Antibiotic-resistant bacteria from livestock pose a deadly risk to people. But the farm lobby won’t let scientists track the danger.

By Melinda Wenner Moyer
Photographs by Patrick Cavan Brown
It wasn’t until a pig nosed me in the backside, in a friendly way, that I mustered the courage to touch one. I had seen thousands of hogs over the past 18 hours, but I had been nervously keeping my hands to myself. This particular pig seemed to disapprove of my restraint. I scratched him on the crown of his pink, wiry-haired head. He snorted loudly.

I was in a pungent, crowded barn on a farm that raises 30,000 pigs a year in Franklin, Ind., a sleepy farming town 45 miles northwest of Indianapolis. The farm belonged to Mike Beard, who was standing next to me. The pigs belonged not to Beard but to TDM Farms, a hog production company. Beard has a contract to raise TDM’s pigs from when they are 14 days old, just weaned from their mother’s milk, until the age of six months, when they are trucked to a processing plant and made into pork chops, sausages and tenderloins. The 40-by-200-foot barn housed 1,100 pigs. Because Beard is paid for the space he provides rather than by the number of pigs, “it’s to the company’s advantage to keep the buildings as full as they can,” he explained.

At 7:30 that evening, a tractor-trailer would deliver 400 more pigs. “EATPORK.” Keith Schoettmer, the farm’s owner and my tour guide, waved me over from a doorway on my right.

The intimidating sign, Schoettmer explained, was among his top concerns. “This is one of the most important signs,” he said. “It’s trying to tell people that we’re the kind of pig that people should be eating.”

The sign, he continued, was not the sight of pigs or the pungent smell of manure. The first thing that greeted me was not the sight of pigs or the pungent smell of manure. It was a menacing yellow sign: “WARNING: DISEASE PREVENTION PROGRAM. DO NOT ENTER.” Because I was there by invitation, I drove in anyway and parked two cars behind a Ford Taurus with the license plate “EATPORK.” Keith Schoettmer, the farm’s owner and my tour guide, waved me over from a doorway on my right.

The intimidating sign, Schoettmer explained, was among his many efforts to prevent pathogens from sickening the 22,000 pigs he raises every year. “The old adage ‘an ounce of prevention is worth a pound of cure’ is not more true than on a pig farm,” he told me. “We’re trying to keep these pigs as healthy as possible.”

It wasn’t the only reason why he had been hesitant to touch my porcine pal. Antibiotics seem to be transforming innocent farm animals into disease factories. The animals become sources of deadly microorganisms, such as the methicillin-resistant Staphylococcus aureus (MRSA) bacterium, which is resistant to several major classes of antibiotics and has become a real problem in hospitals. The drugs may work on farms at first, but a few microbes with the genes to resist them can survive and pass this ability on to their offspring. Researchers admit that it is difficult to connect all the dots, but some big meat companies instruct their farmers to keep researchers away, arguing they need to keep animals free of outsiders and their diseases, which makes it impossible for scientists to solidify the science. As Tara Smith, an epidemiologist who studies emerging infections at Kent State University, tells me, the companies “want us to prove all these steps, but they’re really tying our hands.”

I traveled to Beard’s farm, as well as two others, in an attempt to find the truth. I decided to follow in the footsteps of scientists who have been trying to trace antibiotic resistance down the long road from farm to food plate to understand whether pigs, cows, chickens or turkeys raised with antibiotics really could bring on the apocalypse—or whether these innocent-looking animals, and the billions of bacteria treading inside them, are nothing to fear.

CLOSE QUARTERS: At Keith Schoettmer’s Indiana farm, just weaned pigs are herded to their new home—a crowded pen.

Antibiotics are used more heavily in farm animals than in people. This may be the largest source of antibiotic-resistant bacteria. Drug-resistance genes spread more widely and rapidly on farms than in other species, a new study shows. The agriculture industry says farms are exaggerating, whereas researchers say companies are endangering public health.

