Science Will Win
Season 3, Episode 4

Let’s go back to a familiar scenario. Imagine this: it's a not too distant future. It’s a humid Tuesday evening. You’re hurrying down a crowded sidewalk to catch your train home from the office. The low sun is almost dizzying. Your mind is consumed with thoughts of your latest work projects, making it home on time to take the dog out, and the sweaty shirt sticking to your back underneath your blazer.

But then —

Your foot catches on a curb and you fall onto the sidewalk. You throw out your hands just in time to catch yourself, but a sharp pain mingles with the burn of the asphalt. You blink away the shock to find that you landed palm-down on a shard of broken glass. The jagged edge sliced into the heel of your left hand.

You scramble to your feet. The cut isn’t bleeding much — but you think back to your infectious disease unit in school. Back then, you learned about the danger that infections could pose, and the importance of preventative measures like sanitation. You’ve also been hearing a lot about bacterial infections and superbugs lately on the news, making those lessons all the more salient to you right now.

So, you squeeze through the crowd, hurry to the nearest public bathroom, and rinse off your injury at the sink. You bundle some toilet paper into your hand and rush back to the train to go home.

At home, you refresh your memory on how to properly bandage an injury with ointment and gauze. As you doze off that evening, you try to ignore the momentary twinges of pain.

Despite your best efforts, you start to feel strange just a couple days later. When you unwrap the cut on your hand, you find it swollen. It’s throbbing and hot to the touch.

These look like signs of an infection.

You were hoping it would clear up on its own — after all, you took those preventative safety measures. But you know that a potential infection should be addressed as soon as possible. So, you go to the doctor right after work that day.

The exam room is filled with a sharp, familiar medical smell: a mixture of latex, rubbing alcohol and nose-burning, heavy duty floor cleaner.

Finally, the doctor comes in. You wince as she unwraps your bandage and swabs a fluid sample from your tender wound. She tells you the test will only take about a day to come back, thanks to new artificial intelligence tools. The wound is most likely infected, but they're going to grow bacteria from the sample in a lab to see what the infection is.

The doctor praises your treatment of the wound and commends you for coming in at the first sign of infection. Nonetheless, dangerous infections can still occur. Both of you are aware of the recent spike of antibiotic resistant bacteria in your area. You know about it because infectious disease experts have been using advanced data analysis and AI to track the growth of the outbreak. The uptick led to a public awareness campaign in your city. You can hardly go anywhere without seeing a bus stop ad or hearing a radio segment reminding you to be safe and diligent.

The doctor assures you that most infections are very treatable, and they have new techniques to help with more serious cases.

You feel a little calmer after that explanation. You take some medicine for your slight fever and go home.

As you wait for the call from your doctor, you notice signs of your infection escalating. Your fever gets a bit worse. The cut on your hand is throbbing and aching constantly. You're glad you already went to the doctor, but you can't help feeling anxious. You take a sick day from work and spend most of it sleeping, with a fan pointed directly at your face.

You're jolted awake by the harsh buzzing of the phone on your nightstand. When you hear the doctor's voice on the phone, she sounds urgent. She wants you to come back in right away.

Back on the cold table of the exam room, your doctor tells you that your infection is caused by MRSA. You recognize the word from the campaign ad you see every day waiting for the train to work — so you know it's a bacterial infection, but you don't know too much beyond that.

The doctor starts rattling off an explanation: MRSA is a type of staph infection. It's difficult to treat, since it can be resistant to many antibiotics. There are only a small handful of medicines that can treat it. It's lucky that you treated the wound well and came in early.

The doctor explains that the lab ran the bacteria they cultured from your wound through a series of tests, assisted by artificial intelligence, that identified the best medicines to use against this bacterial strain. You are prescribed an antibiotic that has been suggested in a Clinical Decision Support System, based on your electronic health data.

It's a new antibiotic targeting MRSA that was recently discovered with help from machine learning and approved by the FDA.

Having an infection is scary. But you know there may be options available.

Jeremiah:
Did this story give you deja vu? We started this journey with a similar scenario in episode one. In *this* story, however, better prevention measures and education helped slow the spread of antibiotic resistant bacteria. Then, AI powered solutions — some of which are already a reality and some of which are currently being explored — helped the doctor choose a possible treatment course and broaden their other treatment options.

This scenario is one glimpse at how the innovations we're talking about today might change the outcome of patients in the future.

