Paige Crane

Eman Burney

Noor Burney

Manuel Sandoval

<u>The Underground</u>

Episode 1: The Crusade on Antibiotic Misuse in Pigs

SCRIPT 1

MUSIC FADE IN:

Introduction – [song 1 plays, then fades out]:

"I'll huff and I'll puff and I'll blow your house in". We all know the story of the three little pigs.

The first pig built his house out of straw. The second pig built his house out of sticks. The third pig built his house out of brick and was the only one successful against the wolf.

This is a testament to how hard work and determination in creating solutions pays off. But what happens when we take the easy route creating a false sense of security?

Hello this is Noor

EMAN: Eman

PAIGE: Paige

MANUEL: Manuel

Noor: …and this is **The Underground** where each week we take an exploratory dive into unknown issues surrounding human health. Today we will be focusing on the abuse of antibiotics in pork production. We will examine how this practice exists in the U.S. today.

MUSIC [song 1] TRANSITION #1

[1] Introduction to Bacteria and Antibiotics

MANUEL

It's happened to all of us, one minute we are fine and the next - "DANG IT!" – we're not. Whether it's a paper cut or a gnarly gash, today we do not have to worry that these injuries will be the death of us.

But prior to the 1940s this was not the case. Bacterial and other microbial infections had people on their toes. Something as small as a cut or even a scratch was enough to leave people bedridden, and some never got back up again.

In 1929, all this would change when Alexander Fleming discovered the body's greatest defense against disease and infections – penicillin.

Penicillin was the first of what we now know of as Antibiotics. The term literally means "against life"; in our case, specifically against microbial life. They were seen as a wonder drug! Afterall, how could they not be? What used to be a death sentence was now cured by a simple treatment of antibiotics… and the chance to see the next day.

This "antibacterial craze" swept the nation and their use skyrocketed.

Penicillin marked a turn of the tide in the war against bacteria and now the playing field had been leveled. As we began to gain the upper hand, scientists became more ambitious. Soon a race broke out to produce even more antibiotics, *but* their use did not stop at just human health.

[PAUSE]

Today, nearly 80% of antibiotics aren't even used by people. Nope… instead, they are given to livestock.

That's right! Today cows, pigs, and chickens have involuntarily become the largest consumers of antibiotics worldwide. But unlike the three little pigs, this story does not end with a happily ever after.

[2] Introduction to Antibiotics in Pigs

MANUEL

Antibiotics first came into use in pig farming to treat intestinal and respiratory problems in young piglets. But soon the farmers noticed that they did much more than just treat and prevent infections – they doubled as growth promoters making the pigs bigger and better.

The reason why the farmers saw such drastic changes has to do with how the antibiotics came to change the pig's microbiome, more specifically their gut.

[PAUSE]

While piglets in a farm do not have to worry about building homes or running from a "big bad wolf," they still experience high levels of stress during their pre and post weaning period. These stressors include:

- bacterial pathogens
- oxidative stress
- and inflammation

These stressors lead to reduced growth performance and high mortality rates, or at least they *did*.

With antibiotics, farmers were able to suppress the formation of bacterial populations in the piglets' guts and in doing so, helped the piglets absorb more nutrients from their food. Antibiotics also helped control the incidence of postweaning diarrhea.

Thus, with more nutrients being absorbed and less leaving the pigs, these piglets grew substantially and sold for more at market compared to pigs raised without antibiotics.

[PAUSE]

As word got out about the growth promoting factor of antibiotics, more and more farmers began to use them… A LOT!

Practically, it made sense. They promoted growth, and treated diseases before and after they occurred. On top of that, they were cheap and easy to use. Unlike vaccines that are disease-specific and have to be injected, antibiotics are broad-spectrum and can be given in feed or water.

And so, as the years went by, the abuse of antibiotics in pigs continued.

The farmers began to notice the usual doses of antibiotics were not working. They found themselves using more and more just to keep the pigs healthy.

What was going on? [daunting music, and continues]

What happened next left the farmers *blown away* and scrambling for control. daunting music ends]

MUSIC [song 1] for TRANSITION #2

[3] Introduce Antibiotics Resistance

EMAN

The broad-spectrum antibiotics had killed the majority of the bacteria, but not all. On the other side of the battlefield the surviving bacteria had been hard at work. With the help of selection over time, they had fine-tuned their defense mechanism – resistance.

