A Review of the Record

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REDUCING HEALTH AND SAFETY risks has been a top priority of federal regulation for almost two decades, yet there is little systematic information describing the kinds of risks the government has chosen to regulate or the effectiveness of these interventions. This article is a modest attempt to fill the gap—I hope no more than a first step. I collected data on the best documented federal health and safety regulations and, for the 44 rules for which fairly complete information was available, examined the kinds of risks addressed and the benefits and costs of the regulations. The study was originally undertaken in the course of my work at the Office of Management and Budget's Office of Information and Regulatory Affairs, where my colleagues and I thought comparative data on past regulations would be helpful in reviewing the cost-effectiveness of new regulatory proposals. As it turned out, the study yielded several general insights—some contradicting the received wisdom on health and safety regulation—worth bringing to the attention of a wider audience.

Everyday Risks

Before turning to the risks the government regulates, it is worth examining the risks we all face from various common (or commonly known) events and activities. This will provide some appreciation for the magnitude of the risks involved and the ambiguities inherent in the idea of risk. Tables 1 and 2 list the major causes of death in the United States, and various events and activities which may cause death. (Annual risk is simply the annual deaths from the risk in question divided by the U.S. population exposed to that risk.) As Table 1 shows, Americans on average face about a 9-in-1,000 risk of dying each year, including a 1-in-10,000 risk of being murdered and a 5-in-10 million risk of being killed by a lightning bolt. According to Table 2, the average smoker faces a 3-in-1,000 risk each year of dying as a result of smoking, and the average hang glider pilot faces a 4-in-10,000 annual risk of being killed in a hang gliding accident.

The risk figures in Tables 1 and 2 are not adjusted for age or intensity of activity. Obviously, age has a very large effect on the risk of dying. At age five the annual "background" risk of dying from all causes is less than 1 in 1,000 (actually about 0.3 in 1,000), while at age 40 it is about 2 in 1,000 and at age 80 it is about 83 in 1,000. The risks shown in Table 1, including the 9-in-1,000 annual risk of death from all causes, are averaged across all ages. Since the age distribution of the U.S. population is heavily weighted toward younger people, who have a less-than-average risk of dying, these estimates understate the average annual risk for most individuals.

Similarly, the risk of death from engaging in any particular activity is affected by the frequency or intensity of that activity. The relationship here is complex because in many cases skill and hence ability to avoid accidents improves with increased frequency. The pilot who goes hang gliding 10 hours per year does not face 10

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Table 1
MAJOR CAUSES OF DEATH*

Cause	Annual Death Rate**	Annual Deaths
All Causes	8.7 in 10^3	1,913,841
Heart Disease	3.3 in 10^3	733,235
Cancer	1.8 in 10^3	403,395
Stroke	7.7 in 10^4	169,488
Accident	4.8 in 10^4	105,312
Suicide	1.2 in 10^4	27,206
Homicide	1.0 in 10^4	22,550
All Accidents	4.8 in 10^4	105,312
Motor Vehicle	2.4 in 10^4	53,524
Falling	5.9 in 10^5	13,216
Drowning	3.1 in 10^5	6,872
Fires	2.7 in 10^5	5,991
Poisoning	2.2 in 10^5	4,637
Lightning	5.0 in 10^7	110
Bee Stings	1.8 in 10^7	40

Sources: Calculations based on data from *Monthly Vital Statistics Report*, National Center for Health Statistics (September 30, 1982); *Accident Facts*, National Safety Council, 1983 Edition; *Journal of the American Medical Association* (August 10, 1984); and various reports from the Consumer Product Safety Commission.

*Deaths are for 1979 and death rates are based on U.S. population of 220 million. The list of accident types is selective.

**Annual deaths per exposed population. An exposed population of 10^3 is 1,000, 10^4 is 10,000, etc.

times the risk of the one-time daredevil who flies one hour on a lark; indeed, the pilot's risk might even be lower. On the other hand, where the hazards of engaging in an activity are primarily passive (unrelated to skill), risk may increase proportionately with frequency, or even more than proportionately. A heavy smoker who smokes 10 times as much as an occasional smoker probably faces considerably more than 10 times the risk. (This is the issue of whether "dose-response" relationships are linear or more than linear with increased exposure, discussed in Albert L. Nichols and Richard J. Zeckhauser, "The Perils of Prudence," in this issue.) The average annual figures in Table 2 mask variations such as these.

Everyone dies at some point—our lifetime risk of dying is one in one—and, as Table 1 shows, most of us die of (in this order) heart disease, cancer, strokes, or accidents. Suicide and homicide are a distant fifth and sixth, though probably more frequent than most people realize: the combined risk of being murdered or committing suicide is about the same as being killed in an auto accident. On an annual basis, driving to work is twice as risky as the average job, though only half as risky as working in a mine or being a boxer. The risk of smoking is greater than the risk of military service during the Vietnam era, and nearly as great as the risk of stunt flying.

