Injury Epidemiology: Fourth Edition

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Chapter 15. INJURY EPIDEMIOLOGY AND ECONOMICS

In addition to the humane reasons for pursuing injury control, there are huge cost savings to be realized. The issue is not just studies of the cost of injuries per se, but the extent of cost-savings realizable by reduction of incidence and severity (Currie, et al., 2000). Cost is usually measured in "human capital cost" and does not include the intangible toll of pain, grief, social disruption, and disorganization. It also does not include a substitution of economic productivity with caregiving to the injured by family members which greatly reduces public costs (Rice and MacKenzie, 1989; Leigh, et al., 2000; Finkelstein, et al. 2006).

One of the most controversial uses of epidemiological data is the assignment of economic costs to distributions of injury and disease and the balancing of such costs against the costs of reducing risk. The controversy arises both from repugnance on the part of some people at the notion that all aspects of injury and death can be expressed in monetary values, and from widespread disagreement over the methods when such expression is attempted.

Epidemiologists who describe sets of injuries or assess risks usually do not concern themselves with economic issues directly (other than the cost of the study and efficient study designs), but those who study the effects of programs, laws, regulations, medical care or rehabilitation often encounter economic arguments and research. Occasionally, researchers use cost analysis to attempt to justify greater prevention efforts. For example, one research group estimated the cost of child abuse in the U.S. at $124 billion in 2008 and urged increased preventive efforts based on the cost (Fang, et al., 2011). The purpose of this chapter is to alert injury epidemiologists and users of the data to some of the terminology and issues in the economic analysis of injury data related to decisions regarding injury control.

THE ECONOMIC CONTEXT. Neoclassic economists promote the philosophy that people choose the risks that they take and that almost any organized attempt to reduce the risk will result in failure. As discussed previously, according to this theory, if people have an acceptable level of risk that they will tolerate, and their behavior offsets attempts to reduce risk, any attempt to reduce risk is a waste of money. As noted in Chapters 11 and 12, studies in which individual behavior was observed in situations where risk was reduced do not support the assumption that people usually offset risk reduction by more risky behavior, and many attempts at injury control have had a remarkably beneficial effect.

Most economists argue that the costs of any program, including attempts at injury reduction, should not exceed the benefits. Expenditures for injury control that exceed the cost of injuries reduced are inefficient, they argue, because there is a net reduction in the goods and services available to society (e.g., Anderson and Settle, 1977). To balance costs against benefits, it is necessary to place a monetary value not only on the direct costs (medical care, rehabilitation, funerals) and indirect costs (lost productivity) but also on pain and suffering.

The following data are necessary to estimate costs and benefits:

$a(i)$ = number of injuries of given severity i to which an intervention applies
$b(i)$ = cost of injuries by severity i (including monetary value of pain and suffering)
$c(i)$ = proportion of each severity level i or its consequences reduced by the intervention
d = reduced costs = sum of $a(i) \times b(i) \times c(i)$, where i = each severity level
e = cost of applying or incrementing the intervention (including intangibles, e.g., inconvenience)
f = $d - e$ (i.e., benefit less cost)

Some economists use d/e, the benefit/cost ratio, but benefit less cost is more useful for comparing interventions because the amount of savings is more evident.

Many health professionals and others have adopted the cost-benefit philosophy without carefully examining its philosophical underpinnings. The welfare of a nation is the sum of its gross domestic product, according to the economic viewpoint. All of the dollars are equal, no matter what the consequences of their use. Money spent on addictive substances adverse to health such as opioids and other legal drugs, cigarettes, and alcohol is viewed just as positively as money spent for injury reduction. It does not seem to matter among many economists that some of the gross domestic product is contributing to the destruction of life-sustaining elements of the planet, nor do they consider that many of the most valued aspects of life are not reflected in the gross domestic product (Self, 1977). Perhaps the best that can be said for neoclassic economics is that it is shortsighted.

In the extreme neoclassic economic view, every good, service, intellectual or emotional satisfaction, and health risk is purchased in a market with money or some behavior the value of which can be reduced to money. The "invisible hand" of the market governs supply and demand to produce optimal social welfare, and the government is only necessary to enforce contracts and protect the public from domestic criminals and international threats.

Others recognize that society is much more complex. Organized interests at least partly control some markets and one-sided advertising generates others. For example, in the 1930s and 1940s, General Motors conspired with Firestone Rubber and Standard Oil of California to purchase and dismantle 46 mass transit companies that operated electric streetcars in 16 U.S. states. Although the companies were convicted of antitrust violations, their fines were minimal and the mass transit systems were not restored (Adams and Brock, 1987).

A former Ford Motor Company employee in charge of defective vehicle recalls wrote that Ford engineers considered a vehicle component safe if it did not differ from components on competitors' vehicles. The fires that resulted from placing the Ford Pinto's gas tank just behind the bumper were thought acceptable because other manufacturers placed gas tanks in a similar position (Gioia, 1992). The Director of Automotive Safety at Ford did an analysis that concluded that the cost of gas tank modifications was greater than the benefits (Hoffman, 1984). When corrected for vehicle size, vehicles with gas tanks over or in front of the rear axles had less than half the fire deaths of those with gas tanks behind the axles (Robertson, 1993).

In product advertising, benefits are often overstated and risks are often not mentioned at all except as required for such products as tobacco and prescription drugs. Virtually no product advertising or user instruction gives a precise indication of the risks of using a product -- those that provide warnings state them in vague terms.

One finding regarding cost-benefit analysis shows that it can be pernicious. Reduction of injury in industrial settings may not be cost-beneficial for the business enterprise but are so if total costs and benefits to society are estimated (Ramos, et al., 2014). Businesses that conduct such studies are unlikely to consider societal costs and benefits.

To do a cost-benefit analysis, the monetary value of the reduced risk that includes "pain and suffering" is usually assessed by research on "revealed preference", that is, an implied value from behavior relative to risks, or by directly asking people what they would be willing to pay to reduce risks. To say the least, the research is problematic.

WILLINGNESS TO PAY. The introduction to a book on product labels contains the following statements: "Consumers take precautions whose benefits exceed their costs, and they forgo the other precautions .... To estimate the benefits of precautions the consumer must assess both the effect of taking the precaution on the probability of each possible injury that it protects against and the value of the resulting reduction in the risk of injury." Two pages later, introducing the labels for two products to be studied as to consumer intent to take precautions, the report says, "Because most readers may not be familiar with the four injuries and how they arise, we briefly describe them here" (Viscusi and Magat, 1987, pp. 43,45). How can one assume that the average consumer does a cost-benefit analysis on every product purchased based on the probability of injury if one assumes that readers of a book on risk, who are likely to have a better-than-average knowledge of risks, do not know the risks of injury from commonly used household products?

After attempting to assess the effects of intended precautions of particular labels that did not include quantitative estimates of risk, the researchers attempted to assess how much consumers would be willing to pay, per injury, to reduce them. A quantitative estimate of risk was included in the information given to respondents during the willingness-to-pay phase of the study. The amounts that consumers were willing to have added to the overall costs of the products -- an implied value of "$300,000 for gassings from bleach, $420,000 for child poisonings from bleach, $120,000 for hand burns from drain opener, and $360,000 for child poisonings" -- were said to "appear to be excessive." They found it "implausible" that a relatively minor hand burn would be valued at $120,000, "four times the respondents' average household income" (Viscusi and Magat, 1987, p. 93).

Among the points these economists missed, of course, is that the individual does not have to spend four times the family income to reduce the risk. The cost of the product modifications is spread among tens of millions of consumers and, in the aggregate, people may be willing to pay far more per product to reduce risk than economists' judgment of the worth of the risk. For the individual, the expenditure may be a few cents extra per product for household cleaners that will last weeks or months, a few dollars extra for a child's crib that may last for generations, or a few hundred dollars extra for a motor vehicle that will be used for ten or more years.