[PAUSE]

Bacteria may be too small to be seen by the naked eye, but don't be fooled. They are masters of adaptation. Their biology has allowed them to develop resistance to anything that is thrown their way, given enough time.

They do this through two primary mechanisms:

- mutation
- or horizontal gene transfer

Horizontal gene transfer is the movement of genetic information from a donor to an unrelated recipient and the main mechanism behind multidrug resistance.

[PAUSE]

Horizontal gene transfer often involves the use of bacteriophages and plasmids.

Genes responsible for resistance in one species of bacteria can be transferred to another species through various mechanisms of horizontal gene transfer.

These mechanisms arm bacteria with resistance and once one species has it, the resistance rapidly spreads to others. This means that even bacteria that haven't been exposed to these antibiotics acquire this resistance.

And this is the beauty of horizontal gene transfer. It is simple and efficient. All that's required is selective pressure and this is exactly the mechanism that antibiotics utilized.

Unbeknownst to the farmers, antibiotics had become a double-edged sword.

[4] Too Much too Fast

MANUEL

As mentioned before, antibiotics help suppress the formation of bacterial populations in the pig's gut. In theory, this was perfect. The antibiotics cleared out the bacteria from the pigs gut and in doing so allowed for the

pigs to better absorb nutrients from the feed. This along with the decrease in pigs having diarrhea ultimately allowed them to grow in size. However, in practice, things took a turn for the worse at the farms.

In small quantities, antibiotics can work wonders. It is only when they are used excessively that we begin to see the escalation of resistance.

Because most antibiotics are taken orally the gut microbiome is always affected, regardless of the location of the target infection.

Today we know that the gut microbiome functions as a microbial organ that promotes health, improves nutrient utilization, and inhibits pathogens. It is important to note that there are both good and bad bacteria. The "good" bacteria in your gut work by colonizing the available space and resources that would otherwise allow the "bad" bacteria to thrive.

As their use continues, antibiotics become an environmental stressor and trigger selection for resistance. Therefore, the next time a course of antibiotics is given it will wipe out all the bacteria except for the resistant strains. Antibiotics do not differentiate between the two and annihilate all bacteria they encounter. Because there are no good bacteria left, the resistant bacteria are left to roam free. To colonize, multiply, and take over.

In response to this problem the farmers began to use a wider variety of antibiotics. Without realizing it they had selected for a reservoir of antibiotic resistant genes. One by one the pigs began to become ill and from their fall, a series of multi-drug resistant infections arose.

In 2019, the kidnapping of a little pig would come to show just how severe the situation had become. Her name, Lauri.

MUSIC [song 1] FOR TRANSITION #3 (time 2:07-2:20)

[5] Lauri

NOOR

Lauri's case sounds like it was taken straight from a movie. However, it is a very real and frightening case that opened a floodgate of concerns.

In April of 2019, a group of activists set out on a mission.

They were determined to document the conditions of the farm and then steal a pig. They broke into the farm [if only the big bad wolf had been that determined]. There was no time to ask for permission. It was a matter of time and getting on and off the property quickly.

Everyone involved knew it would be a difficult mission, yet they continued.

[PAUSE]

Inside they were horrified by what they discovered.

- the cries of sick piglets
- shelves and refrigerators full of antibiotics, many of them human grade

According to one of the two videographers of that night, “it was hell in there”

Amongst the chaos, was Lauri. A six-week-old piglet, frozen with fear. Her snout was flecked with crusty lesions, a sign of a skin infection among pigs kept in tight conditions. Lauri was taken away from the farm and to a vet at the University of Tennessee in Knoxville.

At the vet, a test confirmed that the little piggy had pneumonia, anemia, and a multidrug-resistant staph infection (MRSA). Lauri was so ill, not even a hungry wolf would want her. While her future seemed in the balance, things eventually turned around for Lauri. Today she lives in an animal sanctuary grazing and eating pumpkin squash.

[PAUSE]

Lauri’s story is one that is common amongst pigs across America, but very few get a happily ever after.

She is indicative of similar treatment in farms across America. They breed infections with poor living conditions.

- Tight quarters
- poor hygiene (manure all over the place)
- Spread from mom to piglet
- If the pens aren’t cleaned between litters

To be a pig in America means to be under constant stress and abuse until it's …lights out.

Antibiotic resistance is complex because killing the pig does not eliminate the problem. Resistance and bacterial infections do not simply stop at the death of the pig. This problem has evolved beyond the scope of the farm and has also come to affect the nearby environment.

