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Risk Communication

In a world that is fundamentally uncertain, society needs to be prepared to deal with risks and uncertainty in a proper way. However, often this is not the case, and the psychological consequences of misperceiving risks can have severe, physical consequences. First, this entry illustrates why this issue is important. Then, typical misunderstandings that happen in risk communication are explained, as well as how these misunderstandings can be avoided and insight can be reached.

Example

In October 1995, the U.K. committee on the Safety of Medicines issued a warning that third-generation oral contraceptive pills containing desogestrel or gestodene increased the risk of venous thromboembolism by 100%. That is, the risk was twofold. This information was passed on in 190,000 letters to general practitioners, pharmacists, and directors of public health and also forwarded to the media. In response, many women decided not to take the pill any more.

In the following year, the number of abortions in the United Kingdom increased by almost 9%, which makes a total of 13,600 additional abortions, against the decreasing trend in abortions in the previous years. This number is particularly interesting in comparison with the increase in conceptions, which was only 3.3%, a total of 26,000 additional conceptions. That is, the number of additional abortions amounts to more than half of the number of additional conceptions, which at least suggests that out of the additional conceptions particularly many were unwanted. Moreover, the increase both in conceptions and in abortions was particularly pronounced in teenagers. The resulting additional costs for abortion provision to the National Health Service have been estimated to be about £46 million (almost $71 million, at that time).

A closer look at the twofold risk of thromboembolism reveals that it approximately means that the risk of thromboembolism increases from 3 in 20,000 women who take second-generation oral contraceptive pills (i.e., those containing levonorgestrel or norethisterone) to 6 in 20,000 women who take third-generation oral contraceptive pills, while the baseline risk of women who do not take oral contraceptive pills is about 2 in 20,000. That is, the relative risk increase is indeed 100%, but in absolute numbers, this means a risk increase of only 3 in 20,000. Additionally, it needs to be noted that pregnancy increases the risk to 12 in 20,000, which is again twice as high compared with taking third-generation oral contraceptive pills. Had women known these numbers, many unwanted pregnancies and subsequent abortions may have been avoided.

Risk Illiteracy

This example illustrates a larger societal problem. Many citizens are not prepared to deal rationally with risks and uncertainties. This problem is particular in that it is one of those that are not recognized as such in the public, although it may cost lives, cause abortions, or just psychological pain. Such a pill scare will likely happen again, as others did before, and people may not be prepared to react with reason, since many are statistically illiterate in the sense that they do not know about the distinction between a relative risk (100%) and an absolute risk (3 in 20,000).

It has been debated whether risk illiteracy is mainly a consequence of cognitive limitations, as suggested by the extensive literature on risk perception. However, such an internal attribution of the causes has not led to successful treatment. If "probability blindness" were caused by our cognitive limitations, then we just would have to live with it, or, as some have suggested, to keep citizens away from important decisions. In contrast to this view, there are numerous examples showing that risk innumeracy is largely a function of the external representations used in risk communication.

In particular, there are three common representations, *relative risks*, *single-event probabilities*, and *conditional probabilities,* which may be confusing,.

Relative Risks

The increased risk of venous thromboembolism by third-generation oral contraceptive pills put forward as a twofold risk, or an increase of 100%, is a relative risk. As explained before, the 100% mean an absolute risk increase from 3 to 6 in 20,000.

The problem with relative risks is that they are silent about the base rate risk. That is, the risk increase would be 100% independent of whether the increase is from 3 to 6 in 20,000 or from 3,000 to 6,000 in 20,000. However, most would agree that the societal importance of the latter risk increase would be much larger than that of the former (which matches that of third-generation pills). Relative risks thus can be used to make risks loom larger than they actually are. This similarly holds for risk reductions. In the pill example, one could argue that women who switch from third-generation pills back to second-generation pills reduce their risk of venous thromboembolism by 50%, namely from 6 to 3 in 20,000.

However, instead of using the number of diseases as a reference class, one could also use the number of healthy women (i.e., without thromboembolism) as a reference class, and thereby make the relative risk reduction look small. Namely, instead of 19,994 in 20,000 women taking third-generation pills who are healthy, there would be 19,997 in 20,000 women with second-generation pills. The absolute increase in healthy women is again 3 in 20,000, but in relative numbers, the increase in healthy women is only .015%. Thus, a risk reduction by 50% can mean the same thing as an increase in healthy women by .015%. In absolute terms, it becomes transparent that the difference is 3 in 20,000 in both cases.

