AGAINST ALL ODDS
EPISODE 18 – "INTRODUCTION TO PROBABILITY"
TRANSCRIPT

FUNDER CREDITS

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INTRO

Pardis Sabeti
Hello, I'm Pardis Sabeti and this is *Against All Odds*, where we make statistics count.

Predicting the future sounds like the job description of a fortune teller! But there are lots of times in everyday life when you'd want to do just that – without using a crystal ball. Rather than just pulling guesses out of your hat, probability is the mathematical way to make these kinds of predictions. A fifty percent chance of snow. A twenty percent chance of complications from surgery. A one in a hundred seventy five million chance of winning the lottery. You encounter chances like these all the time in daily life. What the heck do they really mean?

They're attempts to quantify uncertainty, something we do all the time when we're trying to make predictions in the real world. For instance, I start my mornings with a forecast of the future… in the form of a weather report. I just want to know if I need to bring an umbrella with me. For meteorologists, a question like that boils down to probability.

> **Kevin Skarupa**
> Mount Washington valley northward a thicker cloud cover ahead…
> There is the sunshine we're seeing…
> Drift in here over the next few…

Pardis Sabeti
When TV weatherman Kevin Skarupa issues his forecast for the residents of New Hampshire, he doesn't know for sure what's going to happen. Weather is an example of a random phenomenon. It's an event with an uncertain outcome, but it does have a regular pattern over time. Nature is predictable and systematic, and he's tracked these patterns before.

> **Kevin Skarupa**
> If we're to make a winter forecast, for instance, we'll look at the last couple of years, we'll look at where the patterns are going to be now. We'll look at what the 30-year average is. We'll look at what the highest has ever been, what the lowest has ever been. And take all that into consideration to have a really good sense as to the overall picture for that particular location.

Pardis Sabeti
Today's meteorologists rely on multiple complicated mathematical models to make their predictions for the public. The models churn through tons of weather-related data points and update several times a day.

> **Kevin Skarupa**

It is weather balloon information—which goes up at the exact same time of day at all the National Weather Service sites—and as they climb up through the atmosphere, pick off all that weather data. It's surface observations, it's what's going on at that moment…as far as humidity, wind, sky conditions, temperatures.

Pardis Sabeti
The models combine all these weather inputs to create maps of what they predict will happen this time based on what they've seen happen in the past when similar scenarios were observed. Over time, the weather exhibits patterns, but for any one particular instance it's not completely predictable with perfect accuracy. That's why forecasters talk in probabilities – even if the public doesn't really understand what a probability like "70% chance of rain" means.

Kevin Skarupa
When a station will put 70% chance of rain, it means that 70% of the viewers, if equally spread out, will see that precipitation that day. That essentially means "coverage," I guess is the best way to look at it.

Pardis Sabeti
So in that case, the forecaster feels sure that 70% of the area will see rain that day. But meteorologists are usually expressing a combination of degree of confidence and area coverage. So they're also using that percentage number to try to quantify the likelihood of precipitation at all. This one probability number does double duty – it's called on to express both aspects of the forecast: confidence and coverage. No wonder we the public get a little confused about what our local weatherperson's getting at!

But as the mathematicians work to refine the computer models and meteorologists like Skarupa work to communicate their predictions more clearly, forecasts are constantly improving.

Kevin Skarupa
Back when I started, snow starting in the afternoon was a logical forecast and a three-day extended forecast was the norm. Now, it's…people kind of want to know what hour it's going to start. And so the bar has been raised for us at the same time while the maps continue to get better.

It's certainly plenty colder than what we have been for the last four or five days…
And a look toward the weekend ahead!

Pardis Sabeti

The probability of any event is the proportion, or percentage, of times it would occur in a long series of repetitions. Random phenomena like weather events aren't chaotic; they're unpredictable in the short run, but have a regular pattern in the long run. They're not random in the sense of having no rhyme or reason.

It's important to understand the concept that this kind of chance behavior is unpredictable in the short term but has a regular and predicable pattern in the long run.