MUSIC [song 1] FOR TRANSITION #4

[6] Resistance in the Environment

PAIGE

If you thought you could build a brick home out of not eating pork, think again.

Because of Horizontal Gene Transfer, we see that even the environment beyond the farm is negatively impacted by overprescription of antibiotics. This occurs from the jumping of bacterial antibiotic resistant plasmid genes from one bacterium to the next, conferring a number of resistances along the way.

A study that examined the effects of antibiotic-laden cow manure, found that the soil exposed to this manure had higher levels of antibiotic resistant genes and
The researchers also found evidence that, "exposure to manure from cattle treated with antibiotics drives changes in soil microbial community composition and ecosystem function."

This means that the antibiotics fed to the cow survived through the entire digestive system [all 4 stomachs] and were still active enough to alter the soil. But how exactly did this happen? Aren't antibiotics supposed to break down? Listen to what one of the researchers, DR. Strickland a professor in the University of Idaho Department of Water & Soil had to say:

[INTERVIEW - Dr. Strickland]: "There's definitely interactions between the soil, the antibiotics and what we're actually able to detect as an antibiotic in the soil. Many antibiotics degrade relatively rapidly or are potentially bound to soils or soil particles through cation exchange within the soil itself. But I think the big question too is that we can go out and say let's go target and look for something like tetracycline in a soil. And the thing is that we might not be able to detect it but there's the potential that actually these breakdown products of antibiotics also exhibit antibiotic properties. But we often times miss those when we are directly looking for those. We look at the end product of organisms that have been exposed to antibiotics, which are antibiotic resistant genes in a soil and try to better understand how those antibiotic-resistant genes increase or decrease when these organisms have been exposed to antibiotic inputs."

Resistant genes are not the only problem for the environment. Even the antibiotics themselves have the potential to disrupt important processes. Among these is the nitrogen fixation in the soil, a process whereby bacteria in the soil convert atmospheric nitrogen into nitrogenous

compounds in the soil that plants can then use. The reason this is important is because neither plants nor animals can use atmospheric nitrogen directly.

More than just the soil being affected, studies on animals, specifically rats, surrounding the farms have found that these off-target animals have higher loads of antibiotic resistant bacteria than those found in other areas.

All in all, this is an issue that has grown beyond the pigs and unquestionably beyond the farm. The problem is much bigger than it seems.

[7] Pig to Human

PAIGE

Because of the transferability to other bacterial species, antibiotic resistant bacteria don't spread only among the pigs themselves, but also between species, from pigs to humans.

A research study published in the New England Journal of Medicine highlights the existence of interspecies transmission. Here, the researchers studied whether or not antibiotic resistant bacteria found in pigs were also found within the human consumer of the pork. From the stool samples of the human research participants who consumed the meat over a period of days, the same antibiotic resistant bacteria within the pig was also found within the human subject's intestines in the days following pork consumption.

Pork companies claim that if the meat is cooked properly, the bacteria should be killed off, but clearly that's not happening. According to CDC estimates from 1998-2008 around 350,000 people get bacterial foodborne infections from eating pork each year. One type of antibiotic resistant bacteria the Campylobacter causes 448,000 illnesses and 70 deaths each year according to a 2019 CDC report. Symptoms of these infections include but are not limited to diarrhea, stomach pain and a fever.

[8] Antibiotic Resistant Infections

NOOR

The most common of these infections is MRSA, Methicillin-resistant Staphylococcus aureus. As the name implies, this is a strain of S. aureus infection that has acquired resistance against the antibiotic methicillin.

If this wasn't bad enough, there are currently NEW variants of MRSA stemming from livestock.

- According to a study done in Iowa, current workers that work with swine on these farms are six times more likely to carry multi-drug resistant *S. aureus* (MDRSA) than people who are not as frequently exposed to pigs.
    - Researchers collected nose and throat swabs, as well as skin swabs to check for *S. Aureus* infections
- Besides carrying multidrug resistant S. Aureus, the Iowa study also found that workers exposed to pigs were more likely to carry methicillin-resistant S. aureus (MRSA), tetracycline-resistant S. aureus (TRSA), and livestock associated S. aureus (LA-SA).
    - **There was a positive relationship between pig exposure and carrying these drug-resistant bacteria**, so the more exposure to the pigs, the higher likelihood of carrying these drug-resistant bacteria.
- The problem ***extends beyond*** the actual workers on the farm being susceptible to multidrug resistant S. aureus. Livestock associated S. aureus (LA-SA) and multidrug resistant S. aureus (MDRSA) were **elevated among the workers' family members**.

