# Economic Evaluation of Public Health Laws and their Enforcement

*A Methods Monograph*

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Making the Case for Laws that Improve Health

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# Economic Evaluation of Public Health Laws and their Enforcement

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## Summary

Policy decisions can be informed by information on anticipated costs and expected future benefits of courses of action. The key questions in economic evaluation of a public health law are whether its benefits, as measured by health outcomes or cost savings, exceed its costs; secondarily, there is the question of the distribution of those costs and benefits across stakeholders. Cost savings are concrete and understandable benefits, and they provide a single compact measure that captures wrecked cars, stolen statues, fractured arms, even deaths.

Economic evaluation begins with the selection of an intervention to be studied and a type of economic evaluation to use. Cost-effectiveness analysis uses naturally occurring outcomes to compare interventions with the same objective. The results are reported as the cost per life year saved or the cost per harm prevented. Cost-utility analysis is a special form of cost-effectiveness analysis in which the outcomes are measured using multidimensional measures of health outcomes such as quality adjusted life years (QALYs) that incorporate both quality and survival information. In cost-utility analysis, the evaluative measure is the cost per QALY gained or saved. Benefit-cost analysis is a third type of economic evaluation, in which all of the health outcomes are measured in monetary terms, with the results reported either as a benefit –cost ratio or as net benefits (i.e., benefits minus costs).

An economic evaluation measures all costs and benefits in inflation-free dollars stated in a base year (for example, in 2012 dollars). An estimate of the costs of the various alternative options is computed. Relevant effectiveness measures are selected, ideally final outcomes like impaired driving crashes averted, and effectiveness estimated. The benefits of the various options are calculated and valued, and then a cost-outcome measure is computed. Cost-outcome measures are the metric used in economic evaluation to compare benefits of an intervention such as a public health law with its costs. In calculating cost-outcome measures, an incremental approach is typical;

with the additional net costs that one alternative imposes over another compared with the additional benefits provided. The ratio of the additional costs over the additional benefits is termed the incremental cost-effectiveness ratio (ICER). Sensitivity analysis is then deployed to deal with uncertainty; it tests whether plausible changes in selected estimates or assumptions affect results of the analysis.

Economic evaluations of public health laws involve decisions and challenges that rarely arise in economic analyses of health care programs and practices. They include methods to value a variety of subtle intangible costs that a law imposes on people by shaping their behavior directly, costs of passing and implementing a law, costs of adjudication and sanctioning, unmeasured anticipated benefits and costs (for example, if a driving curfew reduces crime), and mixing of health benefits with employment or educational benefits. In evaluating public health laws from an economic perspective, a comparison of benefit-cost ratios or incremental cost-effectiveness per QALY gained is a valuable aid in deciding which options represent optimum value for money invested. Researchers also face the challenge of explaining the limits of cost analysis to policy champions.

# Introduction

Understanding costs and benefits of public health laws can help decision makers and the general public understand likely effects on different sectors of the community. Inherent tensions exist when laws or regulations restrict activities that are harmful to health, with trade-offs required between the good of the whole community versus the good of a single individual. For example, wearing a helmet is widely known to substantially decrease a motorcyclist's risk of death or severe injury in a crash and decrease the associated costs, most of which are not borne by the motorcyclist. Legislation mandating helmet wearing while motorcycling, however, restricts freedom of choice and deprives motorcyclists of the perceived pleasure of riding without a helmet.

All decisions involve some degree of weighing anticipated costs and expected future benefits of courses of action. While in everyday decision making, costs and benefits may not all be explicitly considered, or mental short cuts may be used to speed decision making, economic evaluation systematically investigates the costs and benefits of alternative options for meeting an objective such as safeguarding the public's health. While uncertainty may exist in quantifying costs and benefits, the key questions addressed in economic evaluation of a public health law are whether its benefits, as measured by health outcomes or cost savings, exceed its costs; secondarily, there is the question of the distribution of those costs and benefits across stakeholders. Data on cost saving benefits that arise from changing a public health law can be a rallying point in the battle to pass or preserve a public health law. The press, legislators, and the public all care about costs a law can reduce. Cost savings are concrete and understandable benefits, and they provide a single compact measure that captures wrecked cars, stolen statues, fractured arms, even deaths.

This monograph provides an introduction to the economic evaluation of public health law. It begins by briefly reviewing 10 key steps in a typical economic evaluation (Miller & Levy, 1997). It illustrates these steps with an analysis of costs and benefits of voluntary use of a motorcycle helmet.

The second section then elaborates on issues that arise in applying economic evaluation to public health laws, including an explanation of the complex steps required to modify the motorcycle helmet estimate to evaluate passing or enforcing a law that mandates motorcycle helmet use. The third section discusses the issue of how to compare cost-outcome estimates and provides a table of benefit-cost and cost-effectiveness estimates for a variety of public health laws. The fourth section addresses the complexity of communicating economic evaluation to policymakers.