Also, contrary to popular belief, reduction of risk does not necessarily increase the cost of the product. In some cases, a reduction in the cost of the product can accompany a reduction of risk. For example, it takes more material and thus costs more to make the front end of a vehicle sharp rather than smooth. Vehicles with sharp points on their fronts have higher pedestrian death rates (Robertson, 1990). Protruding radio knobs, air conditioning controls, and gearshift controls in vehicles that penetrate the tissues of occupants in crashes cost more than smooth buttons. The increased weight of a motor vehicle increases cost and risk to all road users in the aggregate (Appendix 12-1, Chapter 12). Designers of one of the research safety vehicles in the mid-1970s estimated that, despite numerous features to enhance crash avoidance and crashworthiness, the retail cost of the vehicle if mass-produced would have been no more than concurrently priced compact cars (DiNapoli, et al., 1977).

Although it is claimed that the initial motor vehicle safety standards added several hundred dollars to the cost of new cars, the increases in producer prices of cars during the period of adoption of the standards were not as large as that for other durable goods. From 1964 through 1973, the producer price index for all durable goods rose 35 percent while the increase for cars was about half that, 17 percent (Robertson, 1983).

If purchasers have no quantitative information on the risks of a product, and some manufacturers do not know the risks or do not attempt to reduce risks, even those which would include reduced costs or no increased costs of the product, how can an economist argue that the consumers' use of the product is a "revealed preference" of the balance of costs and benefits? The issue is confounded further by the fact that the persons injured are often not the original purchasers of the product. Certainly, the pedestrian who is struck by the sharp front of a vehicle had no say in its purchase. Based on the age of vehicle occupants injured, ownership of vehicles, and relationship of the injured person to the owner, about 75 to 80 percent of persons injured by motor vehicles were not a party to the purchase (Baker, 1979).

Nevertheless, numerous economic studies attempt to assess the valuation of life and limb by calculation of premiums in wages in risky occupations, demand for products that reduce risk relative to price, behavior implied to trade off risks and benefits, and surveys about people's willingness to pay for reduced risk. One summary of 29 such studies, about half of which were based on wage premiums relative to job risks, suggested a "willingness to pay" value of $2 million per life, about the average among the studies selected, although the results of individual studies ranged from $1 million to $3 million (Miller, 1989).

A very ambitious compendium of the effect of road injury countermeasures, including behavior, vehicle, and environmental characteristics, applies cost-benefit analysis to some (Elvik and Vaa, 2009). While the studies reviewed were limited to a few journals, there are sufficient numbers of studies of countermeasures to produce a reasonable estimate of the effectiveness of many. The cost-benefit analyses were based on Norwegian economics and are more dubious for the reasons mentioned above.

Of course, Norway is a wealthy country. A troubling aspect of cost-benefit analysis is the implications for low-income countries and low-income populations within countries. If the value of life and limb is based on the prevailing wages in a given area, there will be huge differences in the value placed on lives in those areas (Morrow and Bryant, 1995). Many countermeasures that pass a cost-benefit challenge in economically developed areas would not do so in economically poor areas (Hadley, et al., 2013). Given the higher incidence of severe injury in lower-income countries; the economic benefits of a healthier population could be larger than expected (Kotagal, et al., 2014). Several countermeasures used by injury control specialists in the U.S. Indian Health Service have been deemed cost-beneficial using national estimates of the value of life (Zaloshnja, et al., 2003) but on the reservations where they occurred, unemployment is often 50 percent or more and wages of the employed are low.

RISK-BENEFIT. A variation of cost-benefit is the so-called risk-benefit analysis in which historical death rates are used to argue that risks not exceeding them are acceptable. This point is most often made by physicists and engineers who believe public opposition to certain technologies such as nuclear power generation or types of disposals of military nuclear waste is irrational. They compare the risk of these technologies to known risks, such as travel by motor vehicles and airplanes. An early advocate of this view said, "Automobile and airplane safety have been continuously weighed by society against economic costs and operating performance" (Starr, 1969). This anthropomorphic view of society makes no sense in light of the history of either technology or the social processes that led to regulation or lack of regulation (Priest, 1988).

The translation of what has been tacitly accepted into what is acceptable is a prescription for disaster. Risk after risk could be added, each at or below the "acceptable" level, until a substantial number of the population is dead or disabled. Risk-benefit analyses can't have it both ways. On the one hand, they say that risks with a history indicate what is acceptable, but on the other hand, they are fond of lists of dollars spent "per life saved", calculated for a variety of employed or proposed countermeasures to risks, to illustrate governmental irrationality in risk management. One such array showed variation from $100 per life saved for expanded immunization in Indonesia to $200,000,000 per life saved for the control of radiation in "defense high-level waste." Most of the injury-related countermeasures were in the range of $20,000 to $400,000 per life saved, but coal mine safety and other mine safety were said to cost $22,000,000 and $34,000,000 per life saved (Cohen, 1980). The accuracy of all of those estimates is unknown, but some were grossly misstated. For example, high school driver education was said to save lives, but it indirectly increases deaths because of increased licensure and has no effect on crash rates. (Robertson and Zador, 1978).

The implication of a list of costs per life saved is that the efficient allocation of resources should be such that the costs would be similar if rational decisions were made. Sometimes appeals are made to ethical issues such as equity, that is, if the costs per life saved are different, some people are benefiting more from resource allocations than others. Others argue that the differences represent values placed on lives that have different values. For example, much more is allocated to protect the President of the United States than ordinary citizens (Shrader-Frechette, 1985).

Even if the estimates were accurate, the ages of the persons whose lives are extended are very different among the technologies and programs. Cost per year of extended life would result in a very different array of many hazards. Less value is placed on the lives of children by typical discounting to present value in cost analyses. The previously noted list of costs per life saved (Cohen, 1979) also calculated costs per 20 years of life extended, but some of the technologies and programs affect mainly children and youth with more than 20 years of expected life while others "save" lives of people who have a life expectancy less than 20 years.

In the 1990s, a widely publicized compendium of "500 life-saving interventions" more appropriately indicated the cost per year of life saved (Tengs, et al., 1995). The bibliography accompanying the list may be somewhat useful to persons in a position to recommend or initiate programs, but the list is of dubious quality and should not be the basis for decisions. Some of the research on which estimates are based is of doubtful validity. Many of the estimates are based on regulatory analyses by anti-regulation economists or by governmental agencies. In at least one such agency, the National Highway Traffic Safety Administration, two regulatory analyses are often prepared on a given issue, one favorable and one unfavorable to the adoption of a given regulation. When the Administrator decides which way the decision is to be made, the analysis supporting the decision is the one published. (See Appendix 15-1 for my critique of one NHTSA cost-benefit analysis used to support a do-nothing stance on vehicle stability.)

In addition, the noted list of 500 is not exhaustive. For example, only a small proportion of effective highway modifications are included and one of the most cost-effective -- lighting roads at night at high-risk sites (Chapter 7) -- is not mentioned. The cost-effectiveness of many of the technologies and programs mentioned on the list can be increased enormously by targeting them at high-risk populations or environments based on surveillance (Chapter 7). Depending on the extent that certain injuries are more or less likely to cluster, the cost-effectiveness would vary enormously from that list.

For example, in Browning, Montana, the lighting and curb modifications that were installed in a two-mile stretch of road reduced severe injuries by about 75-80 percent (Chapter 7). The changes cost about $6000 and the electricity to light the streets at night costs about $500 per year. The modifications undoubtedly paid for themselves in benefits to society in a few months.

Cost per year of life saved does not take into account the nonfatal injuries that would be prevented or reduced severity which varies per life saved among technologies and programs. Somehow weighting the costs as well as pain, suffering, and other consequences of nonfatal health impairment and including them with the estimates of fatality reductions is very problematic. One book on risk-benefit analysis states that the weighting is "somewhat arbitrary" (Crouch and Wilson, 1982). The authors of that book advocated a thorough risk analysis before decisions are made, but included Cohen's (1979) list of costs per life saved without the column for cost per 20 years of life.

Usually, the attempt to account for nonfatal injuries is made by monetizing both fatal and nonfatal outcomes, which turns risk-benefit back into cost-benefit. Some estimates of the cost of nonfatal injuries are based solely on the cost of medical care and lost workdays. This discriminates against children and the elderly and does not include pain and suffering. It is also difficult to evaluate lost workdays because some work is uncompensated. Also, fifty restricted activity days for a given individual is likely to have a more severe economic impact than that five restricted work days each for ten people (Priest, 1988).

