

Maths + Cancer

Episode 4: Numbers don't tell the whole story with Professor Hannah Fry

Transcript

Vicky Neale:

My name is Vicky Neale, and I'm a mathematician at the University of Oxford. Since March 2021, I've also been having treatment, on and off, for a rare form of cancer. That's been very educational, I've been learning lots about cancer and the various treatments available. While I wish it was less personally relevant to me, I also find it fascinating. I take comfort and have great pride in knowing that I have colleagues in the mathematical community whose research helps to tackle cancer from prevention through diagnosis to treatment. In this podcast series, Maths + Cancer, I'm going to sit down with some of them to find out more about their research, and about the people behind the research. I'd love you to join me for our conversations to learn more about how mathematics and mathematicians are helping to combat cancer.

I'm delighted to say that I'm joined today by Hannah Fry, who, according to her website, is mathematician, science presenter and all round badass. She's Professor in the Mathematics of Cities at the Centre for Advanced Spatial Analysis at University College London, but perhaps better known for her TV documentaries on maths and science, her radio and podcasting work, including The Curious Cases of Rutherford & Fry for the BBC, and as author of the acclaimed book Hello World: How to be Human in the Age of the Machine. Hannah and I are about the same age and as it turns out, were diagnosed with cancer at about the same time, although different cancers with different treatments. Hannah made a 2022 documentary for BBC Horizon called Making Sense of Cancer, in which she explored aspects of cancer diagnosis and treatment from her mathematician viewpoint, informed by her own experience. Hannah thank you so much for joining me today.

Hannah Fry:

Oh, thank you for having me. I jumped at the chance to talk to you, Vicky. Most people don't get a reply from the e-mail, but you, straight away I replied.

Vicky Neale:

I'm honoured. I mentioned maths and cancer right away, right? These are the right words to get your interest.

Hannah Fry:

It was your name, your name popped up and I was always a yes.

Vicky Neale:

There's lots that we can discuss, and it's kind of hard to know where to start. Is there an aspect of maths in the context of cancer that's kind of foremost in your mind at the moment? What are you currently excited about?

Hannah Fry:

Oh gosh, that's such a big question. Uhm, you know, I think the thing is actually, I think the most interesting stuff strangely enough, when it comes to maths and cancer, is the least technical. It's like the idea of you know what does 10% mean and how does it feel? Like that I think is the stuff where the really knotty, you know, like the knotty ideas are uhm, so I'm going to go with that. I'm going to go with that, just the very notion of risk.

Vicky Neale:

I'm so glad you said that 'cause I want to spend loads of time talking to you about this 'cause yeah, I spent a lot of time trying to also understand actually what is probability, and I teach undergraduates about probability, but do I really know what probability means as a human being and all of those kind of things. Yeah, so I'm, I'm sort of torn between the percentages and the kind of very technical data analysis for whole genome sequencing, personalised medicine. There's kind of so many different things, but let's talk about percentages. Do you know what 10% means?

Hannah Fry:

I think it's one of those. It's like trying to hold on to smoke with your with your hands, right? It's like I sort of feel like I've got it, and then if I really, really, really think about it then it does sort of feel like it escapes me. Should I be admitting that? If my students listen... she doesn't know what 10% means.

Vicky Neale:

Yeah, exactly so to the students that I have taught probability to, I definitely understand probability, but also 10% turns out to be, like, really hard.

Hannah Fry:

It's really hard. And in a population it's very easy, but for one individual it's really, extraordinarily difficult, and I think that actually there's a sort of arrogance that goes along with probabilities that in the way that they're discussed sort of on a national and international stage that that really doesn't help.

Like, I saw Max Tegmark, who's a very famous physicist, I saw last night he tweeted that he tweeted that he thinks that there's a 30% chance that the war with Ukraine will end in nuclear, in the use of nuclear weapons, which is an amazing claim. I mean, what does, what does that mean? What does 30% mean there, right? Or like, or Nate Silver and his election predictions and he said 25% chance that Hillary Clinton won't win, that Trump will win, and then everyone you know was like, well, you got it, you called it wrong and he said no, that's not how probability works. But then my question is, in a one shot event, right, which is essentially what you're talking about with one individual person. If you just say 0.1% chance of something happening. I mean, you're just allowed to say any number and then call other people stupid when they're surprised when it happens, you know, like, it's uhm...

Vicky Neale:

Yeah, I think I'm constantly thwarted by the probabilities on the weather forecast, so I was thinking about this, and it seems to me that making decisions about whether or not to have chemotherapy or whatever, you know this is much more serious and frankly much more scary and difficult than, do I take a coat with me when I go to work today or not. But actually, I think there are parallels, like I look at the weather forecast and it says there's a 70% chance of rain and I think, in my head, if I stop and think about this analytically, I go oh, what that means is 7 days out of 10 like this it would rain, and what me the human being thinks is, oh it's going to rain I'm going to take my coat.

