Decisions under Uncertainty: A View from Philosophy

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Workshop Threshold of Toxicological Concern (TTC) for risk assessment of food contact material chemicals

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Risk vs. Uncertainty

"All **risk** assessment approaches have some degree of uncertainty. When the TTC approach is applied, it is important for both risk assessors and risk managers to keep in mind that it is a **probability-based** screening tool and may have additional **uncertainty**."

SCCS/SCHER/SCENIHR. 2012. *Opinion on the Use of the Threshold of Toxicological Concern (TTC) Approach for Human Safety Assessment of Chemical Substances with Focus on Cosmetics and Consumer Products, p. 6.* (Emphasis added)

Risk vs. Uncertainty (cont.)

Frank H. Knight. 1921. *Risk, Uncertainty, and Profit.*

Knightian Uncertainty

"Uncertainty must be taken in a sense radically distinct from the familiar notion of risk, from which it has never been properly separated. [...] The essential fact is that 'risk' means in some cases a quantity susceptible of measurement, while at other times it is something distinctly not of this character; and there are far-reaching and crucial differences in the bearings of the phenomena depending on which of the two is really present and operating. [...] It will appear that a measurable uncertainty, or 'risk' proper, as we shall use the term, is so far different from an unmeasurable one that it is not in effect an uncertainty at all."

Risk: What is Risk?

- any situation, in which more than one outcome is possible and some outcomes are preferable to others
- quantifiable by putting numbers on probabilities
- measurable, manageable "uncertainty"
- requires perfect (or at least robust) knowledge
- does not preclude rational choice
- randomness is not a problem
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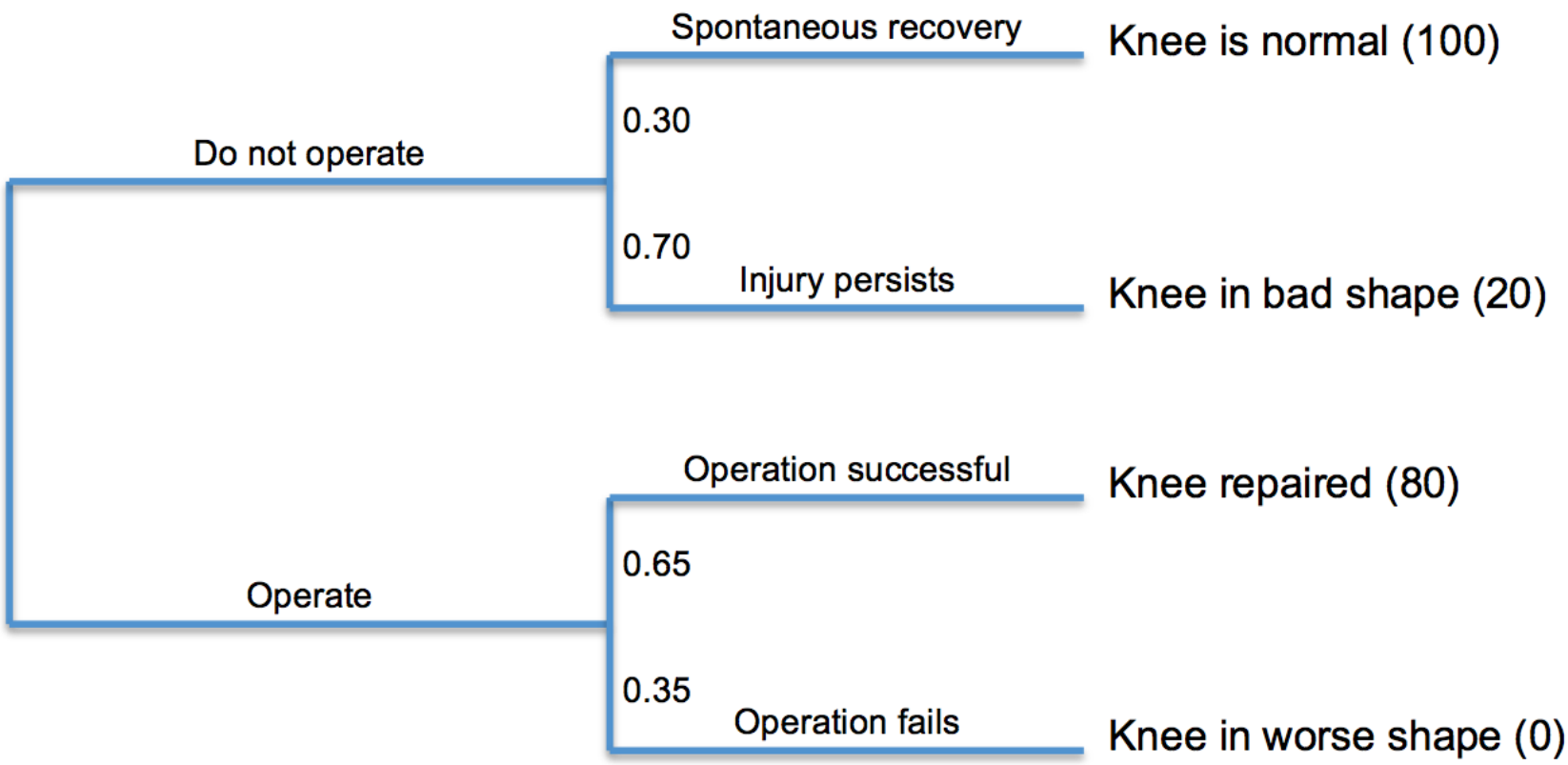
Example 2