Another approach is to somehow adjust for quality years of life, which raises all sorts of issues (Baldwin, Godfrey and Propper, 1990). For example, commodities consumed are used as an indicator of the quality of life. That is a dubious assumption but, if so, how does one deal with the quality of the commodities that are not necessarily reflected in their price? Some analysts have pointed out that the characteristics of people rather than what they consume are more indicative of the quality of life (Culyer, 1990), but those qualities are not indicated in any pricing system.

Questioning people can obtain estimates of the quality of life, but all of the methodological issues of reliability and validity of self-reports are involved (Petitti, 1994). Risks with equal outcomes result in different responses by respondents if presented as gains rather than as losses (Kahneman and Tversky, 1979) or in other contexts (Loomes and McKenzie, 1990; Kahneman, 2011). People who have not experienced given disabilities themselves cannot give informed answers about the quality of life of persons with such disabilities and their families.

COSTS OF INTERVENTIONS. Costs of product modifications and other injury control programs can be estimated more easily than benefits in some cases, but such estimates are often not done. Government budgets for highway modifications, regulatory agencies, and the like are known. The total cost of regulations, however, is more difficult to estimate -- particularly when the regulations are performance regulations. For example, the government standard for energy absorption by steering assemblies during frontal car crashes did not necessarily increase costs. It could have reduced costs if it resulted in attention to designs that used cheaper materials.

Cost per unit of equipment usually declines substantially as the number of units increases – called economy of scale. If the cost-benefit analysis were used to make decisions, rather than its usual use to second-guess decisions after the fact of implementation, the wrong decision could be made if the cost per unit were based on the originally designed equipment rather than large-scale production.

Many programs that have been suggested or implemented to some degree have not included cost studies. Researchers who evaluate the effects of interventions seldom include cost estimates of the interventions. Also, the extant costs of products or their modifications, where known, should not always be accepted as though the least costly technology is used. For example, in Sri Lanka, burnt-out light bulbs are filled with kerosene and used as lamps that increase fire risk compared to more sturdy, and costly, glass lamps (Berger and Mohan, 1996). In such situations, all the alternatives for lighting, including the invention of a product as cheap as or cheaper than recycled bulbs, should be considered before assuming that the situation is determined by economics.

It is often difficult to find data on the extent of implementation of many interventions. Based on literature indicating some benefits of counseling parents on childhood injury risks, economists estimated that such counseling would be cost-beneficial (Miller and Galbraith, 1995). The authors recognized that pediatricians are less likely to have low-income patients and that child injury rates are higher in low-income areas so the results may not be generalizable. Also, to estimate the benefits minus costs that could be realized from expanding such counseling, we need data on the current extent of counseling by physicians. I could find no survey of physicians to determine the extent of such counseling nor is the willingness to counsel and the compensation expected for doing so known. Cost is not the only issue. A survey of a random sample of emergency room physicians found that most did not believe that counseling regarding guns would have any effect on homicides or suicides (Price et al., 2013).

OVERLAP IN EFFECTS OF INTERVENTIONS. Often the same injuries would be prevented by more than one intervention. To the extent that there is such overlap in the effects of two or more approaches, the cost-effectiveness of each will not reflect the cost-effectiveness of applying both at the same time. For, example, fatal crash involvement of 16-17-year-old drivers is increased by high school driver education (Robertson and Zador, 1978). Based on the number of students enrolled in 1985, a report to Congress noted that up to $2.2 billion in 1985 dollars would have been saved in that year if there were no driver education in high schools, including the $163 million cost of the program (Robertson, 1989). Since surveys of schools to determine the number of students enrolled have been discontinued, it is not possible to update those estimates.

Nevertheless, if the minimum licensing age were increased to 18, virtually all of the adverse effects of driver education would be eliminated. Increasing the minimum licensing age to 18 and eliminating high school driver education simultaneously would not save the sum of the injury and program costs of driver education and the cost of injuries of drivers less than 18 because an 18 age limit for licensure would reduce the same injuries and deaths as eliminating driver education. Only the cost of the driver education program could be added to the injury costs saved by raising the minimum licensing age to prevent double counting of cost savings because of the overlap in injuries reduced.

That is a very obvious example of overlap in the effects of countermeasures, but there are instances in which the effects of particular interventions and the overlaps of effects are less well known, even by those in a position to find out. The National Highway Traffic Safety Administration NHTSA frequently issues reports on the involvement of alcohol in motor vehicle fatalities that includes seat belt use and alcohol countermeasures separately. In 2004, an estimated 39 percent of such fatalities were "alcohol-related" and 55 percent of killed vehicle occupants were allegedly not using seat belts (National Highway Traffic Safety Administration, 2006). Not only are these claims of questionable validity (Chapter 12), the claims are often assumed to mean that reductions in alcohol use or increased seat belt use would result in a proportionate reduction in fatalities. Indeed, NHTSA for a time in the Clinton and GW Bush administrations virtually ceased to issue standards for vehicle crashworthiness, rollover resistance, and crash avoidance, claiming that the majority of motor vehicle fatalities are related to nonuse of seat belts and use of alcohol (National Highway Traffic Safety Administration, 1994).

Since belt use is known to be lower among vehicle occupants with high blood alcohol concentrations (e.g., Foss, et al., 1994), the effect of increasing belt use and reducing alcohol use cannot be additive because of the overlap. Indeed, the correlation between alcohol use to Injury Severity Scores and hospital length of stay disappears when belt use is controlled (Anderson, 1990), indicative of confounding.

Also, if alcohol use is lower in later model cars -- those that are more crashworthy (Chapter 12) -- and belt use is higher in such cars, some of the fatalities attributed to alcohol and nonuse of belts may be due to lack of crashworthiness of older vehicles. Alcohol involvement and belt use are correlated to vehicle age. Also, alcohol use and aggressive or impulsive behavior may be attributable to some extent to a common precursor, which suggests the possibility that at least some of the aggressive or impulsive behavior would occur in the absence of alcohol (Chapter 8).

To illustrate the overlap of alcohol and belt use and the confounding effects of other factors on the assessment of the effects of belt use and alcohol, the regression model used to estimate the effects of vehicle modifications, belt use, alcohol, and other factors (Appendix 12-1) was examined in stages. First, regression coefficients of the effects of belt use and alcohol, separately and without control for other factors, were examined. They were combined without the other factors and then combined with the other factors. If the effects of belt and alcohol use are not confounded, the single estimates should not differ significantly from the effects in combination with other factors. The regression coefficients and 95 percent confidence intervals are presented in Table 15-1.

The estimates of belt use effects and alcohol effects, each alone, are greatly reduced when they are considered simultaneously. They are again reduced to much lower levels when the effects of safety standards, other improvements in crashworthiness (NCAP), and vehicle size are all included. Note that the variance explained (R-square) is modest for seat belts and alcohol alone or in combination, but that for the full model is excellent. Belt use observed in traffic was approximately 53 percent in 1991 (Datta, 1990). If the remaining 47 percent of car occupants had been restrained, the occupant fatality rate of 1.6 per 100 million miles would have been reduced by about 21 percent. That is, multiply the coefficient in Table 15-1 by the percent of unused belts (.007 x 47 = .329) and divide the result by the death rate (.329 / 1.6 = 0.21).

Alcohol at 0.1% by weight or more was found in about 23.4 percent of passenger car drivers in 1991 (Klein and Burgess, 1995). Multiplying the coefficient for alcohol (at or greater than 0.1% by weight) by the percent involvement (-.007 x 23.4 = 0.164) indicates that reducing such alcohol involvement to zero would reduce the car occupant death rate by .164, which is 10 percent of the overall rate of 1.6. Uncontrolled estimates of belt effectiveness and alcohol effects on fatal crashes are confounded by their co-variation and the lower belt use and higher alcohol involvement in less crashworthy vehicles.

Table 15-1. Regression Estimates of the Effects on Passenger Car Occupant Death Rates per 100 Million Miles, in Relation to Alcohol and Seat Belt Use Without and With Controls for Other Factors

Variable	Belts Only	Alcohol Only	Belts and Alcohol	All Factors Combined
Belt use, %				
Estimated effect	–.034		–.019	–.007
95% CI	–.028, –.039		–.026, –.013	–.001, –.013
Alcohol > 0.1, %				
Estimated effect		.070	.047	.007
95% CI		.059, .080	.035, .060	001, .013
Standards				
Estimated effect				–.260
95% CI				–.237, –.283
NCAP publicity				
Estimated effect				–.077
95% CI				–.044, –.110
Calendar year				
Estimated effect				–.017
95% CI				–.052, .019
Industrial production				
Estimated effect				.029
95% CI				.015, .043
Expected from vehicle age				
Estimated effect				.444
95% CI				.656, .232
Expected from wheelbase				
Estimated effect				1.066
95% CI				.612, 1.520
Intercept	3.47	–.32	1.11	–.793
R^2	.35	–.39	.46	.92

95% CI, 95 percent confidence interval.

