Determining Risks with Statistics—and with Humanity

By William F. Altman

Mr Allman is a writer for Science 85: this article is excerpted from the October issue of that magazine.

Baltimore Sun, Oct 13, 1985, p.50

Crashing an Automobile at 30 mph is like diving headfirst, off a three-story building. As the car stops, you slam with about the same force into the windshield, wheel or dashboard – or, if you're lucky, the protective arms of a seat belt. Traffic accidents are the leading cause of death for people between the ages of 5 and 34: last year nearly 45,000 people died in auto collusions, the equivalent of a fully loaded passenger jet crashing with no survivors every day. If everybody wore seat belts, more than half of these deaths could have been avoided.

Chances are, you've heard all this before. Chances are you still don't wear a seat belt. Despite millions of dollars spent on advertisements urging people to "buckle up for safety", only about one out of seven people to take better care of themselves.

Paul Slovic, a psychologist and former president of the Society for Risk Analysts, thought he might be able to persuade people to take better care of themselves. According to Mr. Slovic and his colleagues Sarah Lichenstein and Baruch Fischhoff at Decision Research in Eugene, Ore., a cursory look at the probabilities of death by car can be misleading. The chance of being killed in any automobile trip is about one in 4 million-less than the chance of being killed in a year of mowing the lawn. But the long view yields a different story.

"We make about 50,000 automobile trips in a life-time." Mr. Slovic says, : and the probabilities add up to a risk that is not trivial." About one out of every 140 people dies in a car accident: one out of three is injured seriously enough to be disabled for at least a day. If motorists would think in terms of a lifetime of driving rather than single trips, says Mr. Slovic, then perhaps they would decide to buckle up.

Mr. Slovic and co-worker Norman Schwalm produced new seat-belt messages emphasizing the lifetime risks of automobiles. Several hundred volunteers watched the ads and answered questionnaires about which ads they found most effective. Although the results seemed to indicate that the approach showed promise, one thing watching volunteers drive away from the parking lot, noted with dismay that there was no increase

in seat-belt use. The advertising effort, Mr. Slovic says, added “one more flop to an impressive list of failures.” He now supports laws, recently passes in New York and several other states that make wearing seat belts mandatory.

Imagine how the apparent irrationality of Mr. Slovic’s subjects frustrated him. His subjects were, after all, drawn from the general public, the same general public that smokes billions of cigarettes a year by banning an artificial sweetener because of a one-in-a-million chance that it may cause cancer; the same public that eats meals full of fat, flocks to cities prone to earthquakes and goes hang gliding while it frets about pesticides in food, avoids the ocean for fear of sharks and breaks into a cold sweat on airline flights.

In short, we, the general pubic, are irrational and uninformed. We don’t understand probability, are biased by the news media and have a fear of some technologies that borders on the primeval. But a few scientists are beginning to ask if technical savvy is the only qualification needed to be legitimate worrier. They are finding that, while our behavior often appears irrational and confused, perhaps we ‘re not so dumb after all. We may be lousy with mortality statistics, but our fears might tell us a lot about how a risk affects society as a whole.

One problem with the way we deal with risk is that our decisions can be influenced by the way a situation is presented. Suppose someone made you a simple, no-risk offer: Flip a coin – if it’s heads you get $1,000; tails, you get nothing. Suppose further that you have the option of foregoing the coin flip in exchange for sure money. What’s the least amount of money you would take?

If you flipped the coin hundreds of times, your average reward would be $500, so in a utilitarian sense the offer is worth $500, and the rational choice would be to accept no less than $500. According to one study, however, most people would settle for about $350.

Now suppose someone gave you $1,000 but with two options: You can flip a coin to determine if you have to give it all back – or you can simply return a portion of the money. How much would you be willing to give up to avoid flipping?