One way for people to get antibiotic-resistant infections is by eating the contaminated meat.

As we'll see in the case of Mikayla Porter, this can have life-threatening consequences on those who consume "tainted pork".

[9] Mikayla Porter – Pig to Human through Consumption

EMAN

In 2015, 10-year-old Mikayla Porter and her family attended a pig roast where she unknowingly consumed infected pork her parents bought from a local butcher.

For almost a week following the event, Mikayla suffered from fevers, diarrhea, and stabbing stomach pains. Mikayla had food poisoning, specifically from a salmonella variant resistant to antibiotics. The doctors were not optimistic and told Mikayla's parents that their 10-year old daughter could die within hours. However, like Lauri, Mikayla also made it out alive. And while we may sigh with relief knowing that Mikayla survived, let's not undermine the severity of the situation. That summer,

Mikayla was 1 out of 200 reported cases of people ill from eating “tainted pork”.

Mikayla’s case is a perfect example of how quickly antibiotic resistant infections can spread from pigs to humans. Even more terrifying, this is something that can happen to any of us. One moment we are fine, enjoying some food [we assume to be safe], and then next we are in a hospital fighting for our lives. The pork Mikayla consumed had been cooked for the recommended, 13 HOURS, and STILL Mikayla almost died.

At this point the biggest question is why is this happening? Shouldn't there be laws in place to prevent this? Stay tuned to find out..

MUSIC [song 1] FOR TRANSITION #5

[10] Legal

PAIGE

At this point you might be wondering what structures are in place that allow these types of practices to continue?

The most important legislative action to date was the FDA’s Guidance Document #213, which outlawed the use of antibiotics in agriculture for the purposes of growth promotion. This appeared to be a big step in the reduction of antibiotic use in agriculture. However, the late Congresswoman and microbiologist Louise Slaughter pointed out in an opinion piece that the dosage and duration for disease prevention, which is still permitted, is almost the exact same as that of growth promotion. Essentially we see a loophole here, where antibiotics are still administered when the pigs are not actually sick so long as the practice is labeled “disease prevention.”

Louise Slaughter herself introduced legislation in 2013 to the House of Representatives called the Preservation of Antibiotics for Medical Treatment Act, commonly known as PAMTA. This document is important because it is the ideal legislation from the perspective of a microbiologist.

While the legislation did not pass due to pressure from pharmaceutical companies and large farming corporations, the most important aspect of this document was the “phased elimination of nontherapeutic uses in animals of medically important drugs.” Nontherapeutic use means administering antibiotics when an animal is not sick. This means that disease prevention would not be a reason to administer antibiotics to animals, and would effectively eliminate all non-therapeutic uses of antibiotics in pig production.

Currently the only legislation that relates to the issue at hand is the Strategies to Address Antimicrobial Resistance Act, which does not specifically outlaw the use of antibiotics for nontherapeutic uses. However, it does suggest switching over-the-counter antibiotic feed to "available under veterinary oversight". The most important function of the act would be to create a task force to assess the progress to implementations of the government's action plan to curb antibiotics. While some important progress has been made within the last 10 years, there is still a lot of room for improvement, as seen in the case of Denmark.

[11] Denmark: How Legal came Together

NOOR

As a response to findings from the DANMAP surveillance system, which showed a heavy use of antibiotics in Denmark's pig sector for pork production, the Danish Veterinary and Food Administration (DVFA) created the Yellow Card Initiative in 2010 to stop the trend of antibiotic use in pork production and subsequently, growing antibiotic resistance.

- Yellow Card Initiative is aimed at targeting the farms/holdings in Denmark with the highest antibiotic consumption for pork production
- DVFA establishes yearly antibiotic use thresholds for different age groups of pigs
- DVFA also establishes thresholds for antibiotic consumption of every pig herd based on a calculated factor called Animal Daily Doses (ADD)
- **The initiative functions on three different levels: yellow card, heightened farm/holding supervision, and red card**
- If antibiotic consumption *surpasses* the threshold, the farmer gets a warning in the form of a **yellow card**. The farmer then has 9 months to bring their pig herd's antibiotic consumption down to below threshold.
    - If they cannot decrease consumption before the end of the 9 months, then another injunction is put in place on the farm, where the DVFA increases supervision of the farm, they can perform unannounced inspection visits, and will require the owner to meet with a veterinarian and create a plan of action.
- If the owner fails to fall below the threshold even after this next injunction, then the owner is issued a ***red* card**, **where they are forced to lower their stocking density of pigs.**