a) Operate injured knee with success rate of 65% or
b) Not operate with chance of spontaneous recovery of 30%?

Risk: Risk and Rational Choice



Expected utilities:

Operation: $80 \times 0.65 + 0 \times 0.35 = \mathbf{52}$

No operation: $100 \times 0.3 + 20 \times 0.7 = \mathbf{44}$

(cf. Hastie and Dawes 2010, p. 28)

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- When these consequences are not determined, their likelihood is evaluated according to the basic rules of probability theory.
- is a choice that is adaptive within the constraints of those probabilities and the values or satisfactions associated with each of the possible consequences of the choice.

(Hastie and Dawes 2010, p. 16)

Uncertainty

When outcomes are unknown or when we are not able to put probabilities on outcomes, strictly speaking, the rules of rational choice theory are not applicable!

$\Rightarrow$ We are confronted with Knightian Uncertainty!

HOW DO WE DECIDE UNDER UNCERTAINTY?

Uncertainty: The Psychology of Uncertainty

- Humans have a tendency to deny uncertainty. We tend to apply causal thinking to processes that are genuinely random (e.g. Tverskey and Edwards 1966 etc.).

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In science, this tendency is expressed in the urge to **transform uncertainty into risk**, i.e. to use probability-based approaches even in cases where this might not be possible.

Uncertainty: The Swine Flu Case (cont.)

Worst Case Scenarios: Guess probabilities

Estimation (Sep 09):
- 30% clinical cases
- 1/1000 die (roughly 20000 deaths in the UK)

In fact:
- 1/1000 did die
- only 0.7% reported clinical cases

$\Rightarrow$ Worst case scenarios are almost certainly wrong!
$\Rightarrow$ Increased skepticism against science
"They told us we all gonna die. And what happened? Nothing!"

Uncertainty: The Swine Flu Case

Opinion

The risk of swine flu? I haven't a clue…

… writes a professor of risk. But I'm still sending my daughter in Mexico some Tamiflu

It could have been designed to make me feel inadequate. I am a professor of risk, and when my daughter Rosie wanted to spend part of her gap year working on a newspaper, she chose, with a true sense for a story, to go to Mexico.

So it is assumed that I know the chances of her, and everyone else, getting or even dying of swine flu. But I just don't know; risk is such an odd thing — no instrument can measure it but it constantly changes as we find out more information, just as the odds on Barack Obama being President oscillated wildly in the year before the election. What do we really mean by chance and risk anyway?

In some circumstances we can comfortably put a number on risk: if I spend £1 on a lottery ticket, I can calculate from the number of ways the balls can be drawn that there is a 1 in 14 million chance of winning the jackpot. Doing the sums for swine flu is a different matter: a heavenly compere doesn't pull balls with our names on out of a large bag, so epidemiologists resort to computer models of how epidemics work.

But instead of just having pure unavoidable chance, ignorance of the mechanics of the epidemic starts to dominate the calculations. It's a bit like trying to work out the odds of winning the lottery when you don't know how many balls there are.