IN BRIEF

Scientists now counter that the farm industry is the one exaggerating—even engineering—scientific uncertainty to protect their interests. “Frankly, it reminds me of the tobacco industry, the asbestos industry and the oil industry,” says James Johnson, an infectious disease physician at the University of Minnesota who studies antibiotic-resistant pathogens. “We have a long history of industries subverting public health.”

But there is a terrifying downside to this practice, which was one reason I had been hesitant to touch my porcine pal. Antibiotics seem to be transforming innocent farm animals into disease factories. The animals become sources of deadly microorganisms, such as the methicillin-resistant Staphylococcus aureus (MRSA) bacterium, which is resistant to several major classes of antibiotics and has become a real problem in hospitals. The drugs may work on farms at first, but a few microbes with the genes to resist them can survive and pass this ability to fight off the drugs to a larger group. Recent research shows that segments of DNA conferring drug resistance can jump between different species and strains of bacteria with disturbing ease, an alarming discovery. By simply driving behind chicken transport trucks, scientists collected drug-resistant microbes from the air within their cars. Early this year scientists discovered that a gene coding for resistance to a last-resort antibiotic has been circulating in the U.S. and was in bacteria infecting a woman in Pennsylvania. Many researchers worry—and the new findings add fresh urgency to their concerns—that the abundant use of antibiotics on farms is unraveling our ability to cure bacterial infections. This latest research, scientists now say, shows resistance to drugs can spread more widely than previously thought and firms up links in the resistance chain leading from animal farm to human
said Schecter, whose reeding white hair and broad smile reminded me of John McCain, although his accent—″manure,″ a frequent utterance—placed him firmly in the Midwest. Schecter asked me to don protective coveralls and plastic shoe covers while we walked around, too, to protect his hogs from any microbes I might be harboring.

Bacteria are everywhere on livestock farms because everyone is literally wandering around in poop. (Even though I was covered in plastic the whole time I toured Schecter’s farm, I decided to take off my hotel room slippers later.) And like germs in elementary school, the bacteria in this excrement get shared widely—they get burrowed under the fingernails of visitors who scratch the all heads, and they contaminate the hands of farm employees. (I never saw anyone wearing gloves.)

In 2005 researchers in the Netherlands, which has a large pig industry, determined that livestock-associated strains of MRSA were being Dutch pig farmers and their families. MRSA can cause deadly skin, blood and lung infections; it has circulated in hospitals for decades and, more recently, has been affect people outside of medical settings. By 2007 one fifth the Netherlands’ human MRSA infections were identical to bacteria that had come from Dutch livestock. After this discovery, in 2008, the Dutch government announced strict policies to reduce farm antibiotic use, which then dropped by 50 percent between 2009 and 2011. Denmark, another major pork exporter, had already banned the use of antibiotics in healthy pigs in 1999; in general, Europe has taken a harder line against animal antibiotics than has the U.S.

Now scientists know that this livestock-associated MRSA is spreading throughout the U.S., too. When Tara Smith, then at the University of Iowa, heard what was going on in the Netherlands, she decided to test pigs for MRSA at a few Iowa farms where one of her colleagues, a veterinarian, had connections. “We ended up sampling 270 pigs in the first round—we just want as much poop as possible and had no idea what we’d find,” Smith recalls. “About 70 percent of them were positive for MRSA.”

Smith and her colleagues have continued to publish a series of disturbing studies showing that MRSA is all over American hog farms. They found MRSA growing in the nostrils of 36 percent of workers at one large farm and found that feed on anoth er farm harbored MRSA even before it got unloaded from the delivery truck. Two hundred thirty-five yards downwind of an er farm harbored MRSA even before it got unloaded from the delivery truck. Two hundred thirty-five yards downwind of another farm, Smith found MRSA floating in the air. Other resis tant bacteria have been found around poultry farms. After researchers at the Johns Hopkins Bloomberg School of Public Health drove cars, windows down, behind trucks that were transporting chickens in Maryland and Virginia, along the Del marva Peninsula, they found MRSA everywhere—a group of bacteria that causes 20,000 infections in the U.S. every year—in the air inside the cars, as well as resting on the top of soda cans in the car’s cup holder.

