Benjamin Jastrzembski is searching the streets and shops of Bonanza, a gold-mining town in northeastern Nicaragua, for the perfect piece of scrap metal. He spots a stainless steel bowl on a blanket laid out in front of a small shop. “That might work,” he muses as he pays for the bowl.

Jastrzembski, a 2008 graduate of Dartmouth College, sometimes wonders what local residents think he’s up to when they see him carrying around pots or pans or random bits of metal. Sometimes even he wonders what, exactly, he’s doing. But then he’ll be reminded of the difference that a few dollars’ worth of materials can make in this impoverished rural community.

In Bonanza, as well as many other towns in this part of Nicaragua, thousands of people make their living from small-scale, or artisanal, mining. The work is difficult, to say the least. Miners use picks and shovels, and sometimes dynamite, to extract ore from the hillsides above the town.

Then they load the ore into bags and bring it to local processors, where the ore is ground into a coarse mixture. That mixture is combined with mercury, which binds to gold, creating a mercury-gold amalgam that is much easier to collect than tiny flakes of gold alone. The miners take that amalgam and heat it—often over an open flame or a blowtorch—releasing the mercury as vapor and leaving behind the gold.

Sometimes, Jastrzembski says, the process is care-

Toxic pollution from small-scale gold-mining.
Indiscriminate use of an antibiotic that can lead to hearing loss.
Scarcity or nonexistent health-care resources. These are a few of the problems that are drawing more and more people with Dartmouth ties down to Nicaragua.

Bonanza, Nicaragua, is scenic but remote and impoverished. Most residents are involved in some way with artisanal gold-mining—difficult and dangerous work.

Amos Esty is the managing editor of Dartmouth Medicine. Thanks to financial support from Dartmouth’s Dickey Center for International Understanding, he was able to travel to Nicaragua in July 2009 to do on-site reporting and photography for this article (he took all the photos, unless they are credited otherwise).
By the time Ben Jastrzembski applied for the Fulbright, during his senior year at Dartmouth, he was already quite familiar with northeastern Nicaragua. He had made his first trip to the region in 2005. Roughly a quarter of the world’s gold production comes from artisanal mining. Mercury is almost always used by artisanal miners to help recover the gold, and most of that mercury ends up in the environment. By one estimate, for every ounce of gold produced by artisanal mining, two to five ounces of mercury are released.

In Nicaragua, that adds up to a lot of mercury contamination. The country is the leading gold-producing nation in Central America, with more than 500,000 ounces—over 15 tons—produced each year. It’s hard to know exactly how much of that comes from artisanal mining (rather than from industrial mining, which typically does not involve the use of mercury), but it’s a significant portion.

Artisanal gold mining starts with extraction of the ore by hand, below. Then the ore is hauled up from the hills to be crushed. Above, Jastrzembski (left) asks two local miners for feedback on a retort he’s built, while they run their crusher—a machine known as a molino.

I n the summer of 2008, shortly before starting his Fulbright Fellowship, Jastrzembski met James Saunders, M.D., a DMS otolaryngologist who, like Jastrzembski, has a longtime interest in hearing services in rural towns in the Pacific coast. When Saunders heard about Jastrzembski’s upcoming trip, he wondered if the two might be able to collaborate.

While helping from other members of the Dartmouth community, Saunders and Jastrzembski began to plan a research project to investigate the effects of mercury on hearing loss among artisanal miners. Margaret Karagas, Ph.D., a DMS professor of community and family medicine who specializes in studying toxic metals, helped design the project. Several years ago, Karagas and Carol Folt, Ph.D., a professor of biological sciences at Dartmouth as well as dean of the faculty and acting provost, advised another Dartmouth student, Joel Wicker ’03, who was doing a study of mercury exposure in Siuna. The current project, Karagas says, “is sort of the natural follow-up.” The most dangerous forms of mercury is methylmercury, which is created when elemental mercury is released into the environment and taken up by bacteria or by animal species low on the food chain. As methylmercury makes its way up the food chain, it becomes increasingly concentrated—and increasingly dangerous.

In many countries, including the U.S., the main source of methylmercury exposure is through the consumption of fish. But Bonanza residents, even though they eat little fish, may suffer from the effects of chronic exposure to low levels of elemental mercury in the environment. Karagas explains that it’s hard to know exactly what the effects of such exposures might be. “There are lots of questions we do not have answers to, especially at low levels,” she says. “That’s why we’re doing the research.”

With help from others at Dartmouth, DMS otolaryngologist James Saunders and Jastrzembski began to plan a research project to investigate the effects of mercury on hearing loss among artisanal miners.
Mercury is known to be a powerful neurotoxin, and in a study of artisanal gold mining in Venezuela, the United Nations found that about a quarter of miners and their family members in one rural region exhibited signs of neurological damage from mercury exposure. Such damage often takes the form of impaired cognitive function, including problems with vision, memory, and muscle coordination. And although the effects of mercury on hearing loss in humans remain undetermined, a study in monkeys found that animals exposed in utero as they aged than did unexposed monkeys. To examine the possible effects of mercury on miners’ hearing, Jastrzembski returned to Bonanza in October. On this trip, he brought with him a computer program developed several years ago by Jay Buckey, M.D., a DMS professor of medicine and a former astronaut. Jastrzembski used the program, which was designed to assess astronauts’ hearing during space expeditions, to test the hearing of miners in and around Bonanza.

