Sadie Witkowski: Ok Ian, I just have to take a moment to brag a bit.

Ian Martin: You? Brag? I'm shocked!

SW: [laughs] Ok ok. I just wanna brag that I got to attend the big masquerade ball at this year's San Diego Comic Con International.

IM: Ok, I know you're trying to make me jealous. But when I hear masquerade ball, I think people voguing. And when you saw masquerade ball, I'm picturing nerds in masks?

SW: Well, it wasn't either of those kinds of masquerade. You see, that's actually the name for the annual costume contest, where people get to show off the custom cosplay they've worked all year on. And this year, one of the big winners was a girl who made a disturbingly realistic "bloater" from the Last of Us.

IM: You mean she made a scary fungus monster from that HBO show?

SW: Thankfully, I got to appreciate her costume without being chased by a bunch of fungus zombies from the show.

IM: So is that where we're going in our Hollywood series today? Are we talking about The Last of Us?

Tara Kerin 04:08
loved it was so good. The writing is phenomenal. Like I just absolutely wonderful.

SW: We are indeed! With the help of today's guest.

Tara Kerin 00:08
My name is Tara Kerin, I have a PhD in epidemiology. I concentrate on infectious diseases, mostly HIV, but a little spattering of COVID and Zika in there, too.

IM: I've been curious to hear if epidemiologists found The Last of Us as compelling as I did.

SW: Same, which was a big reason I wanted to talk with Tara! And it turns out the show does a pretty good job of exploring some ideas in epidemiology that ultimately come back to math and statistics.

IM: But before we start exploring the fungal wasteland of The Last of Us - let’s do introductions! I’m Ian Martin

SW: and I’m Sadie Witkowski

IM: And you’re listening to Carry the Two, a podcast from the Institute for Mathematical and Statistical Innovation, AKA IMSI.

SW: This is the podcast where Ian and I talk about the real world applications of mathematical and statistical research.

IM: Or in this case, Hollywood!

SW: As we like to say on the show, it turns out that you don’t need a math degree to see how mathematics plays a key role in all sorts of unexpected places.

Tara Kerin 57:08
in all honesty, you know, when it comes to math. I didn't get to the point where I was taking, like, advanced calculus. Honestly, I started to get bored with math when it stopped having an answer. I liked math for having an answer. That's, that's what I wanted.

IM: I love that this show has just become a cycle of showcasing the work of non-mathy people and revealing it’s secretly all math.

SW: Ooops all math! [laughs]

IM: Exactly!

SW: Well for today’s topic on The Last of Us, Tara brought us three core ideas that apply both to her work as an epidemiologist and to the apocalyptic world of the HBO series.

IM: Hmmm…. Based on everything I learned about COVID back in March 2020, I’m guessing we’ll be talking about a disease’s rate of infection?

SW: Right on the money! That’s the first point Tara brought up.

Tara Kerin 09:21

we call it the R naught. It's the R zero, as you've probably seen in the newspapers and different things like that. And it's, it's really fun that that's actually something that everybody kind of understands, you know, that it's important now,

IM: I remember this from the early days of covid, when everyone was trying to figure out how contagious the coronavirus was.

SW: And that’s basically what r-naught is telling us. For example, measles has one of the highest r-naughts that epidemiologists track.

Tara Kerin 12:20
Measles is is the highest we kind of count. And then is 18. So for every person and they are not means like for every person infected, they will infect 18 more people. Which is why it's always a big deal when you have the Disneyland outbreaks of measles.

IM: So how do we calculate the r-zero?

Tara Kerin 09:36
it's a lot of factors. There's the three kind of basic things that go into it,

SW: The first being the infectious period. Or as Tara puts it

Tara Kerin 09:41
time of contagiousness, so how long that you personally are contagious. So for in the game, or the movies or TV as you know, for The Last of Us. You are going to have a very high value for contagiousness because you are willing or, and able to spread it for as long as you know, you're walking.

IM: So it’s the amount of time that you still have the disease and can spread it to others.

SW: Right, how long are you contagious to others. So for real diseases where you aren’t in treatment, it’s an incredibly long time for something like HIV and much shorter for the rhinovirus, or the common cold.

IM: And in The Last of Us, this number is…. Infinite I guess? Since, spoilers, once you get bit by a fungus zombie, you’re forever contagious.

SW: Unless Joel or someone else takes you out, yes!

IM: What’s the second factor for calculating the r-zero?

Tara Kerin 10:12
But the second thing that goes into your r-naught, besides how how long someone is contagious is how easily it can be spread.