Again, the rational choice would be $500. But if you content to accept $350 in the first game, it would seem logical that you should be willing to give up $650 rather than risk flipping for the entire $1,000. Most people, however would not give back more than $350. The outcomes of the games are identical: In each there is a 50-50 chance of winning $1,000. But the presentation of the two games is not identical. In the first, the

choices are between two gains; in the second, the choices appear to be between two losses.

According to Amos Tversky and Daniel Kahneman, that makes all the difference. The two psychologists discovered the fundamentals of our flip-flops about risks: “When it comes to taking risks for gains, people are conservative. They will make a sure gain over a problem gain,” says Mr. Tversky. “But we are also finding that when people are faced with a choice between a small, certain loss and a large, probable loss, they will gamble.”

If we can’t be certain about the risks we face, we at least want to have some control over the technologies and activities that produce them. It has long been known, much to the frustration of some risk experts, that we may be much more willing to accept higher risks in activities over which we have control, such as smoking, drinking, driving or skiing, than things over which we have little control, such as industrial pollution, food additives and commercial airlines.

A feeling of control can actually make a risky technology even more dangerous. That’s because we often have inflated opinions of ourselves. Most of us consider ourselves above-average drivers, safer than most when using appliances and power tools and less likely to suffer medical problems such as heart attacks. “Such confidence is dangerous” says Mr. Slovic. “It indicates that we often do not realize how little we know and how much additional information we need about the risks we face.”

When we think about risk, says Mr. Slovic, we are not only concerned that technology has the potential to cause deaths. We also worry about more subtle aspects: How well do we understand the risk? How will it affect society? Could it wipe out an entire community? Make a particular area uninhabitable for a long time? Would it affect future generation or some members of society more than others?

Mr. Slovic and his colleagues found that when people were asked to apply these societal concerns to the risks of some 90 different activities and technologies, each took on a profile that was broader than a simple death statistic. Some items, such as dynamite, were considered deadly, but also fairly controllable. Others, such as microwave ovens, were thought to involve risks that were delayed in their effects and not well-known, but were also voluntary and unlikely to cause catastrophes.

The respondents overwhelmingly regarded the risks of nuclear power as involuntary, uncontrollable, unknown, inequitably distributed, likely to be fatal, potentially

catastrophic and evoking feelings of not just fear but dread. Automobiles, which kill far more people per year, evoked few of these concerns.

According to Mr. Slovic, we are also concerned about the inherent riskiness of assessing risks. Part of our worry about technologies such as nuclear power, toxic wastes and genetic engineering, for example, stems from the knowledge that the assessments of these risks are not based as much on the experience of a proven track record as on scientific analysis that, like some scientific analysis, might be in error.

Since many new technologies are understood by few people in the first place, says Mr, Fischhoff, the experts are left to asses the quality of their own judgments, which can lead to problems. “Many risk problems force experts to go beyond the limits of available data,” he says. “In doing so, they fall back on intuitive processes much like those of lay people and are capable of making the same types of mistakes.”

The fact that the public is keenly aware that scientists can be wrong is at the root of the concern about the nuclear accident at Three Mile Island. Before the accident, scientists had said confidently that the chances of a serious reactor breakdown were quiet remote. But when a potential disaster occurred relatively early in the history of nuclear power, even though the safety systems worked and the disaster never materialized, the mishap sent out a signal that the overall assessment of the risks of nuclear power might be in error.

Since we often put out fates in the hands of experts, we react strongly to signs that our faith has been misplaced. “With the accident of Three Mile Island,” says Mr. Slovic, “the health and safety consequences were insignificant; no one was killed, and there is probably no latent cancer. But the costs to society were enormous. Because the accident was a signal of potential problems, the ripple effect shut down reactors all over the world at a cost of billions of dollars. That’s an expensive signal.”