[MUSIC]

Jeremiah:
Welcome back to season three of Science Will Win. I'm your host, Jeremiah Owyang. I'm an entrepreneur, AI investor, and tech industry analyst. I'm passionate about emerging technologies and the ways they can shape our world.

This season, we're talking about artificial intelligence and how it can help the scientific community overcome one of the greatest challenges facing humanity: Antimicrobial resistance, or AMR.

In our previous episode, we learned about how artificial intelligence is helping scientists develop new antibiotics and treat patients with the most targeted antibiotics — even for hard-to-treat infections.

For the final episode, we're looking ahead to the future and getting a glimpse of a potential world in which we stay one step ahead of AMR. We'll talk about the education, stewardship, and policy efforts needed for success in the fight against AMR. And we'll explore how AI can empower us in those efforts — and enable more effective, accessible, and equitable healthcare.

[MUSIC]

Jeremiah:
I want to briefly go back in time. Because sometimes, when we're trying to imagine what a different future could look like, it helps to remember things weren't always this way. Back in the 1990s, Dame Sally Davies was working as a physician. It was a time when AMR wasn't thought of as the same looming disaster it is today.

Dame Sally Davies:

The microbiologist would say, well, Sally, this infection, the poor patient that's got it's resistant to drug A just, and he'd open his cabinet, used drug B, and the patients would get better.

Jeremiah:
Over the course of her decades-long career, she's watched as this quickly ballooned into a huge problem.

Dame Sally Davies:
I've never forgotten the six year old who, that I looked after with sickle cell anemia, who was sent to school well by his mother in the morning. She was phoned by the school in the afternoon, she picked him up at three o'clock in the afternoon. He was unwell, she went to the GP who was scared witless how ill he was, and called an ambulance. He was treated with the correct normal antibiotic intramuscularly by injection at 6:00 PM and he was dead by 10:00 PM. So that gives you the feel of how if you've got sepsis with a resistant organism, you can just die despite getting an effective treatment or, and more easily, die if the treatment is ineffective.

Jeremiah:
After working as a physician, Dame Sally Davies spent nearly a decade as the UK's chief medical officer. Today, she's the UK Special Envoy for antimicrobial resistance.

Dame Sally Davies:
As special envoy on AMR, what I do is work with other countries and around the world raising awareness and pushing for action on this dreadful, existential risk of antimicrobial resistance.

Jeremiah:
As we've explored all season, tackling AMR takes a lot of work. One of the key parts of addressing AMR is closing the education gap — on a local, national, and international level. Much of the problem right now is that the public doesn't know about the problem.

Danie Gallego:
The first thing that you learn in antimicrobial resistance, I think, is that people are not worried about resistance because they are unaware.

Jeremiah:
That's Daniel Gallego. In 1995, he was diagnosed with a chronic kidney disease, and he's been undergoing hemodialysis every other day ever since. Daniel knows that the consequences of antibiotic resistant bacteria are very real for scores of people with kidney disease.

Daniel:

Infection is the second cause of all deaths in, in kidney disease. So for us, uh, infection and, and antimicrobial resistance, of course, is a very, uh, critical point, uh, to tackle holistically-this matter.

Jeremiah:
Kidney patients like Daniel have to be constantly diligent about infection. Certain medication — or even chronic kidney disease itself — can weaken the immune system. Daniel himself has had a recurring infection that comes back again and again for almost 30 years.

Daniel:
And I need to take antibiotics, and I've been changing antibiotics to try to improve the, the effectiveness, but sometimes it's not working and I have seen people dying by sepsis, and it's horrible because, uh, you have the sensation of powerlessness. You, you can do almost nothing. Now, uh, the antibiotics are not working and, and they are not another therapeutical options to fight against the, the infection.

Jeremiah:
Which brings us back to Dame Sally Davies, and her efforts to improve communication about antimicrobial resistance. It starts with the way we talk about the problem itself.

Dame Sally Davies:
There are a number of problems with AMR and the understanding of it. The public just about gets superbugs, bugs that seem to be resistant. But if you talk about resistance, they often think it's the human, the patient, rather than the bug. And we have to explain it's the infective organism that has quite routinely developed resistance.

Jeremiah:
What Dame Sally has found when trying to explain AMR in her work is that it can feel like such a broad problem. There isn’t just one type of bacterium or one medicine that’s the issue, and different people can react in different ways. Until now, we’ve been focusing on bacteria. AMR also encompasses resistance across a spectrum of diseases — viral disease, parasites, and fungi. It’s hard for patients and the general public to really get a grasp of it.