SW: So here we're talking about transmission. Things that are airborne spread through a population much easier than something that requires contact with a bodily fluid.

Tara Kerin 10:40
So for instance, you know, if you have to bite somebody, to have it spread, that is harder to spread than if something is airborne.

IM: Right. So while the cordyceps stays in your system forever in the show, it's harder to transmit because it requires you being bitten.

SW: I haven't played the game that the show is based on, but apparently in the game there's an airborne component too. Since in real life, mushrooms produce spores which could conceivably be another way you could get infected.

IM: I see why they didn't do that in the show though. Not very easy or interesting visually.

SW: [laughs] Right, you can't get a jump scare from spores like you do from horrifying zombies. And as for the third major factor in determining r-naught, it's contact rate.

Tara Kerin 10:23
that would be sort of, you know, your likelihood of being infected. So the contact, how many points of contact, how many people you're gonna see, obviously, as part of it,

IM: This is where social distancing comes into play!

Tara Kerin 15:06
social distancing is a really good example of that on how you can influence the r-naught by just taking away one of those parts of components of the, of the calculation. You take away the contact, and then you've, you know, you've lowered the r-naught.

IM: So infectious period plus transmission mode plus exposure, or contact rate, gives you r-zero. Also called r-naught.

SW: Easy math, right?

Tara Kerin 11:41
R naught is also dependent, the way it's calculated is that everybody is vulnerable. So, in the in the science in the calculation of an r-naught, that means that no one has had a vaccine, no one has immunity, no one that you know. This is, this is as if we're all vulnerable, this is how quickly it would spread.

IM: Of course, both the game and the real world have pretty clearly shown us that this just gives us an approximate measure.

SW: Totally

Tara Kerin 13:20
you have, there's three basic things I was talking about. But you also have policy implementation, other environmental factors that can really change stuff.

IM: So did you ask Tara to estimate the R-naught for the cordyceps infection shown in The Last of Us?

SW: Sure did!

Tara Kerin 26:52
the r-naught I would assume in The Last of Us, is somewhere close to infinity, I you know, I can't grasp how that's, it's not just out of the world. But, um, so it might be kind of hard to use that as the example because at that point, math is of no help. It is just you have gone into this post apocalyptic, you know, world, but in the real world, how we take these things and math and use it to determine how infectious This is, again, by using these components of contact, likelihood of infection, and mode of mode of transmission, come up with sort of these arbitrary numbers. But these arbitrary numbers also help us to define policy, they help us to figure out how exactly to prevent infections, how to, you know, if things need to be curbed, if they need to just, you know, let it be, and also how we are going to tackle and things of healthcare,

IM: Ah yes, “flattening the curve.” Are you trying to give me early COVID flashbacks here?!

SW: Sorry! I knew that was a danger when we decided to cover The Last of Us. But let's try to keep it in the realm of fiction as best we can.

IM: Thank you.

SW: But you are totally right that we're going to be talking about flattening the curve, and explaining what exactly we're referring to as the curve. But….

IM: After a short message from UCPN.

[music starts]

[ad break - 9 questions]

[music fades]

SW: Alright, let's talk curves! Or, more accurately, slopes!

Tara Kerin 26:15
I saw a comic the other day that said, one more day where I haven't used y equals mx plus b, and I'm like, Oh, my gosh, I use that yesterday, though. Like, I use that every day.

IM: Now instead of covid flashbacks, I'm getting high school flashbacks!

SW: This is a pretty basic equation that describes a linear relationship, right? And it's the basis for understanding disease spread in epidemiology! Although obviously, this line gets complicated really fast.

IM: Can we do a quick reminder of what everything stands for?

SW: Sure! X and Y are the points, or coordinates, that identify where we are along the slope.

IM: And I remember b is the intercept, you know, where the line or slope starts at the 0 point.

SW: And m is the slope of the line!

IM: Pretty simple, all told.

Tara Kerin 57:47

I do wish that people would think about, like, how much math in general affects every part of your daily life, particularly in epidemiology. But it also doesn't have to be as hard as, as it appears to be. Not everything is super complicated.

Tara Kerin 58:12

You know, your Y equals MX plus B is something that's actually a very simple calculation. It's not super difficult. And these are like the basis of, you know, most of the things that we do

IM: So at the top of the show, you said we were going to cover three core ideas.

SW: Mmmhmm

IM: We've gone over infection slopes and calculating r-naught. What's the last one we're missing?

Tara Kerin 30:58

they also have the ability, at least to in, in the, in the show, I assume there must be a way to do it in the, in the game to have checking to see if somebody has been infected.