If alcohol were eliminated and belt use was 100 percent, almost two-thirds of car occupant fatalities would nevertheless occur. As a practical matter, both goals, however admirable, will not be attained. Many of the fatalities that would be prevented by increased belt use or reduction of alcohol use are the same fatalities. Any cost-benefit analysis or estimate of the cost per year of life preserved, such as comparing belt use laws and alcohol crackdowns as though they were additive, would be distorted.

COST-EFFECTIVENESS AND DECISION-MAKING. There are many technologies, policies, and programs to reduce injury that produce a net benefit, even by the narrow criteria of human capital cost (Robertson, 1989). The failure to adopt them is not an issue of costs, but who pays versus who benefits and who decides whether or not the intervention is used. Many are neglected out of sheer ignorance and inattention by policymakers. Analysis of cost/effectiveness, cost/benefit, or cost/savings (where some costs and benefits are intangible) ignores the feasibility of implementation because of ideological factors and concentrated interests that may oppose certain interventions.

In the United States, the gun lobby claims that the unlimited "right to bear arms" is guaranteed by the Constitution and few citizens are informed of the falsity of the argument (Christoffel and Teret, 1993). In 2008, the U.S. Supreme Court struck down a law regarding limits on gun ownership but made it clear that the Second Amendment to the Constitution does not guarantee an unlimited right to gun ownership by felons and the mentally ill or the right to concealment (Ropeik, undated). Since those injured by guns cannot be denied treatment, false claims are costly to everyone. In one major trauma center, for example, 79 percent of the costs for treatment of gunshot wounds were paid from taxes. Insurers paid an additional 19 percent. Taxpayers and the insured paid for 98 percent of the treatment (Wintemute and Wright, 1992).

Policies such as government subsidization of bicycle helmet purchases, while accepted in Australia (Wood and Milne, 1988), may be difficult to implement in the U.S. Although the majority of motorcyclists are in favor of helmet use laws, a vocal minority has been successful in gaining repeal in a majority of U.S. states (Baker, 1980; Insurance Institute for Highway Safety, 2015). Tax-supported programs, mainly Medicaid, provided 63 percent of the costs of treatment and rehabilitative care for motorcyclists in a major trauma center (Rivara, et al, 1988). The data indicating huge economic losses (Hartunian, et al, 1983; Robertson, 1989) and the evidence that the costs are paid with public monies had little influence on state legislators as they repealed helmet laws when they were intimidated by the minority biker lobby.

The failure of the Occupational Safety and Health Administration to extend relevant regulations to reduce farm injuries is partly due to the myth that farm owners bear the risk and can take precautions they deem appropriate (Kelsey, 1994). This ignores the effects of farm injury and its costs on farmers who qualify for Medicare or Medicaid, the latter when the farm goes belly up due to the farmer's no longer being able to work. Also, many injured farm workers are not owners, are poorly paid, and cannot afford health insurance.

While, in the above instances, seemingly overwhelming ideological opposition or lobbying power drove the decisions, such power is not always as solid as it seems. No one familiar with Tennessee politics would have expected that state to be the first to enact a child-restraint use law, but it did, and other states followed. The gun lobby spent $6 million in an attempt to defeat gun control legislation in Maryland, but was overwhelmingly defeated in a referendum in the 1988 election. The Brady Bill, providing for background checks on gun purchasers, survived the 1994-1996 United States Congress, many of whose members were heavily beholden to the gun lobby. It was later allowed to expire in 2004 as Congress cowered before the gun lobby.

Although there is some uncertainty in estimates of the potential for injury reduction discussed in this book because of variation in sampling error, and the lack of good experimental design in some cases, there is no doubt that a substantial proportion of severe injuries could be reduced by a greater application of current knowledge. The potential cost savings, net of the cost of injury control programs, is in the billions of United States dollars for many interventions for which data are available. Usually, the estimates of cost savings are far more sensitive to the difference in the estimates using the human capital and willingness-to-pay methods than they are to variations in estimates of the effectiveness of a given intervention.

Even if all of the benefits of a given risk-reduction technology or program could be estimated accurately, it is obvious that a great deal of resource allocation will not be made based on such an analysis. If the money in the federal budget allocated to programs for dealing with "defense high-level waste" were reduced, it would not be allocated to private expenditures for the safety of consumer products or more immunization programs in Indonesia.

In those instances where a set of resources are available to a given decision-maker or decision-making body, it certainly makes sense to attempt to allocate those resources to minimize human damage. One interesting issue for research is the extent to which cost-benefit or cost-effectiveness analysis affects decisions. In one study of future decision makers (graduate students in law and business), six experimental groups were given sets of information regarding policies to reduce motor vehicle injury and their expressed preferences were compared to a control group given no information. The information given to the experimental groups was varied by attributable benefit, attributable risk, and relative risk. Generally, groups given data were much more likely than control groups to favor a regulatory policy (60 percent vs. 22 percent). Those given information on attributable risks and benefits in terms of injury reductions were somewhat more likely to favor regulation than those given relative risk information (64 percent vs. 52 percent). No data on costs were included, but responses varied significantly depending on expressed attitudes regarding personal freedom and governmental regulation (Runyan and Earp, 1985).

Suppose that a set of local governments were randomly divided into experimental and control groups and each government in the experimental group was presented data on the benefits minus costs of adopting a set of injury control measures while each one in the control group was presented with the same injury control options without the cost-benefit analysis. Would the experimental communities be more or less likely to take action? If both groups took action, would the experimental group's actions be more efficient, that is, would the experimental governments achieve more reduction of injury costs per dollar spent? Similar studies of injury control for workers in private corporations would be of interest, but the likelihood of gaining access to detailed data in enough companies would be problematic.

APPENDIX 15-1. THE NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION’S COST-BENEFIT ANALYSIS OF A VEHICLE ROLLOVER STANDARD

In 1972, The National Highway Traffic Safety Administration (NHTSA) successfully opposed the Army's proposed sale of surplus jeeps to the public because of evidence of instability of the vehicles. Nevertheless, the Jeep Corporation's civilian version, known as the CJ, continued to be sold -- its commercials showed the vehicle going over hills with all wheels off the ground. In 1973 Ford Motor Company, also a manufacturer of military jeeps, introduced a jeep-like Bronco for civilian use that was discontinued in 1978 (Snyder, et al., 1980). In 1980, the Insurance Institute for Highway Safety’s research and demonstration of the rollover propensity of the Jeep CJ-5 was featured on CBS's popular television program, 60 MINUTES. The stability of other so-called utility vehicles was also of concern because of their high center of gravity relative to track width and resultant rollover rates, but attention focused on the Jeep CJ-5, which was the least stable. After hundreds of lawsuits, the CJ-5 was discontinued in 1984 and the CJ-7 in 1986.

Despite the demise of the pre-78 Bronco and the Jeep CJs, sales of what became known as “sports utility vehicles” (SUVs) increased from 132,000 in 1982 to 856,000 in 1988 (Ward's Automotive Yearbook, 1983-1989). Researchers continued to document their high rollover rates (Reinfurt, et al., 1981; 1984; Smith, 1982), but the government took no action other than to require a vague warning that the vehicles handle differently from other vehicles.

In 1986, a then member of the United States Congress, Timothy Wirth, petitioned NHTSA to adopt a stability standard for all utility vehicles based on the strong correlation of the stability ratio (track width divided by twice the height of the center of gravity) and the rollover rates among vehicles (Robertson and Kelley, 1989). In 1988, Consumers Union publicized tests of the Suzuki Samurai and petitioned the agency to prohibit its further sale based on its rollover propensity. These and other petitions were rejected by NHTSA.