And then I'm a bit surprised when it doesn't rain and my garden hasn't been watered, whereas the days when it's a 20% or a 10% chance of rain and I, and again I sort of understand intellectually what this means, but then then I'm still surprised when I don't take my coat, and I've got soaked and I think in my head I can only, on some level I can only understand zero, 100% and everything else I'm kind of rounding in between those. I can't, I can't 40% take a coat and any more than I can 40% decide I'm having chemo, or it's like, we have these fuzzy probabilities that lead to black and white decisions. And, and it's really hard.

Hannah Fry:

It's really hard, and the thing is, Vicky is we're saying this as you know, people with PhD's in relevant subjects, right? Like university positions. The weather one I think is really interesting because there was, there was one group who conducted a survey of like the general population about what they thought it meant when you say 40% chance of rain. And the responses were absolutely amazing. So some people got it right, right? Like 4 days out of 10, if you relived this same day then it will rain, and some people, though, thought that it meant it was going to rain 40% of the time. Uh, so tomorrow will be 40% rain. And some people thought that like, if you have full rain it'll be like 40% of that. Then some other people thought that if you say you know rain across the UK, it will be 40% of the UK that will be raining. I mean like wildly, I mean something as simple as that, wildly different interpretations.

Vicky Neale:

Totally reasonable interpretations, unless somebody explained it to you. But there is a lot between those different interpretations.

Hannah Fry:

Totally. So of course, then when you come to something like medical care and then you're asking people to make black and white decisions on the basis of a limited understanding of probability, which is fuzzy in the first place. And actually, where the different outcomes of the decisions are, you know, on the decision tree have different impacts on your life, right? Like how do you weight the sort of, the side effects of chemotherapy versus the chance of living free without disease, right? How do you weigh up those things? Intensely personal things that you, you know, have to have a very sophisticated understanding of probability and an ability to be emotionally removed from a situation in order to analyse.

Vicky Neale:

Which is extraordinarily difficult, yeah. So, do you think there's more that could be done to help with how we communicate these probabilities, how clinicians are having those conversations with patients, how as patients you know, I'm a patient, how do I gather that information to help me make those decisions? Because it feels like there's never enough information.

Hannah Fry:

Or maybe it's that the information that we're getting isn't the right kind of information. You know, I really think, so I've had two children and in that, of course there's the medical side, right? There's like the anaesthetist who puts you under if you need an emergency C-section. And there's like, you know, the midwives who, you know, whatever. Like all the way along you have this medical care. But alongside that there's this whole world of people who are there to support you through that process, but to support you as an individual, you know, people who essentially tell you to be your

own advocate and who assure you that if you aren't happy with something you don't have to do it the way that you're being told to do it. And that to ask questions and that to trust your instincts, all the way along, right? Like there's people who are, who are there to sort of teach your husband or your partner, or you know, whatever, your birthing partner to like, massage your back while you're having contractions right. Like all of this stuff exists alongside it, but then I think that when it comes to cancer care you are to a greater or lesser extent, kind of on your own when it comes to dealing with the medical profession, you're sort of just. It's you and the doctor, and there's no one alongside you saying, okay, have you thought about it in this way? Have you thought about it in this way? And I really think. I mean, I think this happened to you as well, but there's this like. I describe it, I call it the orchid room, but basically there's like a little room that they take you into when you get your diagnosis. Did you have one of these rooms as well?

Vicky Neale:

No, I missed out on the orchid room, yeah, I'm short changed. Tell us about the orchid room.

Hannah Fry:

Okay, so straight after I got my diagnosis they were like okay. Come down the corridor this way. And there's this little door, uhm, that I'd never noticed before. And in there was, I mean, it's essentially a glorified cupboard, right? And in there they had two white clean armchairs and a little sad coffee table in the middle with like a box of sort of NHS standard issue tissues. The ones that feel like, sort of greaseproof paper, you know the things I mean? And then, so you sit down opposite this nurse, right? And then, like on the wall, was a canvas, like an IKEA canvas of an orchid. Okay, and I just like, it's obviously, I'm in the cancer room, right? Okay, sure, this is the cancer room. But the thing, I had this really strange out of body experience. Someone actually made the decision to go out and buy that orchid picture as though it would somehow make people in this room feel better about what was going on, it's like, you know what's going to help? Have a picture of a floral scene to take your mind off things. Anyway, it just felt so incongruous.