The program is as well suited for use in rural Nicaragua as in outer space. It runs on a laptop and requires only a small probe fitted with speakers plus a microphone. The program includes three different tests: one that measures the functioning of the inner ear; a second that gets an overall assessment of hearing, and a third that gauges the brain’s ability to process sound. Using the three tests, Buckey says, provides a fairly comprehensive picture of a person’s hearing.

On this recent trip, Jastrzembski also took fingernail samples that will be used to test mercury levels among the miners. The testing is now under way in the DMS Trace Elements Lab, and the results will show whether the mercury used in mining has made its way into the miners’ bodies.

The 2009 trip illustrates how deeply Saunders has become involved in Nicaragua. On the day the Mayflower team flies into Managua, a Saturday, Saunders spends part of the afternoon talking to Maya Enriquez, M.D., a Nicaraguan otolaryngologist who has worked with Mayflower for several years, about how to divide up the volunteers among the various projects. Most spend the week in Jinotega, providing hearing aids, performing surgeries, or finishing up ear infections, so we got the things we needed . . . to treat ear infections,” Saunders says. “Then we realized, ‘Gosh, there’s a lot of hearing loss here, so we need hearing aids’ . . . .” Over time, he says, “you just keep getting deeper and deeper into the problem.” Every summer, the organization brings a number of volunteers to Nicaragua. In July 2009, 26 volunteers joined the trip, including surgeons, medical students, and nurses, plus a number of nonmedical volunteers. Together, they provide services that would otherwise be totally inaccessible to many Nicaraguans.

While Saunders escorts the group that heads for Jinotega on Saturday evening, the volunteers staying in Managua set up shop at the city’s Lenín Fonseca Hospital. The team—which includes physicians, a medical student, a nurse, and a technician—spends several days operating on patients with the help of Nicaraguan nurses and physicians. One volunteer, David Molter, M.D., is a veteran of the Dartmouth team hopes the fingernail samples and the results of the hearing tests will help them determine how widespread hearing loss is among miners in Bonanza, and whether exposure to mercury might be a contributing factor.
In the past, Gudlewski and her colleagues have provided hearing aids to patients in Nicaragua. This year, Gudlewski says, the Mayflower team is equipped with materials that allow her to make an instant hearing aid. Previously, she would have had to make an impression, which would be brought back to the U.S., where the hearing aid would actually be made. But then the hearing aid had to be sent back to Nicaragua, requiring the patient to return to the clinic to pick it up. In the past, Gudlewski says, some patients would have to return one or more times to get their hearing aids. Using the instant materials allows her to ensure that people get the help they need.

A second-year Nicaraguan resident assists him, as Molter operates on a woman with a hole in her eardrum. Molter spends part of Tuesday afternoon doing as he proceeds.

Molter sits down near one of the day’s first patients—a teenage girl. Through a translator, he explains to her family that the girl will soon recover fully. But the girl isn’t listening—clearly she’s already doing well, since she’s talking away on her cell phone.

While Molter and other volunteers provide surgical solutions to Managuans’ hearing problems, DHMC audiologist Kerry Gudlewski, Au.D., an audiologist from New York City, double-checks the hearing aids to ensure that they are set properly.

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Gudlewski visits earlier patients now recovering in the wards. The children, who are mostly between two and five years old, are less sure, she lifts it slowly and waves her hand. Either way, she smiles as she responds. She also makes sure the material doesn’t get to the eardrum.

Molter explains to his patient’s family that she has heard a signal, the girl says in English. Her mother thanks Gudlewski repeatedly, hugs her before they depart. “Hasta pronto,” the girl says as she goes out the door. “See you soon.”

Meanwhile, Saunders has spent several days in Jinotega, performing surgeries to fix chronic ear problems and continuing to study the underlying causes of hearing loss in the region. He has spent a lot of time since his first visit a decade ago trying to piece together the mystery of the widespread hearing loss he has found there.

Saunders has determined that many of these children came from families with a history of hearing loss. But in genetic tests, Saunders found that the mutations usually responsible for hearing loss in the United States were not to blame in Nicaragua. Not a single child had either of two mutations common in the U.S. among people with hearing loss. During this year’s visit to Jinotega, Saunders met with members of a local family that he hopes may help tease out other genetic factors. Many of the members of this family have hearing loss, indicating that there might be a hereditary factor in play. Saunders plans to continue to take genetic samples from family members and have them screened for other genetic mutations that may be responsible.
Saunders did not expect when he first went to Nicaragua that his involvement there would become so consuming. “It can be overwhelming,” he says. But, he adds, “it has been very rewarding for me.”

Some of the deaf children were abused or abandoned by their families before being brought to the home. When they arrive, many have little or no ability to communicate but they pick up sign language very quickly.

Saunders and Fried hope to have the training program off the ground soon. They already have three potential students—including two of the Mayflower’s trips to have access to basic audiology services. Another long-term goal is to establish a nationwide screening program so that children with hearing loss can be identified and helped as early as possible.