This seems to be an effective method for lowering the usage of antibiotics and its effects will be discussed later in the podcast. **While legal solutions are one way to attack this problem, there are alternatives to antibiotics that are being explored.**

[12] Alternatives

MANUEL

Fortunately, there are ways to reduce the amount of antibiotics given to pigs. These alternatives include

- the use of other antimicrobial alternatives
- altering the living conditions
- making the consumer voice heard

Let's begin by looking at one of the many antimicrobial alternatives currently available. [Other examples will be available in the supplementary information in final project]

- the use of essential oils

Essential oils are oils extracted from various plant parts. Research has shown that essential oils have positive effects on digestion, the gut microbial community, antioxidant effects, as well as growth performance and overall welfare.

Dietary supplementation of EO blends was found to increase the population of "good" bacteria [Lactobacillus] and decrease populations of "bad" bacteria [E. Coli].

The biggest advantage of using essential oils is that they have no known negative effect on the microbial population of composition of the digestion tract. In fact, they were found to improve the barrier function of the intestine.

But there is a downside to the application of essential oils and this has to do with their use.

[PAUSE].

The reason antibiotics are used so much is because they are easily and cheaply administered. Essential oils on the other hand require more money and effort to use. For example, they have the potential to evaporate before use. Essential oils are typically mixed into the compound feed directly in the feed mill or via a premix at the farm. Precise mixing equipment is required for a balanced distribution of the essential oils since inclusion rates are relatively small.

If you are a pig farmer and you need quick and cheap solutions, then you will choose antibiotics over essential oils because you know they will work.

In theory the use of essential oils seems like a great solution, but as we are constantly reminded... there is no such thing as a magic bullet [not one quick fix]. Even essential oils must be used with care and thought, or we risk selecting for resistance again.

[PAUSE]

Antimicrobial alternatives are not our only option. As we mentioned before, in order to keep up with the new demand for pork, farmers began to cut corners to maximize profit. In addition to increasing antibiotic use, farmers also changed the living conditions on the farm.

Farmers:

- decreased the pen size to maximize the number of pens in a room
- increased the number of pigs in a pen
- weaned the piglets earlier
- decreased the space for the mothers to nurture the piglets

Environmental factors play a major role in the development and spread of bacterial infections and resistance. In these extremely crowded conditions, piglets are prone to stress-related behavior. This includes cannibalism [yes pigs are omnivores, which probably explains why the third pig tried to boil the wolf] and tail-biting [which is why their tails are curled]. As mentioned before, these stressors increase oxidative stress, which decreases the number of good bacteria and allows for the rise of bad bacteria.

A study found that piglets in confined conditions have a higher count of the infectious disease-causing bacteria compared to piglets in the floor pen with adequate space.

Hence part of our solution is to focus on primary prevention rather than tertiary prevention, which is how the US pig farming industry currently functions.

By creating more open spaces for weaning pigs as well as increasing the weaning period we can reduce the levels of stress and the number of disease-causing pathogens. This in turn reduces the need for antibiotics to begin with.

[pause]

We as consumers AND human beings should also play our part. We cannot just sit back and complain.

- Proposal: advocating for the creation of regulations to increase the standard
- proposal 2: requirement of pork producers to provide greater transparency in the living conditions and sanitation of their pig factories

We cannot think of these alternatives without thinking of how they will affect the financial prospects of farms and consumers alike.

[13] Economics

EMAN

When considering the effects of banning antibiotics for non therapeutic use will have, it is important to consider the economics of it. Afterall, while it is easy to paint farmers as the bad guys one must remember this is their livelihood and, in most cases, farmers have little to no say in what they can use. As a part of the food animal industry, farmers abide by the regulations of feed formulations and antibiotic dosages set by a few integrators.

We can always look to Denmark and say, "Well, they are doing just fine, why are we not following in their steps?" But we must remember that the United States is much bigger than Denmark and we have very different cultures, practices, and priorities.

Denmark introduced their ban and it was enforced both by the people [through stigma and consumer power] and the government [through regulations]. In the United States most people are unaware of farming practices because it is done miles away from them. It isn't until they buy the product and get ill that they get an idea of the problem.