The shape of the epidemic would be a lot more predictable if we knew all about this virus, and in particular something called the "reproductive number", which is how many people each case is expected to infect in an unaffected and unprotected population. For example, each case of measles would be expected to infect twenty people, which is why the fall in MMR vaccinations is viewed so anxiously; for smallpox it's about five and Sars about three.

Epidemiologists and insurers are rushing to estimate this quantity from the limited data; for this virus, it seems to be less than two, so a bit of effort might push it below the magic threshold of one, when the epidemic should disappear.

Meanwhile, my girl in Guadalajara reports that nobody there seems to care much about the reproductive number, and the lack of any clear information has brought a mixture of blind terror and indifference. For every few people not wearing masks someone is wearing four at once, just in case. And it's never long before the wearer's intrinsic Mexican-ness overrides instructions and face masks are yanked down to kiss a cheek or smoke a cigarette. The masks sold out completely on the second day of the scare, leading many people to fashion their own from clothclothes and bits of string.

The health minister in Guadalajara has only just admitted that there may possibly be some local cases, whereas in the UK the papers are providing full histories of every

Rosie reports that for every Mexican without a mask, another has four

contact — invaluable information for the epidemic model. But our ignorance goes beyond not knowing how infectious the virus is and the proportion of cases that die — the virus could mutate or, the fairest outcome, join with avian flu to create a new strain: despite the opportunities for flying-pig jokes, this would be no laughing matter.

At least we can think of these possibilities and weigh them up, inevitably using a lot of judgment stirred in with the science. But our journey through ignorance can lead into the pitch-black of deep uncertainty — Donald Rumsfeld's unknown unknowns. It can be disastrous to believe that you have thought of everything — it seems clear that a big reason for the financial crisis was a belief that risk models were somehow "true" and that the world really worked according to the rules, and there was no preparation for when events did not fit the model.

So we need some humility and to admit that we may be wrong. Pundits may mock the level of uncertainty that says the eventual UK body count could be none or could be a million, but that is simply an expression of honest ignorance. The need is to have emergency systems that are precautionary at first, and then rapidly adapt to new knowledge obtained from good data. Deciding which vaccines to prepare for the winter flu season will require a delicate balance of risks and benefits — a real gamble in the face of uncertainty.

And even if a judgment is inevitable, the reasoning should at least have some science behind it, unlike Egypt's slaughter of the innocent pigs. Perhaps even that is better than the conspiracy theories circulating in Mexico, inviting us to believe that the virus was introduced by the Americans, the pharmaceutical industry or to distract attention from the drug cartels.

Anyway, my gut feeling is that the chances we will see the girl again are looking quite good. But we've sent out Tamiflu just in case.

David Spiegelhalter is Winton Professor of the Public Understanding of Risk at the University of Cambridge. Rosie Spiegelhalter is sticking it out in Mexico

Uncertainty: The Bad News

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The bad news:
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But:
- There are valuable approaches in specific cases (e.g. Martin et al. 2007 on the qualitative assessment of uncertainty in the context of EDCs.)
- It is acknowledged that making explicit he **kinds** and **severity** of the relevant qualitative uncertainties leads do better judgments. Thinking about qualitative uncertainty helps!

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- **Normative** uncertainty is uncertainty about what *should* the case. It arises in the context of evaluative judgments. In the most severe case of normative uncertainty, we face a moral dilemma.

Uncertainty: The TTC Case

Given that there is a high level of confidence in
a) the quality of the toxicity databases
b) the exposure data
c) the appropriateness of extrapolations
then TTC can and should be used as reliable risk assessment tool!

However, what might be "additional uncertainties" (Knightian, unquantifiable, qualitative) in the application of the TTC approach?

Uncertainty: The TTC Case (cont.)

Modal

- Are there potential non-toxicological effects (allergy, hypersensitivity, intolerance)?
- ...

Empirical

- How robust is the structural similarity approach? Does it need revision?
- ...

Normative

- How should the application of the TTC be communicated to the public?
- ...

Uncertainty: The TTC Case (cont.)

This bread contains unintentionally added and/or degradation products of intentionally added chemicals at low concentrations with unknown toxicity. But never mind, we have assessed the risk for your and your children's health using the probability based Threshold of Toxicological Concern approach. There is a very high probability that you do not have to be concerned. Thanks for buying our TTC approved bread!

THANK YOU!

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