In response to the Wirth petition, NHTSA argued that the choice of a specific stability ratio would be arbitrary and that the agency could not, by law, prohibit a class of vehicles (National Highway Traffic Safety Administration, 1987). Neither argument is valid. The death rate increases substantially as stability declines toward a static stability ratio of 1.2 g's of lateral force, which was typical of utility vehicles at the time but below the ratio of all but a few cars. The rollover death rate of the Jeep CJ-5 (stability 1 g) was 19 times that of cars; the CJ-7, pre-78 Bronco, and the Bronco II (stability 1.07-1.08 g's) had rollover death rates 10 to 12 times that of cars and the Samurai's (stability 1.12 g) rollover death rate is 6 times that of cars.

Setting the stability standard at a minimum ratio of 1.2 g's of lateral force would be no more arbitrary than setting the blood alcohol concentration for drivers at 0.08 percent by weight. Since the standard could be met by either lowering the center of gravity, widening the distance between the center of the tires, or both, the standard would not prohibit a class of vehicles. For example, the Jeep CJ5 could have had a stability ratio above 1.2 by lowering its CG height by 5.5 inches and the other utility vehicles would have to be lowered much less than that.

The Consumers Union petition to recall the Samurai was rejected because the Samurai was not as bad as the Bronco II (National Highway Traffic Safety Administration, 1988). Subsequently, NHTSA announced that it would reconsider the rollover issue and specifically singled out the Bronco II because it was worse than the Samurai. In 1990, NHTSA rejected petitions that the CJ vehicles be recalled, saying that their rollover rates were only "slightly" higher than peers. It subsequently also exonerated the Bronco II on similar grounds, stating that they were only a little different than peer vehicles. The leadership of the agency did not seem embarrassed by the logic of saying that a vehicle was not defective because it had an injury rate similar to vehicles with the same defect or lying about the substantial differences in rollover rates among vehicles. Those vehicles would have had no peers in rollover rates had the agency done something about vehicle stability when the issue was raised a decade earlier.

In June 1996, for the third time in a decade, the government refused to adopt a standard for motor vehicle stability. The NHTSA argued that the costs would exceed the benefits (National Highway Traffic Safety Administration, 1996).

NHTSA prefers to measure stability by tipping a table with the vehicle on it and observing the angle at which the upper wheels lose contact, called the tilt table angle or TTA. According to the agency, measuring the center of gravity can damage a vehicle and does not account for the possible effects of suspension. It said a minimum TTA standard of 46.4 degrees would result in 61 fewer deaths and 63 fewer severe injuries, an estimate that doesn't pass the smell test. The agency's studies indicate that stability measured by T/2H accounted for most of the variance in rollover percent of single-vehicle crashes, controlling for behavioral and environmental factors (Harwin and Brewer, 1990; Mengert, 1989) and the death rate per vehicle of lower stability utility vehicles in the is 3 to 20 times that of passenger cars.

To assess the effect of the lack of adoption of a vehicle-stability standard, I conducted a study of fatal crash rates per vehicle year of use for 1989-1993 model vehicles in use during 1990-1994. The 23 vehicles with known TTA up to 47.7 degrees were included to compare the results using TTA and T/2H. The fatality data were extracted from the Fatality Analysis Reporting System. Vehicles in use, 1989-1993 models during 1990-1994, were obtained from published data (Insurance Institute for Highway Safety, 1995), and projected years of use were estimated from published vehicle sales (Ward's Automotive Yearbook, 1995), adjusted for known scrap rates as vehicles age (Oak Ridge National Laboratories, 1984).

The effect of stability on fatal rollover rates per vehicle in use was estimated by logistic regression of the rollover rates with non-rollover rates, wheelbase (distance from front to rear axle), and stability measures included as predictor variables. Non-rollover rates serve as a control for the driver, vehicle, and environmental factors that affect fatality rates generally and the wheelbase has been correlated to rollover controlling for stability (Jones and Penny, 1990).

Table 15-2. Vehicle Parameters and Death Rates Per 100,000 Vehicles in Use 1990–1994

	Death Rate			*Vehicle Parameter*	
	Nonroll	Rollover	Total	*T/2H*	Wheelbase
1989–1993 Isuzu Amigo	7.9	35.8	43.7	1.11	92
1990–1993 Toyota 4Runner	5.0	20.3	25.3	1.08	103
1991–1993 Isuzu Rodeo	6.0	18.1	24.1	1.12	109
1989–1993 Geo Tracker	14.5	17.8	32.3	1.14	87
1989–1993 Jeep Wrangler	10.3	13.0	23.3	1.16	93
1993 Ford Ranger	14.5	12.1	26.6	1.13	125
1989–1993 GM S/T Blazer	11.1	11.4	22.5	1.10	104
1989–1993 Nissan Pickup	15.1	11.2	26.3	1.16	116
1991–1993 Ford Escort	21.5	10.5	32.0	1.38	98
1990–1993 Nissan Pathfinder	3.5	10.0	13.5	1.07	104
1989–1993 GM S/T Pickup	16.5	9.8	26.3	1.16	123
1989–1993 GM 1500 Pickup	10.2	8.9	19.1	1.14	142
1990–1993 Ford Festiva	28.6	7.9	36.5	1.34	90
1989–1993 Ford F250 Pickup	5.6	6.9	12.5	1.11	155
1989–1993 GM Astro	8.1	5.7	13.8	1.11	111
1989–1993 Ford Bronco	4.8	5.6	10.4	1.06	105
1992–1993 Ford Aerostar	5.6	5.4	11.0	1.11	119
1991–1993 Ford Explorer	4.2	5.4	9.6	1.08	107
1989–1993 Ford F150 Pickup	7.4	5.3	12.7	1.15	139
1989–1993 Mazda MPV	6.2	4.8	11.0	1.16	110
1990–1993 GM Lumina Van	6.0	3.9	9.9	1.12	110
1989–1993 Chrysler D150	10.9	3.2	14.1	1.28	115
1991–1993 Chrysler Caravan/ Voyager	6.0	2.2	8.2	1.18	119

Table 15-2 presents the non-rollover and rollover death rates per 100,000 in use per year of the vehicles in the study, ranked from highest to lowest rollover rate.

There is a large variation in both death rates. For example, the Amigo has a rollover death rate 16 times that of the Caravan/Voyager, but a similar non-rollover rate The logistic regression estimates are presented in Table 15-3 separately for T/2H (Model 1) and TTA (Model 2). T/2H is significantly and strongly predictive of rollover when wheelbase and non-rollover rates are controlled, but TTA is not. Rollover rates are significantly higher in vehicles with shorter wheelbases and in vehicles with higher non-rollover rates.

Table 15-3. Logistic Regression of Rollover Rates by Stability, Wheelbase, and Nonrollover

	Coefficient	*p*-Value
Model 1		
Intercept	–3.66	<.01
T/2H	–5.24	<.01
Wheelbase	–0.00	<.01
Nonroll rate	0.08	<.01
Model 2		
Intercept	–9.43	<.01
TTA	0.01	0.61
Wheelbase	–0.01	<0.1
Nonroll rate	0.03	<0.1

To project the deaths attributable to vehicle instability over the expected survival of vehicles, the number of vehicles remaining after scrappage in a given year of the 20 years after manufacture was multiplied by the difference between the rate predicted from the regression analysis for a vehicle of that stability and a vehicle with the same non-rollover rate and wheelbase but a T/2H of 1.2.

Table 15-4 illustrates the calculation of preventable deaths by changing T/2H using the 1991 Blazer/Jimmy (T/2H=1.10) as an example. Based on the logistic coefficients in Table 15-2, the expected total rollover death rate of that vehicle is:

$$\text{Expected} = 1/(1 + e^{-x})$$

where x= -3.664+(-5.236x1.10)+(-.00435x111)+(.0740x9.5), or 0.00011933. Substituting 1.2 for the T/2H of 1.10 in the equation gives the expected rate at T/2H=1.2 is 0.00006923). The difference between the two rates (.0000501) times the vehicles in use in a given year provide the estimate of preventable deaths in that year. Although the fractional numbers during a given year are expected values, the total is a realistic estimate. The 1991 Blazer/Jimmys would be expected to have approximately 107 fewer rollover deaths in the twenty years after their initial sales if the T/2H were 1.2.