Anyway, the point I was going to make was actually one about statistics. Because in that room, what happens is a nurse sits you down and they are there to answer any questions that you have about the process, right? So, you know what time am I going to go into the theatre, what time, what, what happens the night before like? What kind of, how do you like, make sure that your body is washed correctly to be as bug free as possible, what do you drink on the morning of the surgery? You know, what do you get sent home with, what kind of things do you need to have in place? All of that stuff is there. And I think that that's really helpful. It's like without the time pressure. But I also think that actually when it comes to the decisions that we make or that we are presented with, I just, I think that we should have that kind of conversation, but with somebody who really understands risk, you know. And I don't mean just sit down and someone read you a list of statistics or tell you the numbers that are specific to your case. I don't, I don't mean it about information. I mean just the chance to sit down with somebody and them say to you, okay, what is most important in your life, what do you want to preserve above everything else? And how can we decide what to do for your future to make sure that the things that matter to you are at the absolute centre of everything that we're doing? You know, and I, that doesn't, that is actually a statistical conversation, but it's, but it's one that doesn't need to have any numbers in it.

Vicky Neale:

I think that's such an interesting way of putting it that kind of statistical conversation, but it doesn't have to involve the numbers. And I guess in the yeah, I mean in the context of the pandemic, I think

we've seen very publicly different people have different attitudes to risk, and I feel like some of that kind of ties in with this. And I completely agree these are such individual decisions and a potential side effect that would feel really problematic for one person, another person might go well, actually, I'm not, I'm not so worried about losing my hair or you know, I'm not so worried about the possibility that I can't have children in future. Or you know, different people have different perspectives on this and finding space to be that individual human as part of those conversations, and I feel really lucky that there are specialist nurses as part of my team, and I can ring them up and chat to these. And there's a Maggie Centre at the hospital I go to and yeah, there are people around.

But trying to hold on to that individual kind of humanity in the midst of, well, this is the percentage chance that it might work, and this is the percentage chance of the side effect, if those are even quantified. It's really difficult, kind of, I feel as a mathematician, I'm good at understanding numbers, but actually trying to understand that in the context of my life. When it's more scary than do I take a coat to work or not 'cause the worst thing is going to happen if I don't take my coat to work is I get wet, whereas these decisions are much more significant than that. And yeah, in that context, what is 10% and is that is that even a 10% about the thing that I care about or not because different people will have different perspectives. It's so difficult.

Hannah Fry:

I completely agree. I completely agree, it's like. I remember. You know so. I think that there was at one point, I mean the numbers changed throughout, but there was one point where someone said oh don't worry, you've got 90% chance of survival. And I was like, okay. But 90% chance of rain means you bring your coat, but 90% chance of survival means you're suddenly standing in a room with nine other people and someone's going to get shot right, and it's like it's a completely different thing. Yeah, when you are the number the perspective is, it's impossible to describe.

Vicky Neale:

Yeah, I had this moment early on where they weren't quite sure from the initial biopsy whether it was cancerous, or nearly but not quite cancerous, so there's kind of this sort of period of uncertainty waiting, so of course I go and look up, oh, what are the percentages. And I sat there thinking, but these percentages mean nothing. My tumour is this or it's not this, knowing that if you took 100 people like me, these percentages it means nothing at all. Actually this coin has already been flipped. It is a head, or it is a tail, the problem is not not knowing what is chance of it landing that way it's that I don't know which it is.

I think one of the things that might have surprised people and certainly surprised me when I started looking into this is what a relatively small number of people are helped by chemotherapy. You talked about this in your TV film, you sat in on a consultation with an oncologist and a patient. I think the figures there for a particular profile of a person you sort of, you treated 100 people with this chemotherapy, five of them would have their outcome changed as a result of the chemotherapy kind of positively. 18 of those 100 actually just would have lived, and ten of them will still die of their cancer. Is it just me? That number seems really small, like, I mean, we sort of, culturally it feels like chemotherapy is this, I mean, it is an extraordinary treatment. It genuinely saves lives, but you have to treat a lot of people it turns out.

Hannah Fry:

Yeah, I mean, this is the thing that I found really stunning. The sort of explanation of this is that. If you use. Surgery in order to remove the visible signs of cancer, then you can only go so far, there's

always the potential that you have microscopic bits of cancer that are still floating around your body that you just can't see, and so to mitigate against the risk of that, 'cause if that if that's the case, then some of those microscopic bits could embed themselves and then, and then grow into something more substantial, at which point if that happens then you cannot cure it. Right, you can't, you can't ever be cancer free again. So you have this window of time where you can potentially get rid of the cancer completely, and so to mitigate against the chance of you having these tiny bits floating around your body, that is when they give you what's known as adjuvant therapy, so either chemotherapy or radiotherapy. And so it is, as you say, you know, a lot of the time there are people who have had surgery and their cancer has been completely removed. They are already cured. It is absolutely the case that every day in Britain there are people who are having chemotherapy who already do not have to worry about cancer, right? We are treating well people, people who are perfectly healthy with chemotherapy. That is the case. The flip side of that is do you as an individual want to run that gauntlet?