Animal poop is used to fertilize crop fields, too, which means that its bacteria are literally spread on the soil used to grow our food. A 2016 study reported that after manure from hog and dairy farms was applied to soil, the relative abundance of antibi otic-resistance genes in the dirt shot up by a factor of four. In a study conducted in Pennsylvania, people who were the most heavily exposed to crop fields treated with pig manure—for instance, because they lived near to them—had more than 30 percent increased odds of developing MRSA infections compared with people who were the least exposed. Beards run as a second business as a manure applicator—he loads 6,500 gallons of his hog manure into a single tanker truck and applies it to nearby fields—and as he noted, the process is tightly regulated. He has to perform soil tests to ensure that fields can absorb the manure nutrients, and he has to apply the manure at a slow enough rate to prevent runoffs. But problems can still occur. A 2006 Esche richia coli outbreak in spinach was traced back to crop irrigation water that, investigators believe, had been contaminated by pig and cow manure from a nearby farm. The outbreak killed three people.

SPREADING RESISTANCE

Clearly, antibiotic resistance is a problem both for people and for livestock. But how can we be sure that the two are connected and that resistance is exacerbated by on-farm antibiotic use? In 1975 the Animal Health Institute asked this very question and recruited Tufts University biologist Stuart Levy to find out. Levy and his colleagues fed low doses of the antibiotic tetracycline to a group of 150 chickens on a nearby farm that had never gotten antibiotics in their feed and monitored them to see what happened. Within a week, almost all the E. coli bacteria in their intestines were tetracycline-resistant. Three months in, the bac teria growing inside the chickens were also resistant to four other types of antibiotics. After four months, the bacteria growing inside chickens on the farm that had not been fed tetracycline also harbored resistance to the drug. Levy and his colleagues analyzed the bacteria growing inside the farm owners, they found that 36 percent were tetracycline-resistant, compared with only 6 percent of bacteria from their neighbors. At the time, the findings came as a shock. “The idea that you would be able to give animals antibiotics at low levels and not have them develop resistance was the word of the day, and that made our study that much more interesting and unexpected,” Levy recalls. (The Animal Health Institute has not funded any additional studies to confirm his findings.)

One study we reported that more than 90 percent of E. coli in pigs raised on conventional farms are resistant to tetracycline, whereas a whopping 71 percent of E. coli in pigs raised on farms without antibiotics are also resistant. That is because resistance genes spread so well. In a landmark 2012 study, microbiologist Lance Pizzaro, now director of the Antibiotic Resistance Action Center at George Washington University’s Milken Institute School of Public Health, and his colleagues traced the evolutionary origins of the livestock-associated MRSA that was being shared among pigs and their farmers in Europe and the U.S. by sequencing the whole genomes of 88 diverse MRSA samples. Their findings showed that this MRSA strain started out in people as a methicillin-susceptible form of Staphylococcus aureus. Then the bacteria jumped into livestock, where they swiftly acquired resistance to methicillin and tetracycline and spread further.

At first, antibiotic resistance spreads slowly and through parent-offspring relationships—the descendants of resistant bacteria are born resistant, too. But emerging research shows that over time, resistance genes find their way onto nimbler pieces of DNA that dance around the bacterial genome, and many

Making of a Superbug

Antibiotics were created to kill or control bacteria. In doing so, however, the drugs have become a force that shapes bacterial evolution, creating conditions that favor the survival of microbes with genes that help them fight the drugs. These genes get passed to offspring in a process called vertical transfer, so a larger percentage of future generations survive. A wider danger, though, comes through a process called horizontal transfer. Resistance genes actually “jump” to different strains or species of bacteria, spreading widely and rendering drugs ineffective when bacteria infect people.
end up on small circles of DNA called plasmids—copies of which can easily be shared among bacteria of different species. In a 2014 study, a group of international researchers collected samples of antibiotic-resistant E. coli from both people and chickens. Although the bacteria were genetically different, many contained nearly identical plasmids with the same antibiotic resistance genes. It was the organism-jumping plasmids, rather than the bacteria themselves, that spread resistance.