Most causes of death are strongly age-related, and to this extent are involuntary. But many voluntary activities are quite risky, especially when one accounts for the effects of age and intensity of activity. For instance, a 40-year-old (with a background annual risk of dying of about 2 in 1,000) who swims (with an average annual risk of 2.2 in 100,000) increases his risk of dying (by about 1.1 percent). When he is actually in the water his risk is much greater: if the average swimmer swims 10 hours per year and the average miner works 2,000 hours per year, then swimming is about 10 times as risky, minute-by-minute, as mining. And most of us face a far greater risk driving to work than working, not just twice the risk. Even those of us who are miners are safer on the job than behind the wheel.

Federal risk regulations are aimed primarily at reducing deaths from cancer and accidents. These are the second and fourth leading causes of death in the United States, accounting respectively for about 400,000 and 100,000 deaths each year. A good deal of federal accident regulation is concerned with the two activities causing the greatest number of accidental deaths—driving and working. Whether federal regulation is effective in reducing these kinds of risks is another matter. At least in theory, all 100,000 accidental deaths could be avoided, but many cancers are

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diseases of old age, or of unknown etiology, and would persist even if all known causes were eliminated. Moreover, the most important known causes of cancer seem to be immune, for political or practical reasons, to regulatory control. An exhaustive study conducted by Richard Doll and Richard Peto for the Congressional Office of Technology Assessment in 1981 found that occupational and environmental exposures account for only about 4 percent and 2 percent, respectively, of cancer deaths, while food additives account for less than 1 percent. These figures compare with 35 percent caused by diet and

Table 2
RISKS OF DEATH FROM VARIOUS ACTIVITIES

Activity	Annual Risk*	Annual Deaths	Exposed Population
Work:			
All Occupations	1.1 in 10^4	11,200	98,800,000
Mining	5.5 in 10^4	600	1,100,000
Construction	4.0 in 10^4	2,100	5,200,000
Manufacturing	5.0 in 10^5	1,000	19,000,000
Sports:			
Air Show/Air Racing	4.7 in 10^3	5	1,050
Mountaineering	6.0 in 10^4	34	60,000
Boxing	5.4 in 10^4	3	6,000
Hang Gliding	4.3 in 10^4	13	30,000
Swimming	2.2 in 10^5	2,300	102,286,000
Basketball	2.0 in 10^7	4	25,322,000
Other:			
Smoking	3.0 in 10^3	345,000	115,000,000
Active Duty during Vietnam Era (1964-73)	2.2 in 10^3	7,093	3,279,000

Sources: Calculations based on data from *Accident Facts*, National Safety Council, 1983 Edition; *Product Safety and Liability Reporter*, Bureau of National Affairs (October 12, 1984); *Risk/Benefit Analysis*, Crouch and Wilson (1982); and *The World Almanac*, 1976.

*Estimated number of annual deaths per exposed population. An exposed population of 10^3 is 1,000, 10^4 is 10,000, etc.

30 percent caused by tobacco. (Use of alcohol accounted for another 3 percent.)

Table 3 presents estimates of the annual risks of cancer from various everyday activities. Smoking is by far the riskiest cause of cancer, with an annual risk of 1.2 in 1,000 (3 in 1,000 including risks of heart disease). But other activities, both voluntary and involuntary, also carry cancer risks that are substantial relative to those that are targets of regulatory control. For instance, there is a 2-in-100,000 annual risk of cancer from background radiation at sea level, from drinking one beer per day, or from receiving an average number of diagnostic X-rays.

Risk Regulation

Federal agencies have issued many hundreds of rules over the past 20 years aimed at reducing health and safety risks. The numbers would probably run into the thousands if one included the numerous private safety standards issued by the Occupational Safety and Health Administration (OSHA), the numerous food additive, drug, and cosmetics bans issued by the Food and Drug Administration (FDA), and similar actions. Unfortunately, only sketchy or partial information exists concerning the risks addressed by, and the benefits and costs of, most regulations. This is true even for such celebrated cases as the ban of the sweetener cyclamate in the early 1970s and the requirement in the late 1960s that motor vehicles be equipped with seat belts.

I have been able to identify 44 proposed, final, or rejected federal rules aimed at reducing risks of death (as opposed to risks of non-fatal accidents of illnesses) for which reasonably complete information on risks, benefits, and costs was available at the time of rulemaking. I believe this is an essentially complete set of such rules officially published in the *Federal Register.* The rules were published by OSHA, the FDA, the National Highway Traffic Safety Administration (NHTSA), the Consumer Product Safety Commission (CPSC), the Environmental Protection Agency (EPA), the Federal Aviation Administration (FAA), and the Federal Railroad Administration (FRA). Most of the data was provided in the "impact statements" required by various regulatory policy executive orders issued by Presidents Ford, Carter, and Reagan.