The big question, says Mr. Slovic, is whether our worries and fears, which sometimes are the result of faulty logic and misinformation – but also stem from a broader concern for how risks affect society as a whole – should be considered when making decisions about risk. “The dilemma is that if you give extra weight to non-statistical factors such as catastrophic potential, inequality and dread, and therefore choose an alternative – coal-fired power plants, for example over nuclear-power plants- you may actually be harming more people,” he says. “The crux of the problem is finding the proper way to look at risk. One person might believe that rational decisions should be based solely on death, injuries and damage. Another might say there are often important, hard-to-quantify feelings and

values that we need to consider when making a risk decision." And because these feelings include concerns for society at large, we can add a different perspective to risk debates. The scientists are better at seeing the trees, perhaps, but we're better at seeing the forest.

"We come down real hard on the public because they seem uninformed and irrational." says M. Slovic. "But their behavior may tell us something important about the essential elements of a human society. In a sense, there is real wisdom in people's reactions."

This wisdom depends less on understanding the details of scientific risk assessment than understanding the limits of what the science can do. "People are often more scientific in watching the processes of science than scientists themselves," says Mr. Fischhoff. "If the public looks at us with a skeptical eye, maybe they know something we don't"

Ranking the Risks

The general public views and scientists view risks very differently. Those ranking of risks by experts follows very closely actual death statistics. The public, according to psychologists, tends to factor in order considerations – such as how much control they feel they have in a situation. This is why, according to the psychologists, nuclear plants produce more fear than automobiles. (The correlation between the two rank orderings is .5635, meaning in just about half the number of examples do the public agree with expert opinion).

Table 1

General Public Rank Ordering or Risk

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Nuclear Power	P																				E									
Motor Vehicles	E	P																												
Handguns			P	E																										
Smoking		E		P																										
Motorcycles					P	E																								
Alcoholic Beverages			E			P																								
General (Private) Aviation							P					E																		
Police Work								P									E												
Pesticides								E	P																					
Surgery					E					P																				
Fire Fighting											P							E												
Large Construction												P	E																	
Hunting													P											E						
Spray Cans														P												E				
Mountain Climbing															P														E	
Bicycles														E		P														
Commercial Aviation																E	P													
Electric Power (nonnuclear)									E									P												
Swimming										E									P											
Contraceptives											E									P										
Skiing																					P									E
X-rays																						P						E		
High School and College Football							E																P							
Railroads																				E				P						
Food Preservatives															E										P					
Food Coloring																						E				P				
Power Mowers																			E								P			
Prescription Antibiotics																									E			P		
Home Appliances																							E						P	
Vaccinations																										E				P

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P: Public E: Experts

Table 2

Experts' Rank Ordering of Risk

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Motor Vehicles	E	P																												
Smoking		E		P																										
Alcoholic Beverages			E			P																								
Handguns			P	E																										
Surgery					E					P																				
Motorcycles					P	E																								
High School and College Football							E																P							
Pesticides								E	P																					
Electric Power (nonnuclear)									E									P												
Swimming										E									P											
Contraceptives											E									P										
General (Private) Aviation							P					E																		
Large Construction												P	E																	
Bicycles														E		P														
Food Preservatives															E										P					
Commercial Aviation																E	P													
Police Work								P									E													
Fire Fighting											P							E												
Power Mowers																			E								P			
Railroads																				E				P						
Nuclear Power	P																				E									
Food Coloring																						E				P				
Home Appliances																							E						P	
Hunting													P											E						
Prescription Antibiotics																									E			P		
Vaccinations																										E				P
Spray Cans														P													E			
X-rays																						P						E		
Mountain Climbing															P														E	
Skiing																					P									E