Table 15-4. Projected Deaths Preventable During 1992–2011 in the 1991 Blazer/Jimmy If *T/2H* Were 1.20

Year	Projected Vehicles in Use	Preventable Deaths
1992	152,235	7.63
1993	151,623	7.60
1994	149,787	7.51
1995	147,339	7.38
1996	144,279	7.23
1997	140,454	7.04
1998	135,864	6.81
1999	130,356	6.53
2000	123,930	6.21
2001	116,739	5.85
2002	108,936	5.46
2003	100,674	5.04
2004	92,259	4.62
2005	83,844	4.20
2006	75,735	3.79
2007	67,932	3.40
2008	60,741	3.04
2009	54,009	2.71
2010	47,889	2.39
2011	42,381	2.12
Total		107

Had the minimum standard of T/2H=1.2, proposed in 1986, been adopted beginning in 1990 and subsequent models, the estimated deaths that would have been prevented in the 1990-1994 models with T/2H <1.2 are summarized in Table 15-5. There are other vehicles with T/2H less than 1.2 that were not included because of missing TTA. Nevertheless, approximately 5028 preventable rollover deaths are expected in the noted vehicles for lack of a rollover standard in those five years. The Escort, Festiva, and Dodge D150 pickups are excluded from Table 15-5 because the T/2H of each is above 1.2. The rank of vehicles by the number of preventable rollover deaths is different from the rank of fatal rollover rates mainly because of differences in sales volumes. The rate represents the risk to the occupants while the number of preventable deaths represents the loss to society because of the combination of fatality rates and vehicle sales.

Table 15-5. Projected Rollover Deaths Preventable by a *T/2H* of 1.2 in 20 Years of Use, 1990–1994 Models

Model	Preventable Deaths
Amigo	23
4Runner	135
Rodeo/Passport	66
Tracker	49
Wrangler	64
Ranger Pickup	736
Blazer/Jimmy (S/T)	696
Nissan Pickup	144
Pathfinder	131
S10/S15 Pickup	340
GM Light Pickups	592
F250 Pickup	178
Astro/Safari Van	327
Bronco	108
Aerostar Van	312
Explorer/Navajo	590
F150 Pickup	315
Mazda MPV	26
Lumina Van	78
Caravan/Voyager	118
Total	5,028

The effect on rollover fatalities of actually improved stability in a vehicle that did not change drastically in appearance is illustrated by the evolution in designs of the Jeep CJs and Wrangler. Figure 15-1 shows that the first-event rollover and rollover that occurred after contact with another vehicle or object declined as the T/2H gradually increased from 1.01 in the CJ5 to 1.16 in the Wrangler. The non-rollover rate is similar among the Jeeps and is somewhat less than that of passenger cars.

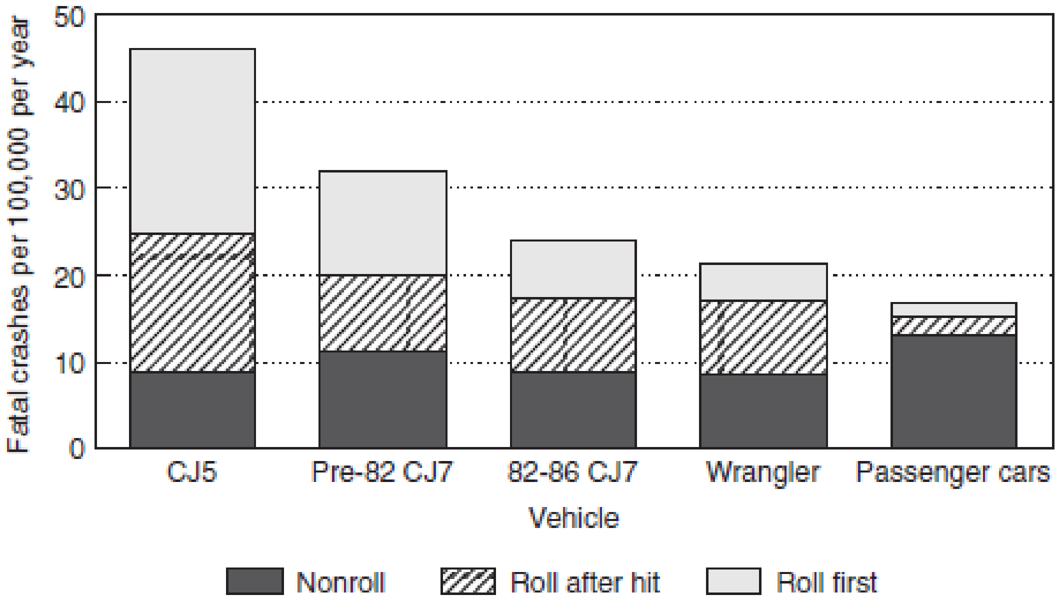

Figure 15-1. Fatal Crashes per 100,000 Vehicles per Year (Fatal Accident Reporting System, 1988–1994).

Only the manufacturers know the cost of changing vehicle parameters but it is possible to relate the relevant parameters to the base price of the vehicles. Ordinary least squares regression was used to estimate the effect of center of gravity height, track width, and wheelbase on the 1993 base price of vehicles in the study (Ward's Automotive Yearbook, 1993).

The base price of the 23 vehicles studied related to vehicle parameters is presented in Table 15-6. Track width and wheelbase are not related to vehicle price when the effect of center of gravity height is considered. For each one-inch (2.54 cm.) marginal increase in center of gravity height, there is an average $1446 increase in the base price of the vehicle. Consumers were charged more to increase their risks.

Table 15-6. Base Price of Vehicles in 1993 in Relation to Center of Gravity Height, Track Width, and Wheelbase (in inches)

	Coefficient	*t*-Value	*p*-Value
Intercept	–10,648	–1.32	.203
Center of gravity height	1,446	4.59	<.001
Track width	–114	–0.53	.599
Wheelbase	–53	–1.63	.119
$R^2 = 0.66$			

Based on the projected 5028 preventable deaths in 5 model years, each year's delay in the adoption of a minimum stability standard of T/2H = 1.2 for light-duty vehicles in the U.S. resulted in the continued production of vehicles that will experience more than 5000 preventable deaths (compared to 68 estimated by NHTSA) and huge costs from nonfatal injuries in rollovers. The government agency responsible for vehicle standards failed in its duty to analyze the problem with due diligence (Frame, 1996) and the manufacturers failed to act on what their historic statements and experience would indicate (e.g., Stonex, 1961). The cost was not the issue.

NHTSA's estimate of deaths prevented is based on a measure of stability (TTA) that is inferior in predicting rollover rates as well as several false assumptions. The agency falsely assumed that increased stability only reduces single-vehicle rollovers. It claimed that most crashes would occur whether the vehicle rolled or not, despite clear evidence to the contrary (e.g., Figure 14-1). It used only one model year when these vehicles are essentially unchanged in design for many years. And it failed to account for the total years of use.

Lowering the center of gravity height, increasing track width, or both can increase stability. If desired ground clearance means a high center of gravity, then appropriately increased track width can offset it. NHTSA argued that the six-inch (3.24 cm.) increase in track width necessary to stabilize some of the vehicles must be accompanied by a ten-inch (25.4 cm.) increase in wheelbase to retain braking stability. Even if that were true, it is not true of the lowered center of gravity. Furthermore, most of the vehicles would require less than a six-inch (3.24 cm.) extension of track to achieve T/2H = 1.2 given the same center of gravity. Curiously, the agency accepts a minimum ratio of wheelbase to track width to achieve braking stability but not a ratio of minimum track width to center of gravity height to achieve turning stability.

NHTSA claims that required changes in track width and wheelbase would eliminate the "compact sport utility vehicle" class of vehicles, which they claim the agency is prohibited from doing by law. Aside from the fact that such vehicle classifications are arbitrary, the assumption is demonstrably untrue. The noted changes in the Jeep from the CJ5 to the Wrangler did not eliminate the vehicle from the "compact sport utility" class and did not change its appearance appreciably. Extending the Wrangler's track width an additional 2 inches (5.08 cm.) or lowering its center of gravity height 1 inch (2.54 cm.) to achieve a T/2H of 1.2 would not do so.