Table 4 lists the 44 regulations along with their year of issuance, issuing agency, and present legal status (proposed, final, or rejected). The important analytic data appear in the last three columns. The initial risk of those exposed to the thing or activity regulated, the number of lives saved by the regulation, and the cost-effectiveness of the regulation measured by cost per life saved. The rules are ranked in order of decreasing cost-effectiveness.

There are several important qualifications to the data in Table 4. First and foremost, the benefits (lives saved) and costs (dollars per life saved)

Table 3
ANNUAL RISKS OF CANCER

	Average Annual Risk*
All Cancers (age adjusted)	2.8 in 10^3
Cosmic Ray Risk	
Frequent airline passenger (4 hours per week)	1.0 in 10^5
Living in Colorado compared to New York	8.0 in 10^6
Camping at 15,000 feet for 4 months per year	2.0 in 10^5
Other Radiation Risks	
Natural background radiation (sea level)	2.0 in 10^5
Average diagnostic medical X-rays in U.S.	2.0 in 10^5
Living in masonry building rather than wood	5.0 in 10^6
Eating and Drinking	
One 12½-ounce diet drink per day (saccharin)	1.0 in 10^5
Four tablespoons of peanut butter per day	8.0 in 10^6
½ lb. charcoal broiled steak per week (cancer risk only; heart attack and other risks additional)	3.0 in 10^7
Alcohol, light drinker (one beer per day)	2.0 in 10^5
Tobacco	
Smoker, cancer only	1.2 in 10^3
Smoker, all effects (including heart disease)	3.0 in 10^3
Person sharing room with smoker	1.0 in 10^5
Air Pollution	
Polycyclic organics, all effects	1.5 in 10^5

Source: *Risk/Benefit Analysis*, Edmund Crouch and Richard Wilson (Cambridge, Mass.: Ballinger, 1982).

*Annual deaths per exposed population. An exposed population of 10^3 is 1,000, 10^4 is 10,000, etc.

of the rules are not actual benefits and costs of the rules in action—obviously they could not be in the case of proposed and rejected rules. Rather, they are generally based on agencies' estimates at the time of the decision, estimates which I sometimes revised for reasons described in a moment. Second, many regulations were projected to yield benefits in addition to saving lives, such as reducing non-fatal injuries and property damage. I accounted for these additional benefits by subtracting monetary benefits from costs and converting non-lifesaving health benefits into an index equivalent to additional lives saved. The conversions were based on leading economic studies of individuals' willingness to pay to avoid risks of death, disease, and injury; 50 non-fatal hospitalizations avoided, or two permanent disabilities avoided, were assumed to be equivalent to one death avoided. Third and finally, the benefits and costs of regulations are typically uneven, both for individual rules and across rules—one rule may impose costs long before it averts fatalities, and one may avert fatalities long before another rule does. For the sake of consistency, I adjusted these temporal variations using a uniform 10-percent discount rate for both benefits and costs.

Students of benefit-cost analysis will recognize an unavoidable imprecision in using a uniform discount rate, and a certain arbitrariness in using 10 percent rather than some other rate. Some regulatory costs displace investment and others displace consumption, and the two effects are not economically identical. Here as elsewhere, however, the analytical demands of tailoring a precise discount rate for each rule were impossibly large, and for comparative purposes the benefits of the greater precision would have been small. Students of regulatory politics will recognize that discounting benefits as well as costs runs afoul of the policies of some regulatory agencies, not to mention the positions of some political representatives and op-ed writers. On this point my procedure is impeccable. Discounting costs but not benefits leads to absurd results, such as that a rule saving 100 lives a decade from now is more desirable than a rule of equal cost saving 99 lives right away, and that all rules yielding continuous benefits are worth any amount of immediate costs.

The use of agency benefit and cost data also merits elaboration. Regulatory agencies, like other organizations public and private, tend to overstate the effectiveness of their actions. Where such biases were evident and easily corrected, I made the corrections. For example, where an agency presented a range of risk estimates but relied on the highest estimate, I used either the intermediate estimate or the one that appeared to be the most reliable. In 12 instances

I used estimates from published studies that appeared to reflect prevailing scientific views more accurately than the agency estimate. For example, in the case of OSHA's ethylene oxide rule, I used a risk estimate from another agency, the EPA, because it was based on epidemiologic evidence rather than on an extrapolation from an animal experiment. For safety regulations, I often deflated agency assumptions concerning accident reduction from 100-percent effectiveness to a more reasonable figure such as 50 percent.