Sun Graphics/Tony DeFeria

Figure 1

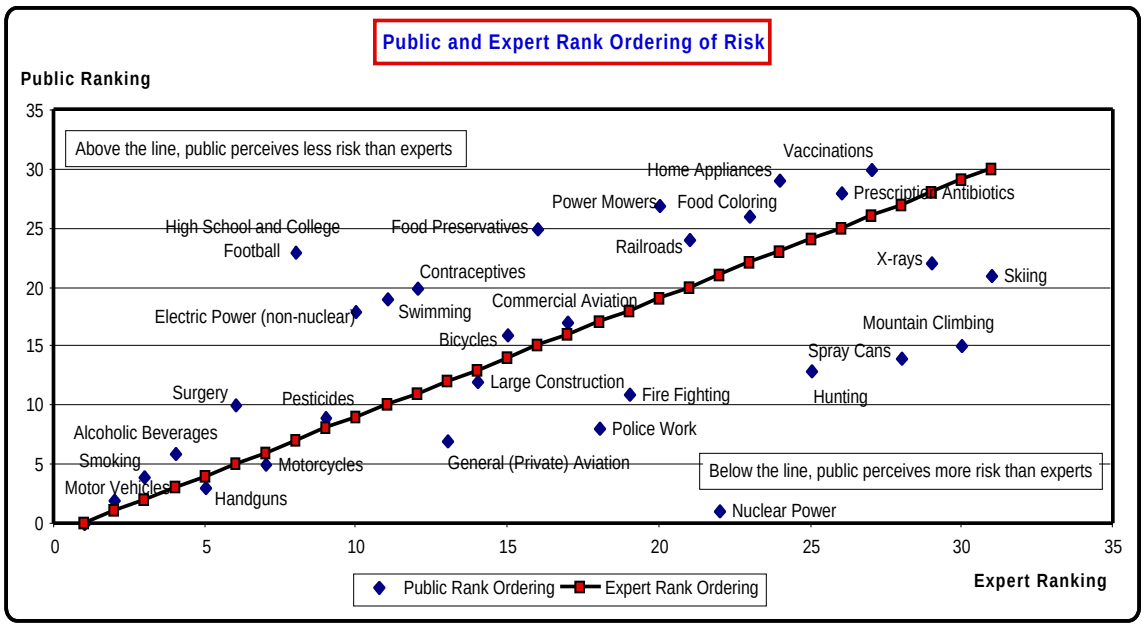


Figure 2

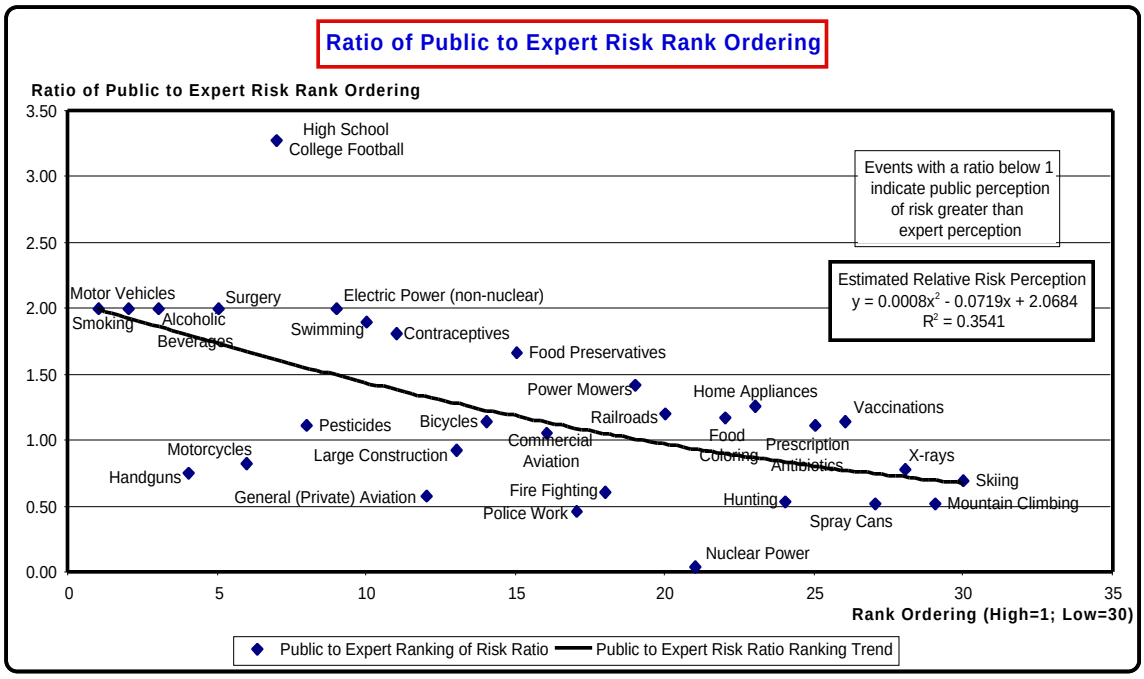
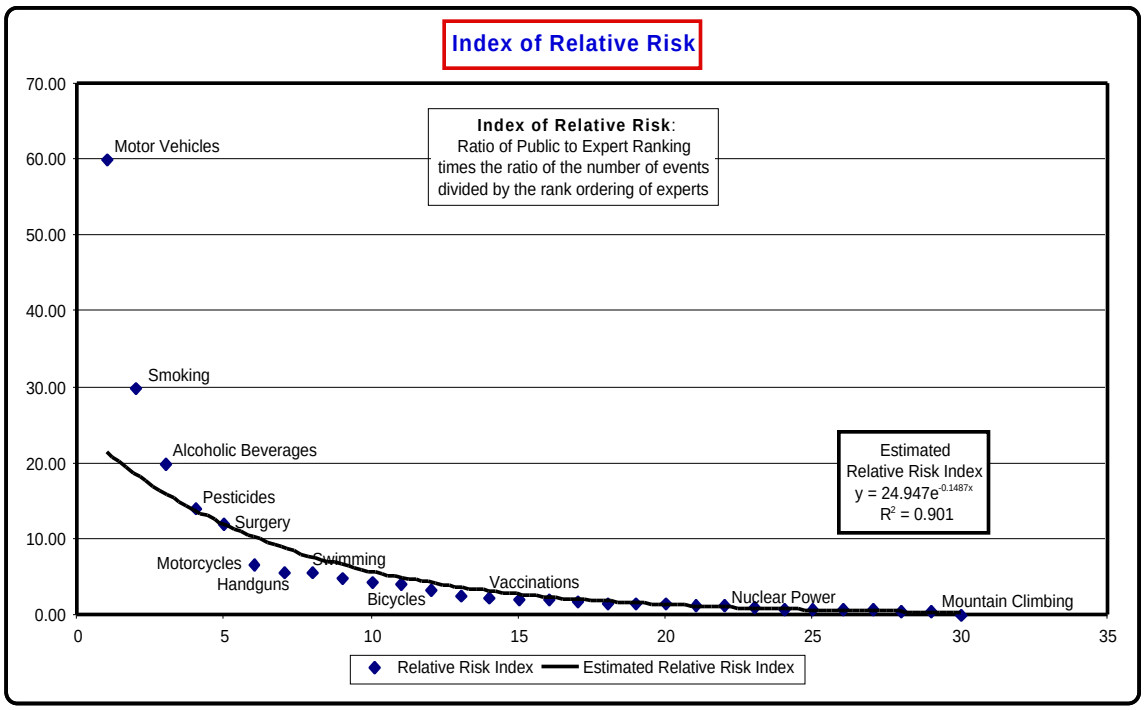


Figure 3


Index of Relative Risk
Index of Relative Risk: Ratio of Public to Expert Ranking times the ratio of the number of events divided by the rank ordering of experts
Estimated Relative Risk Index
y = 24.947e-0.1487x
R2 = 0.901
Motor Vehicles
Smoking
Alcoholic Beverages
Pesticides
Surgery
Motorcycles
Handguns
Swimming
Bicycles
Vaccinations
Nuclear Power
Mountain Climbing
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0
5
10
15
20
25
30
35
Relative Risk Index
Estimated Relative Risk Index