Dame Sally Davies:
Generally, what they're told is, oh, um, you're not responding well to this antibiotic. You the patient rather than the infection isn't responding well, and so we'll swap you to something else. Occasionally it bubbles over when you get a patient with multidrug resistance infections, and then that can hit the newspapers. But in general, it's not a concept that is discussed with patients and relatives even after someone has died. So it stays there in the background, never named. The ghost of the feast, you might call it.

Jeremiah:
The solution that Dame Sally has found is focusing on clear language to explain the science behind AMR, and conveying the reality of AMR. There’s potential for artificial intelligence and

natural language processing technologies to play a big role in that in the future. We're already seeing evidence of that today.

One example is CLEAR, an AI-powered health literacy tool that Pfizer has made available to select patient advocate groups in the U.S. Oftentimes, medical explanations are filled with scientific jargon that the average person may not understand. CLEAR aims to help solve that by using AI to analyze the text first. From there, it makes recommendations so that the text is more understandable for patients, while also being accurate.

[MUSIC]

Jeremiah:
So, in this potential future, we have a better understanding of how AMR works — we're getting educated on the risks, and how to minimize its impacts. And the public is getting that information in clear, understandable language. But we're not going to simply educate ourselves out of this impending AMR crisis. We will need safe, effective antibiotics to back us up. And artificial intelligence can help us with that, too.

In episode three, we talked about the challenges of developing new antibiotics. Bringing a drug through development is a long, complicated, and expensive process. A 2022 study from the World Health Organization found that the cost to develop a new drug ranges from 43 million to 4.2 billion U.S. dollars. And most of that cost comes from the clinical trial phase.

> Subha Madhavan:
> We spend so much money in collecting this clinical data, it would be a shame if we don't leverage all of that data to improve medicine, right? And this is in fact the most expensive data that we collect today. And, you know, if we don't actually make use of that, uh, you know, what are we doing, right? So why are we collecting that data just for that episode to treat the patient? But we should be able to leverage that data more broadly.

Jeremiah:
That's Dr. Subha Madhavan. She is the head of AI and Machine Learning, Quantitative and Digital Sciences, Global Biometrics and Data Management at Pfizer.

> Subha:
> I am first and foremost a computational data scientist, and here at Pfizer, I lead a team of data scientists and statisticians who work throughout the continuum of clinical trials to really enable data collection, data analysis, and also reporting of this critical information, uh, to regulatory agencies.

Jeremiah:

Lately, Subha and her team have been focused on how AI can make all clinical trials more accessible and efficient at every step in the process — from selecting clinical trial sites to administering medications.

At the start, AI can help administrators predict where the next big wave of an infection will hit, and from that, identify the optimal site to set up a clinical trial.

The next step is sourcing patients.

> Subha:
> You of course cannot test billions of people, you know, you want to have enough representation of the broader population that you want to test in your clinical trial. So this is where AI can come in handy, right? So AI can help basically reduce bias in terms of, you know, the Caucasian, African-American, Asian populations, et cetera, that get recruited on this trial and make sure that there is a balance, uh, in the population, which represents the same distribution as the census of that particular country.

Jeremiah:
If you're the patient, you might be approached by your doctor about signing up for a clinical trial that could be a good fit for your health needs. But matching patients to a clinical trial is not an easy task.

AI can help here, too. Research registries like PfizerLink, where people can sign up to get involved in clinical research, use artificial intelligence to help match patients' unique health information to a clinical trial that might be right for them.

> Subha:
> These AI driven patient registries can help identify what we call as cohort discovery, can help identify the right cohorts, um, for this new antibiotic treatment, for example, right? So if you're resistant to one, what is the right next treatment that you can, you can get onto?

Jeremiah:
Once a trial has all its participants, AI yet again comes into play, helping to make the trial itself run more smoothly.

AI can be used to help monitor patients in real time, track symptoms and health state, and identify potential adverse events early.

And these are just some points of data a trial investigator might be considering. They might also be electronic medical records, genomic biomarker data, radiology images, voice recordings describing symptoms. It's a lot to keep track of.

> Subha:

So this multimodal information is really needed to be integrated to get the best value out of each clinical trial. And that's where AI is very helpful. So it can connect the dots across these different modalities of data to derive the best information on whether or not this therapy is working, whether or not this modality is working, what are some adverse events, et cetera.