I should mention that agency procedures for estimating risk and effectiveness typically contain numerous, and subtle inflationary factors (as explained in the accompanying article by Nichols and Zeckhauser); I attempted to correct only for the most obvious. As a result, many of the risk and cost-effectiveness figures in Table 4 surely remain overstated, especially those for cancer-reducing rules. I doubt, however, that any resulting arbitrariness in the ranking of the regulations is large enough to affect the general conclusions set forth below.

I generally accepted agency cost estimates without adjustment. In part, this is because agencies do not follow any explicit policy of underestimating costs. In addition, this is in recognition of the fact that while agencies have incentives to underestimate costs, and often focus on "compliance costs" rather than true economic costs or welfare losses, regulated firms and consumers often discover new—and unanticipated—ways to minimize compliance costs.

What the Record Shows

The regulations in this sample address a very wide range of risks—five orders of magnitude to be exact, which is greater than the difference in the risks of dying from heavy cigarette smoking and playing basketball. At one extreme are several OSHA rules which address occupation risks of 1 or 2 in 1,000; at the other extreme are two FAA aircraft safety rules which address risks of 2 and 7 in 100 million. The EPA and OSHA each have a proposal which would address similarly tiny risks. (Numerous FDA and EPA bans in recent years—not in this sample because of lack of cost information—have addressed even slighter risks; the FDA's proposed ban of the cosmetic coloring Orange No. 17, for example, would have averted a calculated risk of death of 1 in 10 billion and was projected to save one life in 2,000 years.) On average, however, the rules listed in Table 4 address risks that are not insignificant. At about 3 in 10,000, the average annual risk is greater than that of dying in a motor vehicle accident.

The 26 final rules were estimated to save a total of 5,381 lives annually, which is the equivalent of about three-tenths of 1 percent of annual U.S. deaths. The 10 proposed rules (currently in rulemaking) are projected to save a total of only 89 additional lives per year; the eight rejected rules were projected to save a total of only one life per year. A very large share of the regulatory benefits of the rules that were issued—4,030 lives saved annually, or 75 percent of the benefits of all final rules—was due to just four regulations, all dealing with motor vehicle design. These were the NHTSA's collapsible steering column requirement, its passive restraint rule requiring air bags or automatic seat belts, and its standards for fuel system integrity and side-door strength. In contrast, the EPA has issued just one rule estimated to save a large number of lives, which is its ban of trihalomethanes (chloroform and other organics in drinking water), estimated to save 322 lives annually. The other six final rules issued by the EPA save an estimated five lives per year *in total*. OSHA's eight final rules save an estimated 725 lives annually, mostly from the initial (1972) asbestos standard and the recent (1984) hazard communication (chemical labeling) requirements. The other seven final rules, issued by the CPSC, FAA, FDA, and FRA, save a total of 298 lives annually.

The FDA's proposed ban of the cosmetic coloring Orange No. 17, for example, would have averted a calculated risk of death of 1 in 10 billion and was projected to save one life in 2,000 years.

Cost-Effectiveness. Initial risk is not a very good measure of the desirability of a government rule, since small risks may affect large populations and vice versa. Number-of-lives-saved is not much better, since a rule with large lifesavings may be disproportionately more costly than a rule which saves relatively few lives. It may be perfectly appropriate, for example, to regulate bee stings rather than heart attacks if bee sting risks can be reduced cheaply and heart attack

