The Calculus of Risk

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... it is appointed for all men to die ...
Hebrews 9:27, JB Phillips

Life is like downhill skiing on a long, tall mountain – at the foot of which is not a comfortable lodge, but rocks, and a desert, and suffering, and death. We prefer not to think about this simply because it's inevitable. Instead, we think about life, over which we have some control. All the way down, there are risks.

Risk is the *possibility* that something bad or unpleasant may happen. Considering that, let's work out what it means.

When anything is *inevitable*, such as death, or taxes, or the end of thermal lift, there is no "risk."

But for any *time period,* we have a *risk* of dying. Death is a fact; risk is a *concept*.

How this plays out depends on *circumstances*. If you skid by ruddering the turn next weekend during a slow turn to final, your risk, numerically, soars – and in a few seconds is replaced with *fact* – either you fix the situation or become a statistic.

Medical Risk

Because we all understand that we will die, we are more interested in not being crippled or suffering, and in being content, in the broad sense, than in "avoiding death."

When we *calculate* risk, we consider two things: *time* and *circumstances*.

Most medical studies count deaths, surgical procedures, and need for changed treatment – because these things are easy to measure, and it's hard to measure contentment and function. People have disparate wants, and numbering systems like the famous 10-point pain scale are opinions. Ratings quantify but do not measure.

With e*pidemiology*, we grab a group of people within some interesting age band (*time*), in definable *circumstances*, and count up the deaths and diseases. We then translate these *facts*, as proportions, into *estimated risk* for people in the same age band and circumstances.

So reported "death risk" reflects the proportion of people *within a certain period,* in particular *circumstances,* who died during such an observation. For example, males age 35-55 with no history of stroke or heart disease, for a 5 year period.

Medical news reports, in focusing on any successful treatment of a particular disease, ignore the fact that that everyone who does not die of Disease A, dies of something else. Is this better?

For example, preventing sudden death. Success in preventing sudden death guarantees a slow death, right? Who prefers this? Of course, our *choice* is not to prevent death, or to prefer a bad death, but to prolong life.

My 92-year-old man with heart failure chose a "sequential pacemaker" because I assured him that he would no longer be terribly short of breath and could continue to take care of his wife, who needs supervision because of dementia. He didn't want to give up his chance for sudden death, and only did this because he loves her. Now he's happy about his decision, is hoping for another decade, and has a real risk of making it.

Vaccination against epidemic disease is somewhat different. We accept such vaccination to protect *others,* accepting a small risk to ourselves from the vaccine. We must vaccinate 70% of the herd to prevent an influenza epidemic from occurring, for example.

Other vaccination is personal: rabies vaccine for outdoorsmen, for example. People who are *at risk* for rabies are recommended to have the vaccine.

Assessing Risk of Aircraft Accidents Is Similar

If you *intend* to crash, it's not an accident. We call it an accident because it wasn't on the plan for the day. We all know that the risk – the probability of something bad happening – varies with time and circumstances. Fly your glider into a rotor cloud with no attitude indicator, and there's a very high probability that you will come out the bottom in pieces in a few seconds.

On the other hand, flying after 3 beers, which tends to remove "no" from our vocabulary, is less risky than that, but for longer. The principle is the same: the *time* spent and the *circumstances* determine the probability that something bad happens.

One Percent Rule

Medical risk evaluation by aviation regulators tends to follow the 1% rule – a very hazy standard that exists because it's simple, and more rational standards are complex and time-consuming to establish and defend.

The 1% rule stems from assessment of cardiovascular risk – thanks to the famous study of the residents of Framingham, Massachusetts, models have been constructed to translate the fact of their experience to estimated risk of cardiac events.

Airmen with an annual risk exceeding 1% of inflight death or sudden incapacitation are not certified because this is considered a high risk. A 1% *annual* risk of dying of cardiac disease translates to a 1:100,000,000 risk *per flight hour*.