Vicky Neale:

Because there's no way of knowing whether you're one of the 80 who would have been fine anyway, or the 15 whose disease is going to come back and spread for the numbers in that particular example.

Hannah Fry:

Exactly, you have no way of knowing, and would you rather go through three months of very serious life changing side effects and potentially longer-term repercussions. Or do you want to say you know what I'll take my chances, I'll give it a go, and in that example, I mean there were a couple of things really that are worth saying about that example. So, I was in in a cancer clinic with this amazing oncologist, she was so, I really liked her so much, called Judy King and she's so, she cared about her patients so much and really took the time to explain the numbers. But you know, ultimately, like if all you're doing is having a conversation about numbers, there's only so far that you can explain it, right? There's only so well that you can do it.

Anyway, she explained this to her patient. So Judy explained to her patient Anne, so Anne is in her late 60s and she had had breast cancer removed by surgery. And for her, her chances of, if they didn't touch her again, the chances of her surviving another decade were 84%. But if she had chemo she could up it to 88, right? So 4% different. Now for me, if I was in my late 60s. I mean it's different for different people, right? But I think that would be a tough choice, that would be a tough choice. So I spoke to her after the consultation, and I said to her like that, I mean, that's hard, right? How do you feel about it and her response blew me away, because she was like, but I have to have chemotherapy otherwise I'll die. And I was like. I mean, flawed. I didn't want to correct her because I didn't think it was my place to. But I went back in and I spoke to Judy and I was sort of saying, she really didn't understand that, you know, you gave the numbers to her very clearly, but she didn't understand them. And Judy, well, for starters, she said you clearly are much more uncomfortable about this than I am, but the thing is, that you know, perspective is what you were saying about how the numbers mean something, but they mean a different thing when you're in that perspective. And for Judy, she's in the perspective of the population view, right? Her job is the population view.

And so she said, yes, I know this sits uncomfortably with you, but you have to remember that I have to see those 4% of people who could have saved their lives and didn't. Like, that's my job is seeing those people. So from her perspective, every single unnecessary death is a tragedy. So it's understandable that she might, you know, prioritise people having chemotherapy, even if they don't

really understand it and I was like okay, but, I mean, sure. But is it really informed consent, like how do these people really know what they're letting themselves in for? And she replied by saying if they did, they wouldn't go through with it. Which I thought was. I was floored. I was really amazed by that. And The thing is, is that I kind of agree with her, right? I kind of agree with her, because since that documentary was aired earlier this year, I have had a few people tell me that someone has decided not to have chemotherapy on the basis of the documentary. And like every time that happens, I, I mean, I think these are really hard questions without easy answers, right? Because you know, ultimately, if nobody has chemo, if nobody has adjuvant therapy because we're talking about this, more people will die right?

Vicky Neale:

These treatments genuinely do save lives.

Hannah Fry:

Less people will lose their hair, more people will die. And so it's not that I'm saying that chemotherapy is not the right path, right? I'm just saying that whatever we're doing at the moment means that the real choice isn't the patients.

Vicky Neale:

And I guess for some patients actually, maybe they don't want that to be their choice. Maybe some patients would rather go look you're the medical professional if you were in my shoes, what would you do? Please just tell me what to do because I'm in this incredibly scary situation and the biology and the medicine of this is really difficult to understand and please just tell me what to do. And there are definitely patients in that situation. But there are also patients who go, no I want to understand, I want to know what questions to ask to get the right answers to help me kind of work out for me as a person what is the right thing to do. And I can't imagine how hard it is for the clinicians, so we try to work out what kind of patient they've got. And is this the patient who wants to know lots or doesn't want to know? And I mean it must be extraordinary, having such different conversations as a clinician with patients.

Hannah Fry:

I think that wanting the paternalistic approach to medicine, wanting, feeling really scared and just wanting someone to take care of you, I think that is a completely valid choice too. But you know, at the moment the way that they do it, the doctors that I spoke to, so I ended up going to quite a few clinics. And the doctors I spoke to the way that they do it is they ask you what your job is and then they make a judgement call based on what your job is, which I think is really interesting.