IM: Oh yeah, they have the little handheld sensor that lights up green if you're uninfected and red if you got bit.

SW: They never talk about this in the world of the show or the game, but somehow that test is shown to be always 100% accurate.

IM: Oh so you can suspend your disbelief for a worldwide epidemic of mushroom zombies, but you draw the line at testing?

SW: [laughs] Look, we all have our hills to die on.

IM: Mine's that white chocolate isn't chocolate. I don't care what the science says.

SW: But back to *my* hill. In the show, they have a rapid way of testing people for the fungus that seems to have perfect sensitivity and, we assume, perfect specificity.

IM: These… sound like scientific terms with defined meanings.

SW: Right you are!

Tara Kerin 54:05

sensitivity meaning that in any tests that you get, we call them screener tests, you know, whether it be for cancer, whether it be for, you know, COVID, which is, you know, what all of these, your antigen test is your take home test is a screener test. This is basically, there's two ways you can do it, you can have things that are really, really sensitive. You know, say if something is 99% sensitive, it means that it will pick up pretty much everybody who's got it, but it will also, you know, like, it is going to, you know, that's, that's everybody who's got it is a true positive.

IM: So even if you have the tiniest amount of fungus or spores in your system, a sensitive test is going to catch that very small signal.

Tara Kerin 54:48
Like, if you test positive on that test, you really have it.

SW: And for specificity…

Tara Kerin 54:53
Now you have specificity, which is sort of the opposite, which is the negative, you test negative on a test then you were truly negative.

IM: Oh, I really remember these concepts from all the rapid testing we did for covid.

SW: Exactly! The at home tests versus going into a clinic for a PCR test had different levels of specificity and sensitivity.

Tara Kerin 55:03
the idea is that you want to combine the two. So you have high sensitivity and high specificity.

IM: Like, the at home tests weren't always that sensitive and they'd sometimes say you were fine when the lab tests showed that you actually did have covid.

SW: And this kind of testing was extra important for covid, because most people were infectious before they started showing symptoms.

IM: Which made it so much easier to spread.

Tara Kerin 31:13
The Last of Us was also pretty good on showing symptoms soon. Which is sort of another thing that can kind of, you know, help into determining not only policy and the

r-naughts. But like, yeah, that sort of math of like, with COVID, we had a lot of people who were you know, you're most infectious right before you start showing symptoms. Whereas the other way of The Last of Us, you're, you're not going to attack until you're actively showing symptoms.

IM: Oof yeah it would have been much easier to deal with Covid if you showed symptoms sooner and were more aware that you were sick.

SW: I think The Last of Us was such a hit because it really centered good storytelling on how people relate to each other, especially under difficult circumstances. But for the nerds among us, it was also pretty great at including some scientifically plausible ideas.

Tara Kerin 48:17
I did like that idea of having the maternal antibodies, because I mean, this is, this is why women are, you know, encouraged to breastfeed,

IM: Entertainment as an educational tool! I mean, we like to make fun of hollywood and shows getting stuff wrong, but people really do learn a lot from the media we consume.

SW: And in the case of The Last of Us, it's a great tool for introducing the basics of epidemiology!

Tara Kerin 52:48
I think that people don't realize how much math and statistics is in epidemiology. And it's, you know, it's actually wonderful and fantastic.

Tara Kerin 26:10
the great underlying thing of life is math.

[outro music starts]

SW: Don't forget to check out our show notes in the podcast description for more about Tara's research, the science in The Last of Us, and how you can support the ongoing WGA/SAG strike.

IM: And if you like the show, give us a review on apple podcast or spotify or wherever you listen. By rating and reviewing the show, you really help us spread the word about Carry the Two so that other listeners can discover us.

SW: And for more on the math research being shared at IMSI, be sure to check us out online at our homepage: IMSI dot institute. We're also on twitter at IMSI underscore institute, as well as instagram at IMSI dot institute! That's IMSI, spelled I M S I.

IM: And do you have a burning math question? Maybe you have an idea for a story on how mathematics and statistics connect with the world around us. Send us an email with your idea!

SW: You can send your feedback, ideas, and more to sadiewit AT IMSI dot institute. That's S A D I E W I T at I M S I dot institute.

IM: We'd also like to thank our audio engineer, Tyler Damme for his production on the show. And music is from Blue Dot Sessions.

SW: Lastly, Carry the Two is made possible by the Institute for Mathematical and Statistical Innovation, located on the gorgeous campus of the University of Chicago. We are supported by the National Science Foundation and the University of Chicago.