In the airlines, the *size* of risk is related also to the number of souls aboard, and whether any of them is important to world peace. I'm not arguing for or against this standard. I'm writing to give you some perspective on the levels of risk that others find concerning.

Two challenges are that deciding whether the Framingham group is relevant to an individual is not always straightforward, and extending the

model to pilots living in another era entirely is uncertain.

However, as long as we accept the fact that the numbers are only loosely connected to real experience, and that nothing better exists, we can treat the numbers as *proportionate* guides.

Similarly, after a severe closed head injury or non-disabling brain bleed, the seizure risk is 2.5-10% *per year*. This *high-risk* situation brings a one in ten million chance of a seizure per flight hour. (Normal adults have a risk of about 0.015% per year, about a thousand-fold less.)

In general this level of risk is considered completely disqualifying by aviation authorities around the world. With any condition, ask, "Would I be this pilot's passenger?"

Bloating Benefit, Deflecting Blame

In the medical realm, if *risk* is the coin's head, *benefit* is its tail – we can ask ironically, "What is the risk that this treatment will help me?"

Surgical treatment of life-threatening or disabling conditions brings almost 100% benefit and very low risk of harm, such as cataract and gallbladder surgery. Penicillin for strep throat, likewise.

But chemotherapy for cancer generally brings a 100% chance of annoying or dangerous side effects, and benefits that range from less than 10% *response* to some potential for cure. Fear and presumption drive misconception about this.

For example, a woman had breast cancer, and because the results of surgery showed a definite risk of recurrence, was given chemotherapy aimed at reducing that risk – at a time when she had *no detectable cancer*. The treatment was hard on her. Afterward, she said, "That cancer almost killed me!"

No, the chemotherapy almost killed her. It was several years before the cancer recurred and killed her. We cannot know, for any individual, whether suffering through the therapy prolonged her life.

Treatment may have *statistical* significance, which means merely that a benefit is "probably not due to chance." Whether an effect is *useful* cannot be measured statistically.

Consider antidepressants: depression is typically improved in 40-50% of patients who receive *placebo* and 60-70% of those who receive *active drug*. Both placebo and drug are reported to have side effects!

Obviously, this is not like penicillin for strep throat. Antidepressants are not useless, but their benefits are persistently exaggerated and their blunting of intellect ignored.

Bloating Risk, Creating Worry

Whether menopausal women should take estrogens has been persistently controversial for 40 years. Let me say that it's an interesting issue that requires educated judgment, not knee-jerk reaction.

Fundamentally, estrogens are 100% effective in relieving the immediate distress of menopausal estrogen loss, relief of hot flashes and insomnia, mainly. The long-term benefits are *relatively* stronger bones and less vaginal dryness

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late in life. (A miserable thing.)

With best management, what are the risks?

The Women's Health Initiative showed about a 30% increase in the risk of cardiovascular events and a 25% increase in breast cancer diagnosis. This led to a decrease of 80-90% in the use of estrogens among postmenopausal women.

These percentages translate to 42 more breast cancers among 16,600 women (166 v. 124) and 46 more strokes and heart catastrophes (424 v. 378) – about 30 more women per 10,000 in five years, about 6 more per year. Some of the publicity noted that estrogens had a 100% increase in the risk of blood clots to the lungs. One clot without and 2 clots with estrogens.

There was also a 25% decrease in fractures (138 fewer, 650 with v. 788 without estrogens) and a 37% decrease in colon cancer (22 fewer, 45 v. 67).

My point here is that the percentages make these effects seem very large, but the absolute difference, compared to estrogens' reliable benefit, is very small. *Not negligible*, but small.

Heads in the Sand

"You have a spot here," the doctor drones, "It could be cancer – or maybe not."

We docs have a very special ability to create panic with a simple declarative sentence. "Could be" – What's the actual risk? – for people of my age, my sex, my race, my family history, my exposure to "toxins," and so on.