The fact that resistance can be spread in this way— microbiologists call it “horizontal gene transfer” or HGT—is significant. It is as if the doctors suddenly discovered that Huntington’s disease was not just passed down from parent to child but could also infect people who touch one another in passing. It also means that exposing one type of bacteria to one antibiotic in one place has the potential to change how other types of bacteria respond to other antibiotics in other places.

Resistance typically comes at a cost. The mutations draw down the cellular energy a microbe uses to reproduce. Individuals survive, but the whole population grows more slowly. So when bacteria stop being exposed to antibiotics, they evolve resistance mutations that let them maintain resistance genes over multiple generations. Yet new research suggests that when bacteria get exposed to antibiotics, they share their resistance plasmids at a faster rate. Body organisms, or the body matrix, as the researchers call it, body together in the face of a common enemy, sharing their strongest weapons with their comrades. And once bacteria become resistant, the presence of antibiotics only makes them more successful. One reason that resistant infections are so common in hospitals is that the presence of antibiotics only makes them more successful. One reason that resistant infections are so common in hospitals is that the presence of antibiotics only makes them more successful. One reason that resistant infections are so common in hospitals is that the presence of antibiotics only makes them more successful.

Making matters worse, new research suggests that when bacteria get exposed to antibiotics, they share their resistance plasmids at a faster rate. Body organisms, or the body matrix, as the researchers call it, body together in the face of a common enemy, sharing their strongest weapons with their comrades. And once bacteria become resistant, the presence of antibiotics only makes them more successful. One reason that resistant infections are so common in hospitals is that the presence of antibiotics only makes them more successful. One reason that resistant infections are so common in hospitals is that the presence of antibiotics only makes them more successful. One reason that resistant infections are so common in hospitals is that the presence of antibiotics only makes them more successful. One reason that resistant infections are so common in hospitals is that the presence of antibiotics only makes them more successful. 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deputy director for science policy at the FDA’s Center for Veterinary Medicine. In Sep-
tember, he and other scientists held a closed meeting in which they devised a plan to start collecting more on-farm data, but they did not receive the funding they requested to actually start doing it. In fact, for fiscal year 2016, the FDA received none of the $71 million it requested to study antibiotic resistance in animals.

Academic scientists are desperate to go on farms and study farm animals, too, but they are rarely granted access unless they have connections. When Smith hoped to collect samples from industrial turkey farms, she contacted every single registered turkey farm in Iowa. “None of them let us in,” she recalls. “To study hog bacteria, Price and his colleagues have resorted to buying pig mounds at North Carolina auctions to be able to study these animals because they cannot get to live to animals. And remember that study in which Johns Hopkins researchers unveiled chicken delivery trucks in cars? They had to conduct the study like that because they had no other way of getting close to the chickens—the researchers were not allowed on the farms.

It is not that livestock farmers are antimicrobial; it is that their employers, the meat companies, instruct them to keep outsiders away. A whistleblowing report from U.S. poultry farmers who feed 98 percent of hog farmers (Beard being one) contract growers—signs contracts to raise animals for large companies while they make no money without a company contract—often farmers have huge amount of debt to start their business—a new poultry or hog farmer is beholden to these companies because they undertake a huge amount of debt to start their business—a new poultry or hog producer.

ers—they sign contracts to raise animals for large companies and to pursue the voluntary guidances instead.

But the disease-control exemption is a gaping hole in the guidelines, many complain. “Do I think the total volume of anti-
biotic use will go down? I absolutely do not,” says H. Morgan Scott, a veterinary epidemiologist at Texas A & M University. In fact, antibiotic sales to farms have increased each year since the draft guidelines were announced. In 2014 the nonprofit Pew Charitable Trusts analyzed the drug labels of all 137 antibiotics products that will be affected by the guidelines and found that farmers will still be able to administer onequarter of the drugs at the same dosages and with no limits on treatment duration—long as they say they are using them to prevent or control dis-
ease. Even the Animal Health Institute’s Carnevale says the antibiotics guidelines could “change the overall picture of how [antibiotics] are used, but whether [they’re] going to affect total quantities of antibiotics remains to be seen.”