Table 4
THE COST OF VARIOUS RISK-REDUCING REGULATIONS PER LIFE SAVED

Regulation	Year	Agency	Status*	Initial Annual Risk**	Annual Lives Saved	Cost Per Life Saved (Thousands of 1984 $)
Steering Column Protection	1967	NHTSA	F	7.7 in 10^5	1,300.000	$100
Unvented Space Heaters	1980	CPSC	F	2.7 in 10^5	63.000	100
Oil & Gas Well Service	1983	OSHA-S	P	1.1 in 10^3	50.000	100
Cabin Fire Protection	1985	FAA	F	6.5 in 10^8	15.000	200
Passive Restraints/Belts	1984	NHTSA	F	9.1 in 10^5	1,850.000	300
Fuel System Integrity	1975	NHTSA	F	4.9 in 10^6	400.000	300
Trihalomethanes	1979	EPA	F	6.0 in 10^6	322.000	300
Underground Construction	1983	OSHA-S	P	1.6 in 10^3	8.100	300
Alcohol & Drug Control	1985	FRA	F	1.8 in 10^6	4.200	500
Servicing Wheel Rims	1984	OSHA-S	F	1.4 in 10^5	2.300	500
Seat Cushion Flammability	1984	FAA	F	1.6 in 10^7	37.000	600
Floor Emergency Lighting	1984	FAA	F	2.2 in 10^8	5.000	700
Crane Suspended Personnel Platform	1984	OSHA-S	P	1.8 in 10^3	5.000	900
Children's Sleepware Flammability	1973	CPSC	F	2.4 in 10^6	106.000	1,300
Side Doors	1970	NHTSA	F	3.6 in 10^5	480.000	1,300
Concrete & Masonry Construction	1985	OSHA-S	P	1.4 in 10^5	6.500	1,400
Hazard Communication	1983	OSHA-S	F	4.0 in 10^5	200.000	1,800
Grain Dust	1984	OSHA-S	P	2.1 in 10^4	4.000	2,800
Benzene/Fugitive Emissions	1984	EPA	F	2.1 in 10^5	0.310	2,800
Radionuclides/Uranium Mines	1984	EPA	F	1.4 in 10^4	1.100	6,900
Asbestos	1972	OSHA-H	F	3.9 in 10^4	396.000	7,400
Benzene	1985	OSHA-H	P	8.8 in 10^4	3.800	17,100
Arsenic/Glass Plant	1986	EPA	F	8.0 in 10^4	0.110	19,200
Ethylene Oxide	1984	OSHA-H	F	4.4 in 10^5	2.800	25,600
Arsenic/Copper Smelter	1986	EPA	F	9.0 in 10^4	0.060	26,500
Uranium Mill Tailings/Inactive	1983	EPA	F	4.3 in 10^4	2.100	27,600
Acrylonitrile	1978	OSHA-H	F	9.4 in 10^4	6.900	37,600
Uranium Mill Tailings/Active	1983	EPA	F	4.3 in 10^4	2.100	53,000
Coke Ovens	1976	OSHA-H	F	1.6 in 10^4	31.000	61,800
Asbestos	1986	OSHA-H	F	6.7 in 10^5	74.700	89,300
Arsenic	1978	OSHA-H	F	1.8 in 10^3	11.700	92,500
Asbestos	1986	EPA	P	2.9 in 10^5	10.000	104,200
DES (Cattlefeed)	1979	FDA	F	3.1 in 10^7	68.000	132,000
Arsenic/Glass Manufacturing	1986	EPA	R	3.8 in 10^5	0.250	142,000
Benzene/Storage	1984	EPA	R	6.0 in 10^7	0.043	202,000
Radionuclides/DOE Facilities	1984	EPA	R	4.3 in 10^6	0.001	210,000
Radionuclides/Elemental Phosphorous	1984	EPA	R	1.4 in 10^5	0.046	270,000
Acrylonitrile	1978	OSHA-H	R	9.4 in 10^4	0.600	308,000
Benzene/Ethylbenzenol Styrene	1984	EPA	R	2.0 in 10^6	0.006	483,000
Arsenic/Low-Arsenic Copper	1986	EPA	R	2.6 in 10^4	0.090	764,000
Benzene/Maleic Anhydride	1984	EPA	R	1.1 in 10^6	0.029	820,000
Land Disposal	1986	EPA	P	2.3 in 10^8	2.520	3,500,000
EDB	1983	OSHA-H	P	2.5 in 10^4	0.002	15,600,000
Formaldehyde	1985	OSHA-H	P	6.8 in 10^7	0.010	72,000,000

*Proposed, rejected or final rule

**Annual deaths per exposed population. An exposed population of 10^3 is 1,000, 10^4 is 10,000, etc.

risks can be reduced only at great cost. In principle, the best measure of desirability is net social benefits: the value in dollars of the number of deaths averted by a regulation minus the cost of the regulation. Given a ranking of regulations by net social benefits, one would conclude that all those with positive net benefits are worthwhile policies and all those with negative net benefits are not (assuming, of course, one has confidence in the underlying data and the value-of-life figures).

To elide the controversies and uncertainties of choosing a single dollar figure for the value of saving a life, I have chosen a second-best measure of desirability, cost-effectiveness, measured by cost per life saved. Using this measure, the estimates of which are shown in Table 4, one would conclude that all regulations which cost less per life saved than some assumed value-of-life are worthwhile, and that the rest are not. For example, if you think it is worth investing $500,000 to avert one death, then the first 10 rules in Table 4—each of which costs $500,000 or less per life saved—are desirable and the rest are not. If $1,000,000 is the "right" investment in saving one life then the first 13 rules are desirable. If $5,000,000 is the right investment then the first 19 rules are desirable. It is unlikely that a ranking by net benefits would alter our basic conclusions.

It should be noted that these cost-effectiveness figures are generally average rather than marginal ratios. That is, they describe the average cost per life saved of each rule, not the cost of saving one more life. Assuming that the stringency (costliness and lifesaving effect) of regulations can be modified, for example by restricting the use of a substance rather than banning it, then the marginal cost per life saved is the ideal measure of a regulation's cost effectiveness. Unfortunately, the data are not available to make such calculations. We do know, however, that if regulatory agencies choose levels of stringency that are economically appropriate (i.e., where marginal costs are higher than average costs), then our figures understate the relevant economic cost of each rule.