Because, you know, these are decisions that need to be made like, someone is making these decisions. It requires essentially the skill of the doctor, rather than a system that is designed to support true informed consent. Or it relies on the individual being their own advocate. And I feel a bit uncomfortable about that. The other thing is, I think that there's, I think that there's a little bit of a sort of, oh obviously you have the chemo, thing. I think we have, as a society we kind of have this attitude of like oh yeah, obviously have the chemo.

So I was talking to, somebody spoke to me after the documentary was aired and they told me their story and they had had colon cancer, um, they'd had like a small tumour that had been removed successfully. And they were told that there was a one in ten chance that the cancer would come back, and so for their adjuvant therapy, the doctors recommended that they have that section of the

colon removed, which would give them a stoma, a colostomy bag for the rest of their life, oh not stoma, sorry, forgive me, I may have got that wrong, but anyway they would have a colostomy bag. For the rest of their lives. And then also radiotherapy and chemotherapy to reduce that risk, so the side effects of radiotherapy, particularly in that region, are essentially you're left with a non-functioning penis, right? So you have erectile dysfunction. You have bladder issues, you have, I mean, bowel issues are kind of par for the course, plus fatigue, hair loss and you know, sensory, kind of reduction in nervous...

Vicky Neale:

Neuropathy?

Hannah Fry:

Yeah, thank you very much. Uh, you know all of those things come along with it, right? And so he asked them, okay, so right, that feels like a lot for something that's only got a one in ten chance of coming back. That does feel like a lot, and they were like, yeah, but you know it will reduce your chances of the cancer coming back by a factor of two to three. And he was like, okay, but. Why would I go through all of that for something where there's only a 10% chance of it happening, and then there's still going to be a, you know, a like 5, 4, 3% chance there. I mean, this seems insane and then they were like okay, well we can just wait and see. But you know, if you do then you're going to have to have the bag anyway. And he was like okay, but then I'll know that I have the cancer and I'll know the cancers come back and so I'll be in a different situation, like have you ever heard of Bayes theorem, I'll update my priors accordingly.

Vicky Neale:

That's what happens when you let people who are into statistics go to these conversations.

Hannah Fry:

But the doctor, I think just didn't actually have the full understanding of, didn't understand what 10 percent means, right. Like I guess if we come back to what we were saying earlier, he didn't understand what 10% means, so this person they went and spoke to Macmillan and were like what am I missing? Let me talk you through my logic because everyone saying I should do it and I don't see it, so spoke to Macmillan and they were like no, your logic is sound. And so then it's like are we, as a default, right, if these are kind of decisions that we make as a default, and once again I had all the treatment that was offered to me, you know. And I am in no, this treatment does genuinely save people's lives. It's just that, it's the nuances of choice I think is the thing that I'm really trying to get at here.

Vicky Neale:

Yeah it's, the more you think about it, the more difficult it gets I guess. I'm a novice at this. I just approached this from the kind of point of view of a patient, whereas I guess the clinicians and medical teams are thinking about this literally all day, every day cause it's their job.

Hannah Fry:

They are, they are, but they have the population view, right? And I think that is important actually, because there are times when the population view does conflict with the individual view.

Vicky Neale:

And I think that's really interesting in the context of screening programmes as well, maybe. So I spoke to David Spiegelhalter in another episode of this podcast and he was telling us about the work that they were doing on the breast screening information so that instead of the leaflets just going out saying we recommend you have breast screening for people in the right age bracket that, that it's a little bit more nuanced than that, and it's kind of a bit more about, this is the information about how many people might end up being over treated as a result of having this and so on. But again, at a population level it does make a difference and I guess in your case as an individual, that's how your cancer was picked up, so yeah, screening programmes do something useful. But also, it's complicated again at the individual level I suppose.

Hannah Fry:

Completely, do you remember a few years ago? Uhm, there was like a big fashion on morning television to do like, live breast screening or live breast exams. Or like, testicular cancer exams. So, and then everybody would say like oh check your breasts, it saves lives. Uhm, you know that's kind of the common rhetoric. The thing is, is that there was study in China where they got thousands of women who worked for a factory, and they paid them to check their breasts once a month for a number of years and by the end there were no, I mean they split, they did like a controlled trial, right? So you know, it's half and half, randomised trial. And by the end, in the group that did the screen that that checked their breasts there was no difference in the number of women who died from breast cancer, but there was a difference in the number of women who had been diagnosed with breast cancer and had biopsies and treatment.