The requirement for veterinary prescriptions may not put a dent in antibiotic use, either. Many veterinarians prescribe and sell antibiotics for a profit or work closely with the food or phar-
maceutical industries. A 2014 Reuters news investigation re-
ported that half of all the veterinarians who advised the FDA on antibiotic use in food animals in recent years had received money from drug companies. “There are a lot of veterinarians who are attached to industry, who have a conflict of interest and are beholden to the large producers—they are inclined to go along with the status quo,” James Johnson says. Several members of the U.S. Congress, including New York State Representative and microbiologist Louise Slaughte, have introduced bills to more tightly regulate antibiotic use on farms. Slaughter tench drafted a bill that would require Prescribers of Antimicrobial for Veterinary Medical Treatment Act for more than a decade. It has been sup-
ported by 454 organizations, including the American Medical Association. But after being referred to the Health subcommit-
tee of the Energy and Commerce Committee, the bill nev-
er reaches a vote.

One committee member who does not support the bill at this point is Representative Susan Davis of California, who has gone on record warning against the continued low-level of antibiotic use in food animals and the dangers that resistant bacteria pose to our food supply. In a letter to the press earlier this year, Davis said, “We need to do it. I think the bill ‘strikes the appropriate balance need-
ed in the use of medically important antibiotics in agriculture and farming,’” Axthion says. There is also significant opposition to the bill from industry. The National Chicken Council spent $640,000 in 2015 to lobby, in part, against antibiotic-related legislation, and the Animal Health Institute spent $380,000, ac-
cording to records filed with the Senate’s website for Responsibility and Ethics in Washington, Center data also show that veterinary pharmaceutical companies or livestock farming organizations have made cam-
paign donations of more than $15,000 to more than half of the members of the Health subcommittee. “The trade organizations have been down there saying, ‘You can’t show it’s—we that are reducing the resistance,’” says Patty Love, assistant director of the Natural Resources Defense Council’s Food and Water Watch. “That has really gummed up the works for a long time.”

A SMALL SOLUTION

AFTER I LEFT Beard’s farm, I drove two hours to my final destina-
tion: Seven Sons Farms in Roanoke, Ind., which raises pigs on pastures and woodlands without antibiotics. A decade ago Seven Son’s was a lot like the two farms I had just seen—it raised 2,300 hogs a year for Tyson Foods, regularly using drugs. But the farm was worried about health effects, so it made chang-
es. In 2000 Seven Sons became what it calls a regenerative diversified farm, and today it raises about 400 pigs, 2,500 egg-
laying hens and 120 forage-fed cattle on 150 acres of pasture. Blaine Hitzfield, the second of the farm’s seven namesake farmers, took me on a short tour. I saw fewer than a dozen hogs lolling around a half-acre expanse of dirt and grass. Hitzfield joked that Seven Sons was in the process of scaling back, too. “It is not an easy thing to do,” says Bart Vittori, vice president and general manager for pork at Perdue Farms’ food division, which has a $7 billion business. Coleman raises pigs on a vegetarian, antibiotic-free diet. “The demand is out there. Our consumers are smarter than ever, more informed than ever,” Vittori says. “The meat that comes out of Niman Ranch, a network of more than 725 family-run hog, lamb, cow and egg-laying hen farms throughout the U.S., has also been raised without drugs. Products from Coleman, as well as those from niche farms such as Seven Sons and Niman Ranch, are out of the financial reach of many Americans today. But the more that consumers demand antibiotic-free food, the more the farm companies will continue to ban outsiders from their farms. Even so, the weight of the evidence points strongly toward reducing antibiot-
ic use on farms, relying instead on novel infection control reg-
imens or age-old strategies such as providing animals with ample space. Until some of those changes occur, researchers and the rest of us will continue to worry about the growing strength of foodborne bacteria and the increasing weakness of our medicines against them.

MORE TO EXPLORE

Methicillin-Resistant Staphylococcus aureus in Pigs and Farm Workers on Conventional and Antibiotic-Free Swine Farms in the USA. Tarr, E. Smith et al. Foodborne Pathogen and Disease 12, 3-12, April 2015.

Prevalence of Antibiotic-Resistant E. coli in Retail Chickens: Comparing Conven-


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