Frankly, these risks are generally understood epidemiologically in very broad terms, and few doctors keep the nuanced details, when there are any, on the tip of the tongue.

Medical technology has created many (expensive) ways of trying to answer the "maybe not" question, some of which, like breast and prostate biopsy and colonoscopy, carry their own risk of harm or death.

A problem in handling this risk is that you are an individual. You are not a group. You can't be 40% diseased. You either have or do not have the disease. If you have it, it's hidden, or we would not be asking the question.

We have only epidemiology to guide us – the experience of the herd – and we translate the facts of others' health into a risk estimate.

"Screening" for hidden disease is a focus of medical care. Enthusiasm for screening is based on faith that *diagnosis is accurate* and *treatment benign*.

Hypertension and diabetes screening, and pap testing, are examples of this working well: people feel fine, with hidden disease, until irreversible damage has occurred. This can be prevented or mitigated with low-risk, low-cost treatment. These are common diseases, and errors in diagnosis are easily corrected.

The effects of screening for uncommon but greatly feared disease, such as cancer, is fraught with opportunity for error. These diseases are typically difficult to discover early.

Tests may be very good at detecting disease when it exists (*sensitivity*) but may be wrong (*specificity*). If, on any Tuesday, 1 in 1,000 people actually have a cancer, and the test is correct 90% of the time in people with cancer, and wrong 1% of the time in people without it (a very, very good test), then on this Tuesday, there is a 10% risk that the one person with cancer is missed, and 10 people without cancer are told they have it, and embark on further testing (which itself may not be correct).

To view this another way, for every ten people "positive for cancer" on the test, one will have it and 9 will not. It is not possible to be judicious in the use of screening tests unless we understand this. You see the difficulty with screening for disease that's not frequent. And on any given Tuesday, no cancer is frequent, probably not even 1 in 1,000.

Right now, screening for breast cancer with mammograms, for prostate cancer with rectal exam and blood tests, and skin surveys for skin cancer are controversial due to this limitation.

We need to limit screening to people known to be at higher risk, such as having one or more first-degree relatives with the disease (for prostate, breast, and colon cancer) or having more than 5 blistering sunburns, lifetime, for skin cancer.

Will Life Get Better?

A first question is, if an individual feels fine, will sniffing expensively around for hidden disease improve life? The second question is, is our goal to make the *herd* healthier (on the average) or to guide one person down life's ski-slope?

These questions lead to confusion in the doctor's office. We docs are given epidemiologic data, about the herd, and told to make decisions based on that. Yet we are face to face with an individual, who usually does not know or care about the priorities of public-health planners.

People (patients) who understand this are seldom willing to jump off the cliff simply to improve public health statistics. This is perhaps one reason why physicians with disease choose different treatment, in general, than laymen.

Without getting into the nuances, neither breast self-examination nor mammography reduces breast cancer death rates by very much. Yet *judicious* use of both surely changes individuals' lives for the better.

Awhile back, I was with a respected physician colleague while he saw patients in his office. Over and over again, when asked by men whether the exam would include a prostate check or blood test for PSA, he replied, "We don't do that anymore."

This is the "Head in the Sand" approach to screening. It assumes that finding signs of hidden disease can only make life worse.

This is like not bothering with preflight weather briefings because the fatal accident rate becomes only a little higher, and canceled flights are costly.

The best use of screening tests is for people with a high underlying risk of disease, such as a smoker with diabetes. A detail weather briefing, likewise, is more important with an approaching front than in the middle of a high.

A final question, one that rarely is answered dispassionately, is: Is the treatment better than the disease?

Very few people are able to comfortably refrain from treatment. And those who can are often pressured intensely by family (kids) to "try" or "don't give up." Yet "observing" the low-grade prostate cancer, or with incurable cancer, easing

off on chemotherapy, often results in a much more comfortable life.