Jeremiah:
And it's important to explore these different methods of data collection because it can make clinical trials and healthcare more accessible. Using wearables or apps to collect data makes it possible for patients to participate in a trial *remotely*. This means a wider array of people can participate in clinical trials than ever before. The Pf(IR)e Lab at Pfizer is currently testing different ways wearable trackers can be incorporated into clinical trials.

These innovations can make healthcare more accessible, regardless of where a patient lives.

Subha:
You know, it used to be, even if you just kind of went back 10 years ago, the best care would be in these tertiary care facilities, right? If we trained these AI models with patient data and the outcomes from tertiary care facilities, you could literally bring that same level of care to everybody around the world.

Jeremiah:
The trial doesn't end with collecting and monitoring the data. A crucial part of the process involves clinicians compiling a clinical study report to summarize the findings of the trial. And that can take a while. AI can help with making this writing process faster, cutting down on weeks of work. It may seem basic, but it could mean a drug gets to market sooner.

Subha:
Now, imagine application of generative AI, right? So if we could apply generative AI to automate some of these sections with the human in the loop, of course, you need the experts to be reviewing the output that's coming out of these generative AI, and this can help us optimize the time it takes to generate these very critical documents. So even if you brought the time down by about, you know, 20 to 30%, you are saving days before which this can be submitted and therefore, uh, be made available in the market to patients that need them.

Jeremiah:
These implementations of AI are already in use, and there are more coming down the pipeline.

Of course, AI is meant to enhance and empower humans, not completely replace them. That's why Pfizer's AI projects should have human oversight to ensure the AI is secure, valid and safe, and that there are no errors or biases in their data and models.

Even beyond clinical trials, Subha is looking forward to the ways AI can help doctors make use of all the patient data they are constantly collecting. For every eight hours scheduled with patients, physicians spent five or more hours working on electronic health records. When it really comes down to it, doctors need more time. AI may help with that.

> Subha:
> People are putting in a lot of effort into collecting this data. AI will be helpful to really take advantage and leverage, uh, this data.

Jeremiah:
When doctors get help with data entry and collection, they free up some time and energy to spend time with patients. Artificial intelligent assistants could also help while physicians are considering different treatment options. Here's one way that plays out. It's something Dr. Jay Purdy, Vice President and Therapeutic Area Lead in global medical affairs at Pfizer, finds especially exciting.

> Jay Purdy:
> So when a physician's in a hospital and they choose an antibiotic, an artificial intelligence system could remind them, hey, do you remember that two weeks ago a pathogen was isolated that was resistant to that antibiotic in that patient, or could remind them, you remember that in our hospital, most pathogens of that type are resistant to the antibiotic you're giving the patient. And those sorts of reminders that keep track of risk factors for the patients are important.

Jeremiah:
Remember the scenario we described at the beginning of this episode? This extra decision-making help from artificial intelligence *before* prescribing an antibiotic is an important part of good antibiotic stewardship. Antibiotic stewardship helps doctors and patients be responsible with the antibiotics that we do have, and ensures we slow the evolution of dangerous bacteria.

> Jay:
> One of the areas that we're looking at is looking at risk factors for multidrug resistant infections.

Jeremiah:
Not every patient requires the most powerful antibiotic. So which patients are most likely to benefit? The answer to that question lies in the data. Does this patient have a drug resistant pathogen? What are their other risk factors? Artificial intelligence can help quickly analyze these data points.

> Jay:
> Once you think you've isolated some of those, what you need to do is take those risk factors to a different data bank and see is it valid that it—it's called validation of those

risk factors. Now that's an area that it really could be useful, that would physicians' attention on those patients most likely to have the resistant pathogens.

Jeremiah:
This brings us to the final hurdle to slowing the increasing risk of antimicrobial resistance: fostering and ensuring an environment of trust. Here's Ranjit Kumble, who you heard from in episode two. He leads the Enterprise Data Science Team at Pfizer Digital.

Ranjit Kumble:
People's medical information is, it's very, very private and personal to them, of course. And, you know, the, the fear that that information might be used in some identifiable manner that isn't appropriate is I think something that, you know, causes some degree of concern, even though, you know, the regulations, the safeguards, and the ethical frameworks are all there in place to prevent that.

Jeremiah:
It makes sense that patients might have some concerns. We're talking about artificial intelligence — a relatively new technology that many don't know much about or are even fearful of. Patients learn to trust their doctors with personal, private information about their bodies and health. But people aren't always ready to extend that trust to artificial intelligence or additional third parties.