And so, you know, I think even that claim of, like check your breasts, it saves lives. I think you have to really interrogate the evidence on that, because I think that that we have these kind of instinctive reactions. But then, but then again, at the same time, right, I say all of this stuff. I say all of this stuff about screening, you know, and how you've got to really carefully balance that that issue of over treatment. But at the same time, I have been tempted, because I was so scared when it happened to me. I was so scared. I have genuinely been tempted to go and get one of the, like, blood tests, the cancer screening blood tests just to be like, okay, I just wanna, I just wanna be sure that everything is okay. Uhm, yeah. And I think that it's like. Who is not gonna, who is not going to go for a breast screening appointment for fear of overtreatment? Probably no one. But who is, who is going to go to one for fear of dying from breast cancer, you know? And I, and I think, actually maybe what we're saying, maybe everything we're saying here doesn't matter, maybe ultimately the only thing that matters is that people feel comfortable and as safe as possible and live without the sort of shadow of disease for as long as possible. Maybe that's the only thing that matters. I don't know what I'm talking about, Vicki, I think that's the big conclusion.

Vicky Neale:

So, conclusion after sometime discussing it, we don't really know what 10% means.

Hannah Fry:

It's good to be intellectually humble, though, isn't it?

Vicky Neale:

I'm just going to interrupt briefly to let you know that if you're enjoying this episode of Maths + Cancer, then please do head to ox.ac.uk/cancer to find the other episodes in the series, in which my amazing guests tell us about some of the many intriguing ways in which maths and stats are helping us to understand and tackle cancer.

In your book, you write about the potential for things like AI or machine learning or whatever phrase you want to use for things like diagnostic scans. Is that something that you've kind of revisited after your own experience of going through cancer treatment, have you been thinking more about the role of algorithms and data in that context?

Hannah Fry:

I write critically about it, let's be fair.

Vicky Neale:

Yes, in a fair and balanced way, maybe.

Hannah Fry:

That's fair. There's a really nice phrase from the Nobel Prize winning economist Danny Kahneman. There's a phrase that has that I really like, which is that humans have a habit of taking a really difficult question and swapping it for an easy one without noticing they've made the substitution. And I think when it comes to cancer, the really hard question, I mean, it's the question ultimately that we've been talking about this entire time is, whose life can be saved with cancer treatment, right? That is such a hard question. And I think that there is a danger sometimes of swapping that for the much easier question which is, whose image has cells that indicate, has pixels that indicate, abnormal cells, right? And that, 'cause that is not the same question.

And there's a really interesting study that happened in Denmark in the 1970s, which I think really hammers home why this is not the same question. So, this group of pathologists they wanted to know how common cancer was among the healthy population. So people just wandering around, not care in the world, how many of them have cancer that don't know about it. So, what they did is they took 77 women who had had recently died from all kinds of different things. So like car crashes or heart attacks, that sort of stuff. So, these women were like a range of ages and a portion of them had never been diagnosed with cancer in their lives, right? So that chunk of those 77 women had never been diagnosed. So what they did is they, with the permission of their families, they performed double mastectomies on these women, and they searched through all of their tissue trying to find any abnormalities. And in 77 women like maybe one had cancer and didn't know, that would have been my guess, right? Like very few. But actually, when they looked, I think it was around 1/4 had some abnormalities that would have counted as either cancerous or precancerous in their tissue...

Vicky Neale:

A quarter feels like a lot.

Hannah Fry:

Yeah. So they've redone this study quite a few times since then, 77 is quite a small number, right? So they've redone this study a number of times, there's a nice meta study on it. But they've done it with thyroid cancer and prostate cancer as well, and so it's a bit difficult to get exact estimates. There's also some question over whether you should have autopsies or MRI studies. Blah blah blah.

But somewhere between 7 and 9% of us have something in our bodies at any time that is cancerous or precancerous right now. Here's the thing, that number is huge, like it's about 10 times the number of people who end up getting diagnosed with cancer. And the thing is, is that partly it's like, well, uhm, partly it's because actually your body is quite good at dealing with this stuff, like quite

often, precancerous changes are dealt with by your body and never go on to become something that can harm you.

Vicky Neale:

You I was discussing this with a medical physicist called Tom Whyntie in another episode of the podcast who was talking about the genetic modifications and that actually sometimes the body just spots there's something wrong here and just gets rid of the cells.

Hannah Fry:

Totally, yeah, totally. That happens quite often. In fact, it might even be most of the time. I mean, Tom Whyntie would know this better, but I think most of the time, like precancerous changes are dealt with by the body. But then the other thing is that even if it does go on to be something that that grows, actually a lot of cancers are so slow growing that they sort of never go on to become something that will kill you. You'll die of something else long, long, long before. And so the thing about this, I think what this study, or those kind of autopsy studies tell us, is that if you suddenly become really good, like amazingly good at finding abnormal tissue, then what you really, because you cannot tell the difference between abnormal tissue that will kill you and abnormal tissue that won't, and so you suddenly, you know, begin to alert people to their totally harmless tumours that they really didn't need to worry about, you know.