Cost-effectiveness can change dramatically as stringency is varied. For instance, OSHA's estimates of the costs and benefits of its pending grain dust rule show that most of the rule's lifesaving benefits would come from regulating large export grain elevators, while most of the costs would come from regulating small country elevators. This means that while the regulation appears reasonably cost-effective based on its average cost per life saved, the marginal cost of including small country elevators in the regulation is relatively high. As a general matter, it is impossible to predict how a ranking by marginal cost-effectiveness would differ from the ranking in Table 4, but it is unlikely that these differences would upset the basic implications of the average cost-effectiveness figures, to which I now turn.

The most obvious implication of these figures is that the range of cost-effectiveness among rules is enormous—equal to or greater than the range of initial risks if one includes the two OSHA proposals for EDB and formaldehyde at the bottom of the list. Even excluding all proposed rules and the least cost-effective final rule, issued by the FDA, the range is still three orders of magnitude: OSHA's arsenic standard costs nearly 1,000 times as much per life saved as NHTSA's steering column standard. Notwithstanding the data limitations mentioned above, it is reasonable to conclude that large improvements in welfare—many more lives saved for the same investment or the same number of lives saved for a much smaller investment—are likely to be achieved by reallocating resources within these 25 final rules.

The most obvious implication of these figures is that the range of cost-effectiveness among rules is enormous.

Comparing the cost-effectiveness of rules by year of issuance, agency, and legal status, the most important variable turns out to be legal status. The average and median of cost-per-life-saved estimates for the 26 final rules are $23 million and $2 million, respectively, compared to $400 million and $289 million, respectively, for the eight rejected rules. Evidently, very low benefits or high costs is one factor that may lead to the rejection of a regulatory proposal, although it is not possible to infer from the data how important this consideration is or what role it plays in rules that are eventually adopted. For the 10 proposed rules, the median of cost per life saved estimates is $10 million and the average is $9.1 billion, reflecting the two unusually cost-ineffective rules at the bottom of the list.

There are also some striking variations in cost-effectiveness between and within regulatory agencies. Taken as a group, the final rules issued by the three Department of Transportation agencies (the FAA, FRA, and NHTSA) are about 83 times more cost-effective than those of OSHA and 40 times more cost-effective than those of the EPA. But there are even greater variations within the EPA and OSHA. The EPA's 1979 trihalomethanes rule is 177 times more cost-effective than its 1983 standards for mill tailings at active uranium mines. OSHA's 1978 arsenic rule is 185 times less cost-effective than its 1984 servicing-of-wheel-rims rule. OSHA's least effective rule is its third oldest rule in the sample, while its most effective rule is among its more recent; in contrast, the EPA's most effective rule is its oldest in the sample while its least effective rule is among its more recent. Whereas some OSHA rules have become more cost-effective in recent years, EPA rules have become less cost-effective.