So companies like Pfizer are creating their own principles, policies, and guidelines to help ensure data and AI are used responsibly, for the benefits of patients, customers, colleagues, and society. Next to human oversight, which has been mentioned before, respecting individuals' need for privacy and transparency in the use of data and AI is one element of that.

Ranjit:
You know, when we've looked at, for example, the rollout of AI systems for very powerful applications in other industries, what we have seen early on is that, um, if everything isn't super easily explainable, it can cause people to maybe draw the wrong conclusions. And so transparency is everything right from the outset to make sure that never happens.

Jeremiah:
Another area of focus is equity. Since AI is trained on past data provided by people, it's possible that it could repeat or mimic the same old mistakes, or perpetuate the same biases that people already have.

Pfizer has a digital tool called Ethicara which helps internal AI practitioners address critical ethical considerations in AI projects. For example, Ethicara can be used to analyze artificial intelligence algorithms for bias in the data or bias in the algorithm itself, and to recommend mitigation steps.

Ranjit:

> There are amazing opportunities for predictive algorithms to help a doctor suspect that a patient who's reporting certain symptoms to, to them at that moment may need to be considered for let's say a rare condition and thereby speeding up the process of identifying and diagnosing it in breakthrough ways. But if that prediction is only really accurate for certain subpopulations and not for others, it's only going to keep making disparities and inequities worse. Cuz' at the end of the day, if these principles are not being adhered to, then the true benefit to patients isn't realized.

Jeremiah:
National governments are also taking notice, and working to get ahead of any potential pitfalls when it comes to using artificial intelligence tools. In October 2022, the Biden Administration unveiled The White House's Blueprint for an AI Bill of Rights. It outlines a set of principles to help responsibly guide the use and design of AI. Also, the EU drafted the AI Act, the world's most far reaching attempt so far to mitigate the potentially harmful effects of artificial intelligence.

Creating a common language for responsible AI use could potentially encourage more global collaboration. And that's something Ranjit believes is essential to properly take advantage of the benefits of AI.

> Ranjit:
> By collaborating on areas of common need, while ensuring that all regulations are followed at every country's level, we have that opportunity to kind of learn as a whole system without in any way compromising what's required in each, in each local environment.

Jeremiah:
If we stay on our current trajectory, The O'Neill Report stated that AMR could cause up to 10 million deaths annually by 2050. The impact of unchecked illness could cut over $3 trillion off of the global GDP and plunge tens of millions more into poverty.

Antimicrobial resistance is already affecting people in low- and middle-income countries more intensely. In these regions, people are 1.5 times more likely to die of drug resistant infections than people in more wealthy countries.

That makes it all the more important to use these AI tools to their fullest today, while keeping an eye on the future. When Dame Sally Davies considers the future of AI and antimicrobial resistance, equity and access is one of her top concerns.

> Dame Sally Davies:
> So it's not that the rich countries are walking away with the spoils and the new treatments and the innovation. We have to find ways to make them equitably accessible. But we can, and we must.

Jeremiah:
Antimicrobial resistance has become a global crisis over the span of a few decades. But I think what's important to focus on is the fact that scientists, doctors, and policymakers working together *could* just as quickly mobilize, and use new technologies and ways of collaborating to help stop this crisis before it boils over. Because we can't solve tomorrow without making big changes today.

With that in mind, I'd like to close out our series with one real way we're already working toward that future change. When we asked Dame Sally about the role technology plays in these efforts, here's what she told us:

> Dame Sally Davies:
> I think it's very exciting that recently we saw that an antibiotic had been developed using AI technology.

Jeremiah:
What Dame Sally is referring to is a recent study published in the journal *Nature Chemical Biology*. In it, researchers demonstrated that AI was able to narrow down a potential new antibiotic to treat one type of serious hospital infection.

It took the AI just an hour and a half to produce a shortlist. From there, scientists began the testing process and found one that could potentially target one specific type of resistant bacteria. The testing and synthesis process continues.

This is just a start, but it's a promising one. As Dame Sally Davies put it:

> Dame Sally Davies:
> AI is going to play a big role and that's absolutely great. Bring it on.

Jeremiah:
That's all for this season of Science Will Win. Thank you so much for joining me on this journey. We hope you join us for future seasons!

Science Will Win is created by Pfizer and hosted by me, Jeremiah Owyang. It's produced by Wonder Media Network. Please do take a minute to rate, review, and follow Science Will Win wherever you get your podcasts. It helps new listeners to find the show. Special thanks to the responsible AI and anti-infective teams at Pfizer. And thank *you* for listening!

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