The official who signed the three Federal Register entries rejecting a rollover standard commented in a newspaper article that the total death rates in some of the less stable vehicles are less than average (Stepp, 1996). While that is true because some have longer than average wheelbases and lower than average non-rollover rates, as can be seen in Table 15-1, that is not an excuse for failure to reduce rollover rates where feasible and practicable. If a physician argued that we should not treat cancer because heart disease is declining, the comment would not be treated seriously, even in a newspaper. The official who commented subsequently retired from the government and went to work for the American Motor Vehicle Manufacturer's Association, a typical "revolving door" problem between industry and government in the United States. The government official who signed the rejection of the petition to recall the Samurai retired to work for the Association of International Vehicle Manufacturers, also a Washington lobbying organization.

NHTSA's claim that the standard would be costly also is not supported by the Jeep's history and the vehicle price data. The 1993 Wrangler's base price, US$ 11,410, was among the lower-priced vehicles for sale in the United States in that year. The correlation of price to vehicle parameters indicates that a substantial price increase is associated with raising the center of gravity height when wheelbase and track width are controlled statistically. There is increased cost both in vehicle price and death and injury to riding high. While the redesign of vehicles undoubtedly bears costs, the vehicles are periodically redesigned anyway and it is not clear that increased stability would result in a net increase in costs given the apparent higher marginal price of a higher center of gravity.

References – Chapter 15

Adams W and Brock JW (1987) Bigness and social efficiency: a case study of the U.S. auto industry. In Samuels WJ and Miller AS Corporations and Society: Power and Responsibility. New York: Greenwood Press.

Agran PF, Dunkle, DE and Winn DG (1987) Effects of legislation on motor vehicle injuries to children. Am J Dis Child 141:959-964.

Anderson JA, McLellan BA, Pagliarello G and Nelson WR (1990) The relative influence of alcohol and seatbelt usage on severity of injury from motor vehicle crashes. J Trauma 30:415-421.

Anderson LG and Settle RF (1977) Benefit-Cost Analysis: A Practical Guide. Lexington, MA: DC Heath.

Automotive News Market Data Book. Detroit, MI: Automotive News, 1989-1995.

Baker SP (1979). Who bought the cars in which people were injured? an

exploratory study. Am J Pub Health 69:76. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1619006/pdf/amjph00686-0077.pdf
Baker SP (1980) On lobbies, liberty, and the public good. Am J Pub Health 70:573-574. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1619450/pdf/amjph00679-0015.pdf
Baker SP, O'Neill B and Karpf RS (1984) The Injury Fact Book. Lexington, MA: DC Heath.
Baldwin S, Godfrey C and Propper C (eds.) (1990) Quality of Life: Perspectives and Policies London: Routledge.
Berger LR and Mohan D (1996) Injury Control: A Global View. Delhi: Oxford University Press.
Christoffel T and Teret S (1993) Protecting the Public: Legal Issues in Injury Prevention. New York: Oxford University Press.
Cohen BL (1980) Society's evaluation of life saving in radiation protection and other contexts. Health Physics 38:33.
Crouch EAC and Wilson R (1982) Risk/Benefit Analysis. Cambridge, MA: Ballinger.
Culyer AJ (1990) Commodities, characteristics of commodities, characteristics of people, utilities, and the quality of life. In Baldwin S, Godfrey C and Popper C (eds.) Quality of Life: Perspectives and Policies London: Routledge.
Currie G, Kerfoot KD, Donaldson C, Macarthur C. (2000) Are cost of injury studies useful? Inj Prevention 6:175-176. http://injuryprevention.bmj.com/content/6/3/175.long
Datta TK, Guzek P (1990) Restraint System Use in 19 U.S. Cities: 1989 Annual Report. Washington, D.C., National Highway Traffic Safety Administration.
DiNapoli N, Fitzpatrick M, Strother C, Struble D and Tanner R (1977). Research Safety Vehicle Phase II, Volume II, Comprehensive Technical Results. Springfield, VA: National Technical Information Service.
Elvik R, Vaa T (2009) The Handbook of Road Safety Measures.Second Edition London: Emerald Group.
Fang X, Brown DS, Florence CS and Mercy JA (2012) The economic burden of child maltreatment in the United States and implications for prevention. Child Abuse and Neglect 36:256-165.
Federal Highway Administration (1994) Technical Advisory: Motor Vehicle Accident Costs. Washington, DC: U.S. Department of Transportation.
Finkelstein EA, Corso PS, Miller TR (2006) The Incidence and Economic Burden of Injuries in the United States. New York: Oxford University Press.
Foss RD, Beirness DJ and Sprattler K. (1994) Seat belt use among drinking drivers in Minnesota. Am J Pub Health 84:1732-1737. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1615187/pdf/amjph00462-0022.pdf

Frame P (1996) Has Martinez dropped the ball at NHTSA? Automotive News. June 24, p. 1.
Garrott WR (1993) Measured vehicle inertial parameters – NHTSA's data through September 1992. SAE Tech. Paper Series 930897. Warrendale, PA: Society of Automotive Engineers.
General Accounting Office (1978). Unwarranted Delays by the Department of Transportation to Improve Light Truck Safety. Washington, DC: Comptroller General of the U.S.
Gioia DA (1992) Pinto fires and personal ethics: A script analysis of missed opportunities. J Bus ethics 11: 379-389.
Hadley KHW et al. (2013) The cost of injury and trauma care in low and middle-income countries: a review of economic evidence. Heal Pol Plan 2013:1-14. http://www.pricelesssa.ac.za/Portals/0/Documents/Trauma%20and%20Injury/Wesson%20HKH%20The%20cost%20of%20injury%20and%20trauma%20care%20in%20LMIC%20countries.pdf
Hartunian NS, Smart CN, Willeman TR and Zador PL (1983) The economics of safety regulation: lives and dollars lost due to repeal of motorcycle helmet laws. J Health Polit Policy Law 8:76-98.
Harwin EA, Brewer HK (1990) Analysis of the relationship between vehicle rollover stability and rollover risk using the NHTSA CARDfile accident database. J Traffic Med. 18:109-122.
Hoffman WM (1984) Case study: The Ford Pinto. In Hoffman WM et al. Business Ethics: Readings and Cases in Corporate Morality. New York: Wiley. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1695178/pdf/amjph00532-0098.pdf
Insurance Institute for Highway Safety (1995) Vehicle by vehicle death rate comparisons. IIHS Status Report 30:4-6. http://www.iihs.org/externaldata/srdata/docs/sr3009.pdf
Insurance Institute for Highway Safety (2015) http://www.iihs.org/iihs/topics/laws/helmetuse/mapmotorcyclehelmets
Jones IS, Penny MB (1990) Engineering parameters related to rollover frequency SAE Tech. Paper Series 900104. Warrendale, PA: Society of Automotive Engineers.
Kahneman D and Tversky A (1979) Prospect theory: an analysis of decision under risk. Econometrica 47:263-291. http://pages.uoregon.edu/harbaugh/Readings/GBE/Risk/Kahneman%201979%20E,%20Prospect%20Theory.pdf
Kahneman D (2011) Thinking Fast and Slow. New York: Farrar, Straus and Giroux.
Kelsey TW (1994) The agrarian myth and policy responses to farm safety. Am J Pub Health 84:1171-1177. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1614759/pdf/amjph00458-0117.pdf