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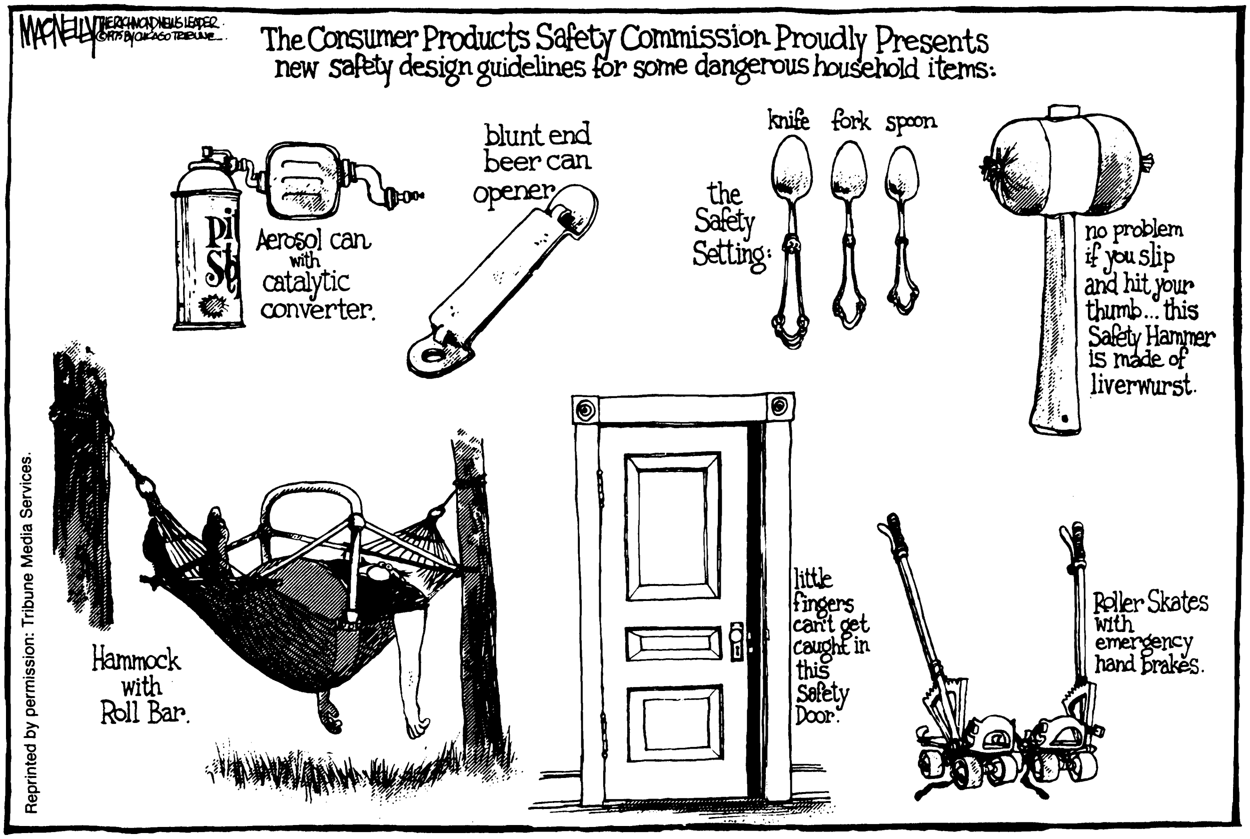
Health vs. Safety. While it is tempting to attribute the differences in cost-effectiveness among regulatory agencies to differences in management or political pressures, there seems to be a more fundamental difference: *safety regulation appears to be far more cost-effective than health regulation.* This may be seen by considering separately those final and proposed rules aimed at reducing safety risks (17 rules) and those aimed at reducing health risks (19 rules, *all* of which were directed at cancer risks). On average, the cancer regulations are 8,000 times more costly per life saved than the safety regulations—$4.8 billion compared to $600,000. The median of cost-per-life-saved estimates for the cancer regulations (which largely eliminates the effect of the few highly ineffective proposals at the bottom of the list) is 75 times higher than for the safety regulations—$37.6 million compared to $500,000. For OSHA, the one agency that issues both safety and health (in practice, cancer) regulations, the median of cost-per-life-saved estimates for the seven safety rules is 123 times higher than the median for the six cancer rules. In fact, even OSHA's most costly safety regulation costs less per life saved than its least costly cancer regulation. On the basis of this data, it can be concluded that with $1 billion in resources available for risk reduction, we could save 2,000 lives through safety regulation or 27 lives through cancer regulation. (This assumes that additional opportunities exist for promoting safety and health similar to those addressed by the rules in this sample.)

These differences between health and safety regulations really should not be surprising; in large part, they are dictated by statute. The safety statutes, such as those authorizing the NHTSA, the CPSA, and OSHA, almost invariably speak in terms of regulations that are "reasonable," "practicable," "appropriate," and so forth. In contrast, the health statutes, including not only the much-discussed FDA Delaney clause but also the relevant portions of the Clean Air Act and the OSHA statute, speak in terms of absolute or near-absolute protection.

While these differences in cost-effectiveness may appear extraordinarily large, they are probably understated by a large margin. For one thing, as the accompanying article by Nichols and Zeckhauser explains, the risks of cancer, and thus the likely effectiveness of cancer rules, are routinely overestimated by federal agencies; safety risks, by contrast, are less likely to be overestimated because of the greater availability of hard data. I was unable to correct fully for the bias in cancer risk estimates. Also, cancer is primarily a disease of old age, while accidents, especially occupational accidents, strike a younger group. A more refined measure of regulatory benefits, such as cost *per year of life* saved, would likely show an even greater difference in cost-effectiveness.

This finding stands in sharp contrast to the conventional view of the effectiveness of health and safety regulation. Students of OSHA regulation such as Robert S. Smith, W. Kip Viscusi, Zeckhauser, Nichols, and John Mendeloff have all recommended that OSHA shift its focus from safety to health risks. Their essential argument is that private incentives are stronger for safe conduct than for health-improving conduct, meaning that OSHA—and by extension other regulatory agencies—has more to contribute, in the



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way of cost-effective lifesaving, to health than to safety. The assumption is that safety risks are more obvious than health risks to potential victims, and that causation and hence private liability is usually clearer for accidents than for diseases.