Vicky Neale:

I'm picturing now some kind of person with, like superhero with special goggles or something and they can look at a person and just go. Oh look, you've got, you've got cancer or precancerous cells, and actually it's not so clear that having these special glasses is going to help, because you end up treating lots of people, scaring loads and loads of people, but not necessarily saving that many more lives.

Hannah Fry:

And I think this is what I mean about that Kahneman question, right? Because while it is certainly true that we want to be as good as possible at detecting abnormalities in the situations where we know that we're looking for them and want to find them, right. But I also think that like, increasing the sensitivity of our screening programmes isn't the full question, like the full question is whose life can be saved with cancer treatment, and AI, as exciting as it is about like you know, medical imaging and machine vision, it's not answering the most important question of all, just a tiny, tiny part of it.

Vicky Neale:

I'm really interested in whole genome sequencing, and I do not pretend to understand whole genome sequencing, I've just, you know, dabbling around the edges trying to get my head around what is going on with this thing?

Hannah Fry:

We don't even understand 10% Vicky come on.

Vicky Neale:

Exactly, no, there's a long way from 10% to whole genome sequencing. I think that if whole genome sequencing starts to enable clinicians to have a greater understanding of a person's tumour or their cancer, more generally, not only tumours and to be able to have a better insight into, is this cancer

likely to remain self-contained, or is it likely to spread to another part of the body and therefore have more significant issues? Is this cancer likely to respond to this particular treatment or not? Those kind of questions seem so important in all of these decisions and these conversations we're having, the conversation we were having earlier about chemotherapy and the risks of side effects and the possible benefits and so on. Actually, if there are ways to understand somebody's cancer better to answer some of those questions, then in a way you can remove some of those probabilities or change what the probabilities look like in a really different way.

And I was having a conversation with an expert on a charity helpline about what is whole genome sequencing. You know what's going on, this would come up in the context of my own treatment and they were explaining that this is about gathering these, kind of vast amounts of data so they can take a tumour, they can take some healthy cells from the person and compare to find out what are the genetic mutations that are going on in this cancer. Can we understand what it is? What are the changes? The problems in that DNA, that's causing this cancer to grow uncontrollably, which is essentially my crude simplification of what's going on.

So you end up with these colossal amounts of data and I guess whole genome sequencing is only now starting to be possible in the NHS. Thanks to, of course, the biotechnology that makes it practical, but also the computing power to do it, but then the specialist on the helpline was explaining to me that there are these kind of people who then sit with these massive piles of data to try to, to find the patterns. And those are my people, I don't understand at all the molecular biology or whatever the right phrase is, but massive spreadsheet, loads of data, find patterns in it. Like yes, these are my people. I'm really proud that I have colleagues that do this because actually by finding those patterns they are uncovering information about treatments that could be better targeted or which cancers will or won't develop in certain ways, and so on, I think that's a really exciting prospect

Hannah Fry:

I agree. Do you remember that Laplace writing on probability, where he says that probability is just there to cover up for the fact that we don't know stuff? I mean his was a bit more articulate. And in French. But that was the gist of it right? Like you don't know stuff, yeah, so make it up with the probability, right?

It's to cover up for our lack of knowledge, and then I think Poincaré came along a bit later and was like no, there's like inherent randomness in reality. But I do think that is what we're talking about here, you know, like when I think it comes to medical statistics, we're using probability and what happened to people like you before, because we don't know because we don't know, we don't have a causal understanding of what it is in the genome that that goes on to create these fundamentally different outcomes.

And I think that the personalised medicine that you're describing is like a really exciting potential path for the future. And this is something I came across in my work with Deep Mind because they are looking at the connection between the genotype so what's in the genetic code and the phenotype, so how that cell ends up being expressed and how it ends up performing. Uh, I mean insert biology here, right? Not my field.

Vicky Neale:

It's a problem with having a maths and cancer podcast, it turns out there's a whole lot of biology, and I did GCSE double science a long time ago. And it didn't really address these things.

Hannah Fry:

This is the useful thing about doing that Curious Cases with Adam Rutherford, who's a geneticist, I can do the computer science and physics you know, and a bit of chemistry. And like I'm very, very comfortable with all of that, but anything that's like, it's just like, yeah, just leave a blank bit in the script and fill it in.

Vicky Neale:

Adam, fill this in.

Hannah Fry:

Exactly, uhm, but yeah. I mean, I think that the some of the work more generally about trying to understand the causal mechanisms between the way that genes are expressed. Uhm yeah, I. I mean, I think that there are. There's different directions that people are coming at this right? I hope that they'll culminate in something better for the future.