Take the example of flipping a coin. The toss can come up heads or it can come up tails. Our first toss is tails – let's record it on this graph of the proportion of heads we get. The next toss is heads, so now our proportion of heads to the number of tosses is 0.50. Next comes two tails in a row, dropping the heads proportion to 0.25. The proportion of heads is pretty variable at first… but over time the proportion of heads gets closer and closer to 0.50 and stays there. The same thing happens if we run a second trial – this time we get a bunch of heads in a row at the start, but over time, the proportion of heads hovers right at 0.50. We don't know what's going to happen on any one toss, but over time we can predict we'll get this proportion of heads and tails.

As on this graph, we always assign probabilities a value between 0 and 1. Events with a probability closer to 0 are less likely to happen, and those with a probability closer to 1 are more likely to happen. Our .50 probability for heads in a coin toss means that either option is equally likely – 50/50.

When you're talking about the probability of a giant asteroid slamming into the earth, you want that number to be pretty darn close to zero! Luckily for the rest of us, NASA's Near Earth Object program is closely monitoring asteroids with the potential to do serious damage to our planet.

> **Donald Yeomans**
> Asteroids are very diverse objects. They run the gamut from ex-cometary fluff balls that you could break apart with your bare hands, to rubble piles that are held together by little more than their own self-gravity, fractured rock, solid rock, slabs of solid iron.

Pardis Sabeti
While "near-Earth space" is home to over 9,000 known asteroids, only about half of them are large enough and have orbits that come close enough to the Earth to classify them as PHAs – Potentially Hazardous Asteroids. Scientists around the world are keen to track these PHAs as closely as possible to figure out if any of them are on a collision course with the earth.

> **Paul Chodas**
> When an asteroid is first discovered we only have a few observations. As we add observations to the data set, the possible set of orbits gets smaller

and smaller. That is the uncertainty region at any given time. As we add data, the uncertainty region will get smaller and smaller.

Pardis Sabeti
As the scientists refine the predicted orbits of the asteroids, they can start to work on computing the probability of a collision. They try to calculate the percent chances that any particular PHA will hit our planet.

Donald Yeomans
The poster child for near-Earth objects is an asteroid we call Apophis. It's an Apollo-type asteroid and it's coming very close to the earth in 2029. Just a few earth radii above the surface, and well below the altitude of some of our communication satellites. It'll be a naked-eye object in April 13th, Friday the 13th, in 2029.

Paul Chodas
Now when it was first discovered we didn't know how close it would come to the earth. In fact, the uncertainty region during its passage by the earth was so large, that the earth was right in the middle of it…. As we got more and more observations of the asteroid, we're able to see that that uncertainty region no longer intersected the earth. So we know Apophis will pass by in the year 2029. Very close, but it will not hit.

Pardis Sabeti
Well that's certainly good news, but it's not the end of the story. Apophis' close encounter with the earth's gravity in 2029 will bend its trajectory, which makes the job of predicting where it will go from there much more difficult. If Apophis were to skim by the Earth on one particular orbit, the threat level goes up once again.

Paul Chodas
If it should happen to go through this little keyhole, which is very narrow, only about 600 meters wide, it will receive a gravitational boost just in such a manner that it will come back and hit the earth in the year 2036.

Pardis Sabeti
Based on the latest observations and updated data, researchers have now effectively ruled out the chance that Apophis will be on that one specific gravity-boosting route, so the probability of a 2036 impact has plummeted toward zero. But scientists still scan the skies for other Near-Earth Objects with collision probabilities closer to one, since even a small object's impact has potential for great destruction.

Donald Yeomans
It would cause significant regional damage. It wouldn't be a global problem but it would, if it hit on land it would certainly reduce a, a large

region to rubble. And if it hit in the ocean, which is more likely of course, it would cause a tsunami, so that the surrounding coastlines would be in trouble, or at least the low-lying coastlines would be in trouble.

Pardis Sabeti
Researchers continue working on strategies to deflect an asteroid before it can cause big problems for us earthlings. Just ask a dinosaur how deadly an asteroid impact can be!

For *Against All Odds*, I'm Pardis Sabeti. See you next time!

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