For some of the children who live at the home, their hearing loss is so severe that it would be impossible for them to attend school otherwise. For others, it gives them a place where they are more accepted than they were among their families.

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Saunders adds, “I can’t imagine myself not being involved in this part of Nicaragua for the rest of my life.”

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But Saunders notes that there are other possible explanations for hearing loss in Nicaragua. One is the easy access Nicaraguans have to a class of antibiotics called aminoglycosides, which are known to have ototoxic side effects. Pharmacies in Jinotepe sell such antibiotics for just a dollar or two—no prescription needed.

Then there’s the ubiquitous environmental noise. Gudlewski says the lack of awareness about the danger of exposure to loud noise in Nicaragua is similar to the situation in the United States 50 years ago. She often sees patients in the U.S. in their 60s or 70s with significant hearing loss because they worked in noisy environments without ear protection. Now, she says, things have improved; she hopes that some of the children who live at the home will have the opportunity to avoid constant exposure to loud noise; she hopes the same will eventually be true in Nicaragua. “For a lot of these people, prevention is the only treatment you can give them,” she says.

It’s also possible that the high rate of hearing loss is the result of some combination of genetics, environmental influences, and the use of ototoxic antibiotics, with each factor exacerbating the others. Recent research has found that the combination of aminoglycosides and exposure to loud noise can cause greater hearing damage than either alone.

While Saunders continues to try to unravel the causes of hearing loss in Nicaragua, all of the Mayflower volunteers work to ameliorate its effects. Just last year, Mayflower opened a home for deaf children that now houses about 15 youngsters between the ages of 6 and 13. Jinotepe also has a public school that offers special classes for deaf children, a service that is not available in the isolated mountain villages outside the town.

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For the home, the new home for deaf children. When Gudlewski is done, she explains that the mother will be contacted when the hearing aid is ready to be picked up. The mother asks if Gudlewski will be there to put it on—she wants to bring Gudlewski a souvenir to help her remember Nicaragua. Gudlewski smiles. It’s a nice gesture, but it’s clear she won’t need a souvenir to make the trip stick in her mind. “I can’t wait to go back,” she says. “I’d go back next week if I could.”

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During the day, the children attend classes at a Jinotepe public school, wearing the uniform required of all the school’s pupils—white shirts, with blue pants for boys and blue skirts for girls. They return to the home after school.

In July, many of the Mayflower volunteers worked at the home, painting rooms and finishing work on a bakery attached to the facility. When it opens, the bakery will provide sustainable funding for the home. The work progresses steadily during the day while the children are in class. But in the late afternoon, after they return, work slows as some of the volunteers put down their paintbrushes to play with the children.

Later in the week, Saunders returns to Managua, where he and Fried, the audiologist from New York, will meet with officials from a public university. They hope to set up a program that will train Nicaraguans to become audiology technicians. That way, some services that are now available only when Mayflower volunteers are in the country can be provided year-round.

Fried says there is no program in all of Central America as rigorous as the one they’re planning; it will be a nine-month course. Their long-term goal is to establish permanent clinics in different parts of Nicaragua so residents will not have to wait for Mayflower’s trips to have access to basic audiology services. Another long-term goal is to establish a nationwide screening program so that children with hearing loss can be identified and helped as early as possible.

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was someone fighting to stand on his own, to help his caregivers bring him back to good health. I have come to believe that this real me is something like the soul. It is what remains when an illness suddenly strips away good health and personal history. But it's invisible to those treating the illness unless they look carefully, and it's often obscured even from the patient himself.

There were moments in the hospital when I recognized only a faint flicker of this soul, so how could I expect the doctors and nurses to see it? Nonetheless, no matter how wasted a patient is, there remains an essential self he desperately needs to hang onto. And if he is to recover in a timely and effective way, he needs to believe that others see that essential self, too.

I now think that looking for this is key to healing the very sick. It will never supplant medicine's therapeutic arsenal. I could not have survived without the brilliant, aggressive care I received. I know I was lucky to have so many important pieces in place when I fell ill. That cannot be the case for every patient.

At one point near the end of my third week in the hospital, internist Ed Merrens explained to me, “When you came to the hospital, we took control of your body. Now, we are going to give it back to you.”

Only by relinquishing myself to the experts was I able to survive. But once I did survive, I needed to be seen and understood so I could begin to really recover.

My recovery has been nearly total. There was a little permanent damage to my lungs, so I have to be careful if I get a chest cold. But through running and weightlifting, I have regained the body I lost during all those weeks in bed. In the fall of 2008, Dr. Walter O’Donnell, the Mass General pulmonologist who has monitored my return to health, looked up with a warm smile from the results of a breathing test I’d taken an hour earlier and said, “We just don’t see results like this.”

Even so, I don’t run many races these days. But I did mark my recovery by doing the grueling Mount Washington Road Race again the next year, in June 2007. The 7.6-mile course has been called “sadistic” for its vertical rise of nearly 5,000 feet. I finished further back than I ever had. But it may have been the most satisfying race I’ve ever run.