."

FROM INDOORS TO OUT

Despite all that, winning the NIEHS grant wasn't easy. Questioning the need for researching a chemical that had not yet been shown to be harmful to humans, the institute did not initially fund the scientists' 2006 proposal. While the news was bad, the timing was good.

A handful of new studies just appearing in scientific journals were tentatively linking PBDEs to hormone-related abnormalities in humans. One study conducted in Finland found that boys born to women with high levels of PBDEs in their placentas and breast milk had an increased likelihood of having undescended testicles. A Swedish study showed an increased risk of testicular cancer in men whose mothers had high levels of PBDEs while pregnant. Other research, done in Japan, found lower sperm counts in men with high levels of PBDEs in their blood.

"The findings in human studies are consistent with the findings in animal studies," says McClean. "The animal studies demonstrated that PBDEs have potent anti-androgenic activity. They are powerful endocrine disrupters."

Citing the new research, Webster and McClean resubmitted their proposal. Meanwhile, in February, as researchers across the country were pondering the damage PBDEs might do to a human body, they learned what they can do to a career at the Environmental Protection Agency (EPA). Deb Rice, a respected neurotoxicologist, was ousted from her leadership position on an EPA panel after she warned Maine legislators about the probable health hazards of PBDEs.

A few weeks later, the journal *Nature* reported that her firing had followed a complaint to the EPA from the American Chemical Council, an industry group. For environmental scientists, Rice's dismissal was proof that chemical companies would continue to fight efforts to regulate PBDEs.

In June, Webster and McClean finally got the word that their proposal would be funded. The research, which Webster hopes to launch this summer, calls for a four-year examination of PBDE pathways in three microenvironments: homes, workplaces, and cars — fifty of each. His team, including researchers from SPH, from elsewhere on the Medical Campus, and from the Centers for Disease Control, will use X-ray fluorescence to measure PBDE levels in appliances and furniture. They will sample the environments at three six-month intervals and will draw blood from fifty people (twenty-five men and twenty-five women) who inhabit those spaces. The men and women will also be queried about their diets. The goal, says Webster, is to track PBDEs from products to air and dust to humans, and to test the humans for hormonal abnormalities.

"Between the home and work environments, 90 percent of our time is spent indoors," says McClean. "We want to predict how these chemicals get into people. The industry has always said, 'We don't know how they get there, but they did not come from our product.' We want to find out. We want to learn how much comes from diet, how much from inhalation, and how much from other contact with dust."

What they hope to learn may help them understand not just "what the consequences are," McClean says, but "how we can make rational decisions about how to reduce exposure."

Which, of course, is going to be the hard part. "PBDEs are an indoor problem now," says Webster. "But in the future, as people throw all this stuff out, it's likely to become an outdoor problem. It's really an environmental disaster waiting to happen."

Webster and McClean worry that even if residents of the United States and Europe dutifully dispose of their televisions and couches in environmentally sound ways, barges laden with PBDE-rich waste will end up in landfills in other parts of the world.

"Once that happens," says McClean, "PBDEs will get into food systems, and once they get into food systems they work their way up the food chain." And at that point, he says, we may no longer need to worry about PBDEs in house dust landing on our food: our food will arrive with them inside.

There are, Webster points out, a couple of reasons for hope. One, coincidentally, was also revealed at the 1998 conference in Stockholm where the alarm first sounded. The same research that found frightening increases in PBDEs in breast milk also found decreasing levels of PCBs, two decades after they were banned. Now, restrictions on the use of PBDEs in Sweden have led to declining levels of the substance in people there. "We need to be smarter in the future," he says, "and design products so that fire retardants stay in them or aren't needed at all." ■

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