Not only are lay people often confused about relative risks, but experts are as well. For example, decisions by health authorities on which treatment to fund have been shown to be largely affected by the representation format: Rehabilitation and screening programs were evaluated much more positively if their benefits were described in terms of relative risk reductions.

Single-Event Probabilities

An everyday life example of single-event probabilities can often be heard in the daily news when the speaker indicates the chance of rain for the next day. A statement such as that the chance of rain tomorrow is 30% remains unclear to many. In the end, it can only rain or not. The problem is that it is unclear to what the 30% refer to, that is, the *reference class* is missing. Some people believe that there will be rain in 30% of the area, others think that it is 30% of the time. The right interpretation, however, is that out of 100 days that are exactly like tomorrow, it will rain in 30 of them.

In medical contexts, single-event probabilities are often used to communicate the risks of a treatment, such as side effects. A psychiatrist often prescribed fluotexine (Prozac) to patients with mild depression and told them that the risk of having sexual problems (e.g., impotence or loss of sexual interest) as a side effect was 30% to 50%. Many of his or her patients were anxious hearing those numbers, because they interpreted them as meaning that *every* patient would have problems in about 30% to 50% of their sexual encounters. However, the numbers actually mean that out of 100 patients 30 to 50 will experience a sexual problem. Hearing this interpretation, patients were much less afraid of taking Prozac. This example illustrates again a reference class problem: While the patients had their own sexual encounters in mind as a reference class, the doctor was referring to patients as a reference class.

Therefore, the solution to such misunderstandings is clear: clearly indicating a reference class (e.g., sexual problems will occur in 30% to 50% of patients) or using a frequentist formulation (e.g., out of 100 patients, 30 to 50 will experience a sexual problem).

Conditional Probabilities

The chance of detecting a disease with a medical test is usually communicated as a conditional probability, namely the sensitivity of the test: "If a woman actually has breast cancer, the chance of getting a positive mammogram in a mammography is 90%." That is, it is the probability of testing positive *given* breast cancer. However, this is often confused with the positive predictive value of the test, the probability of having breast cancer *given* a positive test result, which is not the same. This can be illustrated with a more intuitive example. Up to 2008, every American president was male. That is, the probability of being male given that one is president of the United States was 100%. The reverse, obviously, does not hold: Given that one is male, chances of being or becoming president of the United States are still rather low.

The question is how to get from the sensitivity of the test to the positive predictive value, which is the information one really needs. Two further pieces of information are necessary. First, one needs to know the base rate of the disease; here, this is about 0.8%. Second, one needs to know the false-positive rate of the test, that is, the probability of getting a positive test result *given* that one is actually healthy, which is about 7% in this case. Formally, the sensitivity, the base rate, and the false-positive rate can be combined to calculate the positive predictive value by applying Bayes's theorem. However, both experts and laypeople often have trouble with Bayes's theorem, and it is much simpler to think about such problems in terms of natural frequencies.

That is, instead of combining conditional probabilities, imagine 1,000 women. Out of these, 8 (= .8% base rate) are expected to have breast cancer, the remaining 992 are expected not to have breast cancer. Out of the 8 women with breast cancer, about 7 (= 90% sensitivity) will test positive. Out of the remaining 992 women without breast cancer, about 69 (= 7% false positives) will also test positive. That is, there are 76 women who test positive, out of which only 7 actually do have the disease. Therefore, the probability of a woman to have breast cancer given a positive test, the positive predictive value is 7 out of 76, which is approximately 9%.

Again, being confused by conditional probabilities is not only a problem of laypeople but also of experts. Only a very small proportion of physicians who were given numbers such as conditional probabilities actually combined them correctly to figure out the positive predictive value. The error that was most often observed was that the positive predictive value was confused with the sensitivity, which often resulted in overestimating the predictive power of the test (here, 90% instead of 9%). Sometimes, the false-positive rate was subtracted from the sensitivity, which still led to an overestimated predictive power (here, 83% vs. 9%). When doctors were given the same test properties in natural frequencies, they were much more likely to give the correct answer. Also, training in how to translate conditional probabilities into natural frequencies has long-lasting positive effects on the accuracy of such calculations, while training with Bayes's theorem does not seem to be very helpful.

Implications

People have to deal with risks and uncertainties everyday, in particular in the medical domain. Yet the ideals of informed consent and shared decision making will not be entirely realized until medical evidence is properly understood. Appropriate risk communication is thus a necessary step toward this goal.

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See also Bayes's Theorem; Informed Consent; Numeracy; Risk Perception; Shared Decision Making

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