Klein TM, Burgess M (1995) Alcohol Involvement in Fatal Traffic Crashes, 1993. Washington, D.C., National Highway Traffic Safety Administration.
Kotagal M et al. (2014) Health and economic benefits of inproved injury prevention and trauma care worldwide. PLOS ONE http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0091862#pone-0091862-g001
Kravitz H (1973) Prevention of falls in infancy by counseling mothers. Ill Med J 144:570-573.
Loomes G and McKenzie L (1990) The scope and limitations of QALY measures. In Baldwin S, Godfrey C and Propper C. Quality of Life: Perspectives and Policies. London: Routledge.
Leigh JP, Markowitz S, Fahs M, Landrigan P (2000) Costs of Occupational Injury and Illness. Ann Arbor: University of Michigan.
Miller TR (1989) Willingness to pay. In Rice DP, MacKenzie EJ, (eds.) Cost of Injury in the United States: A Report to Congress, 1989. San Francisco and Baltimore: Institute for Health and Aging, University of California and Injury Prevention Center, Johns Hopkins University.
Miller TR and Galbraith M (1995) Injury prevention counseling by pediatricians: a benefit-cost comparison. Pediatrics 96:1-4. http://www.columbia.edu/itc/hs/medical/residency/peds/new_compeds_site/pdfs_new/miller.pdf
Mengert P, Salvatore S, DiSario R, Walter R (1989) Statistical estimation of rollover risk. Cambridge, MA: Transportation Systems Center. Free online at: http://ntl.bts.gov/lib/33000/33400/33408/33408.pdf
Morrow RH and Bryant JH (1995) Health policy approaches to measuring and valuing human life: conceptual and ethical issues. Am J Pub Health 85:1356-1360. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1615602/pdf/amjph00448-0030.pdf
National Highway Traffic Safety Administration (1983) The Economic Cost to Society of Motor Vehicle Accidents. Washington, DC: U.S. Department of Transportation.
National Highway Traffic Safety Administration (1987) Federal Motor Vehicle Safety Standards; denial of petition for rulemaking; vehicle rollover resistance. Fed Reg 52:49033.
National Highway Traffic Safety Administration (1988) Denial of motor vehicle safety defect petitions. Fed Reg 53:34866.
National Highway Traffic Safety Administration (1992) Rollover prevention. Fed Reg 57:242-252.
National Highway Traffic Safety Administration (1989-1992). Fatal Accident Reporting System. Washington: U.S.Department of Transportation. Data downloadable at: http://www.nhtsa.gov/FARS
National Highway Traffic Safety Administration (1991) Technical assessment

paper: relationship between rollover and vehicle factors. Washington, DC: U.S. Department of Transportation.
National Highway Traffic Safety Administration (1989-1991). National Accident Sampling System (NASS), Crashworthiness Data Subsystem, Analytical User's Manual. Washington, DC: U.S. Department of Transportation.
National Highway Traffic Safety Administration (1994) Consumer Information Regulations; Federal Motor Vehicle Safety Standards; Rollover Prevention. Fed Reg 59:33254-33272.
National Highway Traffic Safety Administration (1996) Federal Motor Vehicle Safety Standards; Rollover Prevention. Fed Reg 61:28550-28561.
National Highway Traffic Safety Administration (2006) Traffic Safety Facts 2004. Washington, D.C., U.S. Department of Transportation. http://www-nrd.nhtsa.dot.gov/Pubs/TSF2004.pdf
Oak Ridge National Laboratory (1984). Scrappage and Survival rates of passenger cars and trucks in 1970-82.Ward's Automotive Yearbook. Detroit, MI: Ward's Communications.
Petitti DB (1994) Meta-Analysis, Decision Analysis, and Cost-Effectiveness Analysis. New York: Oxford University Press.
Preusser DF, Williams AF, and Lund AK (1985) Driver licensing age and lifestyles of 16 year olds. Am J Pub Health 75:358. Free online at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1646245/pdf/amjph00280-0048.pdf
Price JH et al. (2013) Perceived role of emergency department physicians regarding anticipatory guidance on firearms safety. J Emerg Med 44:1007-1014.
Priest WC (1988) Risks, Consensus, and Social Legislation: Forces That Led to Laws on Health, Safety and the Environment. Boulder, CO: Westview Press.
Ramos DG, Arezes PM and Alfonso P (2013) Economic analysis of occupational risk prevention: a case study in a textile company. In Steenbergen RDJM et al., (eds) Safety, Reliability and Risk Analysis: Beyond the Horizon. London: CRC Press. http://repositorium.sdum.uminho.pt/bitstream/1822/33689/1/CI262_cd_176.pdf
Reinfurt DW, Li LK, et al. (1981) A Comparison of Crash Experience of Utility Vehicles, Pickup Trucks and Passenger Cars. Chapel Hill: University of North Carolina Highway Safety Research Center.
Reinfurt DW, Stutts JC and Hamilton EG (1984) A Further Look At Utility Vehicle Rollovers. Chapel Hill: University of North Carolina Highway Safety Research Center, 1984. http://www.hsrc.unc.edu/research_library/PDFs/Further84.ocr.pdf
Rice DP, MacKenzie, EJ (eds.) (1989) Cost of Injury in the United States: A Report to Congress, 1989. San Francisco and Baltimore: Institute for Health and Aging, University of California and Injury Prevention Center, Johns Hopkins University.

Rivara FP, Dicker BG, Bergman AB, Dacey R and Herman C (1988) The public cost of motorcycle trauma. JAMA 260:221-223.
Robertson LS (1983) Injuries: Causes, Control Strategies, and Public Policy, Lexington, MA: DC Heath.
Robertson LS (1987) Childhood injuries: Knowledge and strategies for prevention. Springfield, VA: National Technical Information Service (PB88-172507/WHP).
Robertson LS. (1989) Potential savings from injury prevention. In Rice DP and MacKenzie EJ (eds.) Cost of Injury in the United States. San Francisco and Baltimore: Institute for Health and Aging, University of California and Injury Prevention Center, Johns Hopkins University.
Robertson LS (1989) Risk of fatal rollover in utility vehicles relative to static stability. Am J Pub Health 79:300. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1349551/pdf/amjph00229-0046.pdf
Robertson LS (1990) Car design and risk of pedestrian deaths. Am J Pub Health 80:609-610. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1404635/pdf/amjph00218-0087.pdf
Robertson LS (1993). Fatal car fires from rear-end crashes: the effects of fuel tank placement before and after regulation. Am J Pub Health 83: 1168-1170. Free online at: https://ajph.aphapublications.org/doi/pdf/10.2105/AJPH.83.8.1168
Robertson LS and Kelley AB (1989) Static stability as a predictor of overturn in fatal motor vehicle crashes. J Trauma 29:313.
Robertson L S and Zador PL. (1978) Driver education and fatal crash involvement of teenaged drivers. Am J Pub Health 68:959-965. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1654060/pdf/amjph00473-0025.pdf
Ropeik D (undated) The Supreme Court ruling on the 2nd Amendment did NOT grant an unlimited right to own guns. Bigthink.com. http://bigthink.com/risk-reason-and-reality/the-supreme-court-ruling-on-the-2nd-amendment-did-not-grant-an-unlimited-right-to-own-guns
Runyan CW and Earp JAL (1985) Epidemiologic evidence and motor vehicle policy making. Am J Pub Health 75:354-360. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1646225/pdf/amjph00280-0044.pdf
Self P (1977) Econocrats and the Policy Process: The Politics and Philosophy of Cost-Benefit Analysis. Boulder, CO: Westview Press.
Shrader-Frechette KS (1985) Risk Analysis and Scientific Method Boston, MA: D. Reidel.
Snyder RG, McDole TL, Ladd WM and Minahan DJ (1980) On-road Crash Experience of Utility Vehicles. Ann Arbor: University of Michigan Highway Safety Research Institute.

Starr C (1969) Social benefit versus technological risk. Science 165:1232-1238.
Tengs TO, Adams ME, Pliskin JS, Safran DG, Siegal JE, Weinstein MC and Graham JD (1995) Five-hundred life-saving interventions and their cost-effectiveness. Risk Analysis 15:369-390. http://www.econ.ucsb.edu/~tedb/Courses/UCSBpf/readings/interventions.pdf
Viscusi WK and Magat WA (1987) Learning About Risk: Consumer and Worker Responses to Hazard Information. Cambridge, MA: Harvard University Press.
Whitfield RA and Jones IA (1995) The effect of passenger load on unstable vehicles in fatal, untripped rollover crashes. Am J Pub Health 85:1268-1271. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1615587/pdf/amjph00447-0086.pdf
Williams AF, Karpf RS and Zador PL (1983) Variations in minimum licensing age and fatal motor vehicle crashes. Am J Pub Health 73:1401. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1651252/pdf/amjph00647-0057.pdf
Wintemute GJ and Wright MA (1992) Initial and subsequent hospital costs of firearm injuries. J Trauma 33:556-560.
Wood T and Milne P (1988) Head injuries to pedal cyclists and the promotion of helmet use in Victoria, Australia. Acc Anal Prevent 20:177.
Zaloshnja E, Miller T, Galbraith M, Lawrence B, DeBruyn L, Bill N, Hicks K, Keiffer M, Perkins R (2003) Reducing injuries among Native Americans: five cost-outcome analyses. Acc Anal Prevent 35:631-639.