In 1999, research was done on the impact a ban like Denmark would have on the US swine rations. They found that:

- The cost per head would increase from $5.24 to $6.05
- However because of the higher prices due to smaller pork supply, net profit would decline by $0.79 per head
- The net present value of profit that the industry lost over 10 years is $1.039 *billion*
- Whereas the cost of adding a trough and space was projected to a total of $960 *million*

But what are the results of these changes? Do we see less infections? Dr. Landecker says it best.

[INTERVIEW -Dr. Landecker]: "What has been disappointing about the Denmark example is that it has not necessarily reduced the incidence of antibiotic resistant salmonella in the meat industry in Denmark to the extent that people were hoping for. It has reduced it but people were really hoping it would go away. You take these measures and you want to see dramatic results, and that has not been the case, and this goes back to what we were talking about before. Once you put these things in the environment, in the evolutionary heritage of the whole lot of all kinds of different species of bacteria, then the way that *it* continues to survive and magnify might have been dissociated from antibiotic use, it might be that once those resistance determinants are in place, the continued use of, let's say, quaternary ammonium compounds, is actually selecting for the gene cassettes, or these complex genetic formations where you have resistance to lots of things in one place and it just it takes ***one*** pressure to select for *all of those* because they are travelling together in a kind of genetic package. So we hope, we want, as legislators to make legislation, see a change in practice that then has the wished for change in disease patterns or resistance patterns and it's pretty clear from the Denmark example that once it's out of the bag, it's out of the bag. **And just working on antibiotic availability or use is not enough to control the problem."**

While we are on this topic it is also important to ask how the farmers are being affected by the outbreaks of antibiotic resistance and look into the effects stigma has on making change.

[14] Stigma Faced by Farmers

While popular media, research studies, and articles have all pointed out the presence and dangers of antibiotic resistance, the social and mental impact on the dissemination of this information on pig farmers has not been discussed as much.

In an interview-based study, Danish pig farmers were asked about antibiotic resistance and their experience with its relation to pig farming. There was a shocking number of negative responses from the pig farmer community. Farmers spoke out about feeling socially shamed by their community due to the concern about MRSA being spread from the pig farmers and their families, to other members of their community.

Feeling angry and distressed, pig farmers are speaking up about other people's conception of pig farming and the belief that pig farmers themselves are solely responsible for antibiotic resistance and its spread. Scientific experts and public officials even perceived pig farmers to be "stubborn...and deviant" and oftentimes mentioned the lack of

responsibility on the pig farmers' part in this public health crisis (Fynbo and Jensen 3).

It is important to talk about the stigmatization of farmers because it is easy to pin them as the villians in our story, but they are also victims. So this begs the question, who is the real villain? Who is our "big, bad wolf" and more importantly, will we ever find our brick home?

[15] Conclusion: Who is our big bad wolf and will we ever build our house of bricks

The use of antibiotics and then its overuse parallels the straw and stick homes the first and second pigs built. Quick and easy solutions to a problem. But we all know how that ended.

And the important thing to also realize is that there is not just one wolf, it's a ***whole pack***.

For instance, We typically think of farms as hundreds of grassy areas with small-town farmers. However, the reality is the concentrated feeding operations that pack pigs into poor living conditions. Most recent estimates claim that about 30 % of American Farmlands are owned by major corporations. This means these corporations have the power to decide *what* is grown and *how* it's grown on their land.

On top of that, the loss of power and the decreasing population of ***independent*** farmers has contributed to the *gain* of power these large companies receive.

Pigs and even livestock alone are just a small sector of a larger problem. Even if we win this battle, we have a whole war and we are seriously outnumbered. Simply put, we cannot continue to make the problem worse. It could be that one of the aforementioned alternatives that we have discussed today could be the solution but it will require work and sacrifices that major corporations and political entities are not yet willing to make, perhaps for valid reasons such as the economic prosperity of farms.

Nevertheless, we have the necessary tools to curb this issue at least in agriculture and even beyond. There is a solution out there, we just have to come together, instead of pointing fingers, and understand broader structural changes must be made. And if we don't, the way we utilize modern antibiotics will be a thing of the past.

*Outro Music [0:00-0:10 plays], then fade music to: **Special thanks to Dr. Strickland and Dr. Landecker for their time. And to Professor Kelty and Zia for their support throughout this process.** [rest of outro music resumes then fades out].