Vicky Neale:

I find myself often with all of this stuff feeling just monumentally grateful that I live near Oxford where there is a world class hospital and there are amazing specialists. And if they say Vicky, we want you to have a scan. I can have a scan, and if they say Vicky we want this or that or whatever, these things are possible and there are so many parts of the world where that's just not the case at all, let alone parts of the UK where you know it's harder to access health care and so on.

And I was just musing the other, I don't have an answer to this, but I was just musing the other day, wondering how maths and stats can help with potentially making that kind of health care more equitable. Are there, are there things that that can happen in maths and stats that mean that some of these kind of disparities, whether between different groups within the UK but also worldwide, can be lessened because there's so much inequality, and I feel like I have the absolute best possible treatment. And I'm so conscious of how privileged I am in that respect.

Hannah Fry:

Yeah, I mean I think it does come down to how you measure good treatment. Because I think at the moment like the key metric of success is survival, right? But I think you also have to take into account survivorship. You know how well you're living and how many chronic conditions you're left with after treatment.

Vicky Neale:

I guess we know that there are cancers where outcomes in the UK and not as good as they are in some other developed countries.

Hannah Fry:

Yeah, but unless, I think unless you have really good metrics for what it means for somebody to have good treatment, you know the scans that you can go and have, and the conversations that you can have with your oncologists. How do you compare that with elsewhere in the country unless you have that sort of metric.

You know it's interesting that you say that actually, and maybe I say this because I was treated in Lewisham rather than Oxford, although I love Lewisham. I couldn't help feel almost the opposite. So

of course I am really grateful for the for the treatment that I received. But I also, I think I had this idea before I was ever sick that that modern medicine really knew what it was doing. And actually, I think once it comes down to it, you know, it's still plumbing and carpentry, like it's still pretty barbaric. Like it's still like, oh, don't like that, lop it off, like get in there with a saw and like, some pliers and just take it away. You know, like I, I really felt like after I had my, I had quite radical surgery on my pelvis and it like it felt as though it wasn't that far removed from when they used to just lop people's limbs off, like it really did feel like that.

Vicky Neale:

I hope they gave you better anaesthetic.

Hannah Fry:

Oh, did you not get good anaesthetic?

Vicky Neale:

No, I mean, the 200 years ago or something.

Hannah Fry:

I mean come on, they had opium then, they were fine.

Vicky Neale:

A totally different kind of question. Uhm, what advice would you give to somebody kind of early in their studies now who's interested in using maths and stats to improve our understanding of cancer and to improve healthcare?

Hannah Fry:

Oh gosh, I think talk to patients. I think that's the biggest thing because I think that actually, I don't just think this is true of specifically, you know maths and cancer. I think it's true of pretty much maths and anything because I think it's very, very easy to fall into the trap of thinking theoretically about things without stepping outside of your world and getting a real genuine understanding of it.

And I think that actually if you are interested in that sort of thing and you can be involved in volunteering for patient groups or survivor groups you know, or even groups of people who are like terminally ill and having treatment. Uh, you know, in order to prolong their lives. I think that it's only through that perspective that you really see that these are not just numbers. And I think having that perspective is absolutely critical if you're ever going to make a real difference.

Vicky Neale:

I think it's such good advice, remembering that these are not numbers. There are people.

Hannah Fry:

Yeah, it is a bit ironic. I do feel as though you know, I spent so many years training as mathematician like really technical training, and then I feel like all I do at the moment is be like, stop with the numbers, like put the numbers to one side.

Vicky Neale:

That's why I called this episode something like when the numbers aren't enough 'cause I just kind of felt like, it felt like that might be your slant on this, and I think it's really important. I want to showcase that maths and stats are extraordinary and making a real difference, but also, they're not the only answer.

Hannah Fry:

Completely, but I think you know what, just to slightly reign that back in, I think it's only because I really, really understand them that I feel qualified enough to say that you have to park them. At some point.

Vicky Neale:

Thank you so much for your time today and thank you for raising these issues with such a wide audience in such an engaging, and articulate way. And if you ever do figure out what 10% means please do let me know.

Hannah Fry:

I promise, with 90% probability.

Vicky Neale:

Thanks for listening to this episode of Maths Plus Cancer. I hope that you found the conversation as interesting as I did. There are more episodes of Maths Plus Cancer, as well as features about Oxford's research into cancer, at ox.ac.uk/cancer . If you're enjoying exploring how maths and stats help us to understand and tackle cancer, I'd love it if you'd tell your friends about the podcast. And please do join in on social media using the hashtag #MathsPlusCancer. That's plus the word, not the mathematical symbol...