For example, one of my patients was hospitalized in April, nearly dead and feeling horrible from the chemotherapy for his metastatic colon cancer. We are not going to cure this. He hates the idea of "giving up." But "not giving up" will kill him in short order. Ten months later, with no chemo, he's "feeling OK" – his aches and pains merely arthritic. The cancer will eventually get him, but life is now tolerable.

When we fail to honestly tell patients there is no cure (technically, "preserving hope"), they then choose therapy that makes them suffer terribly, with a high risk of death. The death certificate says "cancer" because it's hard to write "iatrogenic."

Handling Risk

A few years ago I took off in our airplane on a trip with my wife. About five minutes into the flight, presumably to stave off boredom, she said, "OK, you just died." (Wishful thinking, as it turned out.) "What do I do now?"

This is a very good question. Even though I'd thought about this in the armchair, answering this question during actual flight kept us occupied for a long time, as I tried first one way and then another to invent a protocol that was understandable, memorable, and manageable. It did not feel like a success.

The point is that she was thinking about risk, and we tried to work out a way to mitigate its effects on her in a complex airplane.

In general, we are surrounded by risks. Some adverse consequences of risk are intolerable, unthinkable, or tragic, and we do everything we can to manage the circumstances to minimize this, and to form a plan to adapt to difficult situations. If we realize belatedly that an assembly step was done wrong; if we fly into turbulence; if our leg cramps up; if the air around us congeals into cloud – what do we do?

1 – Realistic Assessment

Good judgment is impossible without accurate information. It's important to know everything of importance – it's also important to realize what we don't know. Risks must be judged based on their *likelihood* and the *severity* of an adverse outcome.

That is, a risk may be unacceptable either because a bad result is likely (skidding the turn to final) or because the consequences are severe (death, dismemberment).

Judging risk requires that we understand the workings of aircraft systems, our bodies, and the weather.

2 – Adjustment

When the risk or possible cost seems high, it's not always best to turn away. Judging risk more often should bring *flexibility* to our plans. We can ask for counsel, get more information, adjust the circumstances, pull in our spurs, and so on.

3 – Communicate

Most things we do involve other people. The risks I accept as a physician are borne by *the patient* who is trusting me for good advice. The risks I take as a pilot or a driver are borne by my passengers. This is important to remember, and our decisions are wise only when we take *their* priorities into account.

This can be resolved only through discussion. Because telepathy fails, we always enter a conversation disagreeing in some way because we can't know each others' thoughts. Yet we tend to assume that others must perceive and know what's obvious to us.

We can only discover our differences by talking. We can only agree by comparing knowledge and priorities. This requires *communication*, which is *first*, listening, and *second*, responding. We tend to assume that everyone else knows what we know, and that friends share priorities. This is comfortable but false.

What to Do about Risk

We cannot escape risk. Until the crystal ball starts working, we have to make decisions based on our understanding of how the systems work, and what has been experienced by others in the same circumstances.

As George Santayana famously said, "Those who cannot remember the past are condemned to repeat it." (*The Life of Reason*, 1905.) This applies to medicine, where epidemiology is our history, to pilot decisions, where hangar flying is our history, and could be applied to politics, if anyone were listening.

Neither the good outcomes we intend, nor the bad results we would regret, are inevitable. Both success and accident are *probable* – we can use knowledge and judgment to adjust the probabilities.

References

A very incisive video lecture (56 minutes) on errors in judging health-risk statistics

http://tinyurl.com/gugn6xa

Gerd Gegerenzer, Director, Max Planck Institute, Berlin

This is absolutely worth an hour!

Dr. Gegerenzer has written several lay books on the calculus of risk and decision making:

Simply Rational, Risk Savvy, Rationality for Mortals, Gut Feelings, Reckoning with Risk, Calculated Risks, Adaptive Thinking; The Empire of Chance: How Probability Changed Science

Women's Health Initiative – Of many publications, the first was JAMA **288**:3;321-333, July 17, 2002

And a critique is at http://tinyurl.com/WHI-critique Nuclear Receptor Signaling, October 30, 2006.

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