Based on this data, we may speculate that the received wisdom on health and safety regulation is incorrect. Perhaps, as some have suggested, workers' compensation programs (which limit liability for accidents) have seriously dulled private incentives for occupational safety—although this would leave unexplained the relatively high cost-effectiveness of transportation regulations. Perhaps the same "fear of cancer" which has led to such extreme regulatory efforts and political histrionics has also led to careful private behavior (for example in factories where asbestos, arsenic, and other known carcinogens are in use), leaving little for government standards to contribute. Certainly our lack of definite knowledge about the etiology of cancer, which is a major reason private incentives for cancer protection are said to be inadequate, is a problem afflicting government as well as private decisionmaking. It may simply be easier for government officials to commit resources in the face of ignorance. In any event, these data suggest that regulatory reformers should attend not only to reducing the overregulation of cancer risks, but also to the possibility of increasing safety regulation.

"Relief" vs. "Reform." The data in Table 4 can also be used to assess the effectiveness of President Reagan's regulatory reform program under Executive Order 12291. Under this order, agencies are directed, to the extent permitted by the regulatory statutes, to initiate new rules and rulemaking proposals only when the potential benefits exceed the potential costs. In addition, rulemaking priorities are to be set according to cost-effectiveness. According to some critics, the program is really intended to provide "relief" rather than "reform," that is, to reduce the cost of regulation for American business regardless of whether or not this is good social policy. (See, for example, George C. Eads and Michael Fix, *Relief or Reform? Reagan's Regulatory Dilemma*, The Urban Institute, 1984.)

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The evidence on this score is mixed. Eleven final rules in the sample were issued before 1981, when Executive Order 12291 was implemented, and 15 have been issued since. The average of cost-per-life-saved estimates for the rules issued under the executive order is lower than for the earlier rules ($17 million versus $30.4 million), but the median is higher ($2.8 million versus $1.3 million). At the same time, the statistical variance of the cost-per-life-saved estimates is much lower, one-third of what it was previously. Evidently, as a group the rules issued by the current administration are more consistent in terms of cost-effectiveness and no less stringent. While one cannot draw strong affirmative conclusions from this data, it would appear that Executive Order 12291, as intended, has brought regulatory reform, not relief.

A note of caution is in order with respect to the 10 rules still in the proposal stage (all issued since 1983). Here the costs per life saved and the range in these costs are extremely high. Four of the proposed rules (two apiece for the EPA and OSHA) have costs well over $100 million per life saved, making them more costly per life saved than any other rule issued in the current administration or, with the exception of the one FDA rule, any previous administration. Obviously, if all or even most of these proposals are put into effect, it will be difficult to detect a pattern of "relief" or "reform."

Concluding Thoughts

Regulation is not a scientific exercise in social welfare maximization, and the data compiled here, for all of their limitations, show that this is so. Government rules address trivial as well as substantial risks, exhibit huge variations in cost-effectiveness of lifesaving, and appear seriously imbalanced in the direction of health as opposed to safety risks. We would surely be able to avert more deaths or make ourselves richer in other ways, without any increase in deaths, by simply rearranging priorities. But setting aside the question of whether or not we would be better off with a different set of rules, has the net effect of these rules been beneficial? I will conclude by hazarding an answer to this question.

As mentioned earlier, deciding whether a risk-reducing regulation is worth its costs necessitates that we posit some value for lifesaving. The best measure of this is the amount individuals are willing to pay for lifesaving when confronted with actual decisions involving risk. For obvious reasons this is not easy to measure. Among other things willingness to pay (which includes willingness to forego income) varies from one person to the next, making it difficult to choose one figure for gauging decisions affecting many persons. Nevertheless, many careful studies have been performed by observing, for example, the wage premiums offered for risky jobs and other trade-offs between safety and price. There are, by my count, 16 careful studies estimating individual willingness to pay for risk reduction. The estimates vary from about $400,000 to about $9.7 million per life saved, with a mean estimate of $3.3 million and a median estimate of $1.7 million. Roughly speaking, people appear willing to spend (or forego receiving) between $400 and $9,700 to avoid a one-in-1,000 risk of dying.

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While the range in these estimates is quite wide, it is not nearly as wide as in the cost-effectiveness estimates. In fact, these estimates of willingness-to-pay fall in the middle of the costs per life saved for the 26 final regulations. This suggests that about half of these rules are cost-beneficial and half are not. The clearest line of demarcation is between the EPA's 1984 benzene fugitive emissions rule, costing $2.8 million per life saved, and the EPA's 1986 arsenic plant rule, costing $19.2 million per life saved. The EPA's 1984 radioneuclides rule and OSHA's 1972 asbestos rule might be placed in either category. That is, one could find evidence and advocates for the proposition that $2.8 million, or even $6.9 million or $7.4 million, is an appropriate social investment in saving one life. But most assuredly, when a regulation costs $19 million or more per life saved (not to mention $72 billion per life saved)—as do 10 of the final rules listed in Table 4—it is very likely that resources are being wasted and better life saving strategies are being foregone. Such regulations force far more risk-averting actions than we observe with informed private decisions. ■