## Steps in Conducting an Economic Evaluation

### Step 1: Define the Intervention

The first step in conducting an economic evaluation is to carefully define the intervention to be evaluated. This includes deciding on objectives of the evaluation, alternatives to be compared, target population, setting of the intervention, and time horizon over which costs and outcomes will be calculated. As our example, we take the objective of computing the return on voluntary investment in a motorcycle helmet by a motorcycle operator. The two alternatives evaluated are to ride one's motorcycle in the United States helmeted or unhelmeted. We estimate a helmet has a five-year useful life. This initial analysis assumes a helmet use law is not in force.

### Step 2: Choose a Type of Economic Evaluation

The type of economic evaluation is determined by how health outcomes are measured. If naturally occurring outcome measures are selected, then the type of economic evaluation is a cost-effectiveness analysis. Naturally occurring outcomes include generic outcomes that can be compared across all interventions (for example, fatalities prevented, life years gained) or more specific outcomes that can only be used to compare interventions with the same objective (for example, the number of assaults prevented). The economic evaluation results are reported as the cost per life year saved or the cost per assault prevented. Cost-utility analysis is a special form of cost-effectiveness analysis in which the outcomes are measured using multidimensional measures of health outcomes such as quality adjusted life years (QALYs) that incorporate both quality and survival information. A QALY is a health outcome measure valued at 1 for a year in perfect health and at 0 if someone is dead, with values less than 0 (fates worse than death) allowed. In cost-utility analysis, the evaluative measure is the cost per QALY gained or saved. Benefit-cost analysis is a different type of economic evaluation in which all of the health outcomes are measured in monetary terms, with the results reported either as a benefit –cost ratio or as net benefits (that is, benefits minus costs). In our motorcycle helmet example, we will illustrate both a benefit-cost analysis and a cost-utility analysis.

### Step 3: Determine the Perspective

The next analytic decision is to choose a *perspective*. The perspective determines whose costs and whose benefits count. For example, discomfort associated with wearing motorcycle helmets is a cost to wearers but a benefit to health insurers as fewer injuries to helmeted motorcyclists will reduce the costs paid out for medical and related treatment. Any cost savings attributable to a public health law represent a benefit to the agency or individual who would otherwise pay these costs. The broadest perspective for an economic evaluation is the societal perspective, which incorporates all costs and benefits regardless of who incurs the costs and who obtains the benefits. This is the perspective recommended by the US Panel on Cost-Effectiveness in Health and Medicine (Gold et al., 1996). Other perspectives include those of the government, the healthcare sector, health insurers, healthcare institutions, employers and individuals. Choice of perspective depends on the objective of the study, and more than one perspective can be adopted if appropriate. Whatever perspective is adopted, it is important that it is clearly stated and justified.

Public health laws often reflect tension between what maximizes utility of individual participants in an activity versus the utility of non-participants who are affected by that activity. Legislatures may attempt to protect both interests. For example, Texas requires motorcyclists who choose not to wear a helmet to show proof of health insurance that would partially cover the medical care cost of any traumatic brain injury that could result from a motorcycle crash. Examining costs and benefits to those who are regulated by public health laws versus those affected by problem behaviors corresponds to the distinction between adopting an internal versus external perspective. The *individual or internal perspective* – costs and benefits to those who are regulated – provides insight into the likely intensity of opposition to a law. Risk misperception often causes people to underestimate costs of their behavior. An analysis showing that people choose a behavior because they under-perceive their risks – for example, because they think the risk of being in a motor vehicle crash is half of the actual risk – strengthens the case for regulatory action. An analysis of individual costs requires estimating discomfort, inconvenience, and psychic losses associated with behavioral controls. When evaluating minimum drinking age laws, helmet use laws, gun control, and other laws that interfere with personal freedom, economists often focus on the *external perspective* – costs and benefits of problem behavior accruing to people other than the person whose behavior is constrained. High external costs justify public intervention. To justify public health laws that interfere with personal freedom of adults, the record needs to show that the behavior being regulated unduly burdens members of the public who do not engage in that behavior.

The definition of external costs presented here is not universal (Miller, 2001). Consistent with our definition, the highway safety literature defines external crash costs as costs that one group of road users involved in crashes impose on another group of crash-involved road users or on people who were not crash-involved (Elvik, 1994; Lave, 1987). Elvik (1994) clarifies this definition, arguing all costs borne by the family due to injuries to a drinking driver or pedestrian should be treated as internal and all other costs including costs of injuries to other family members who might have been injured in the crash as external. This external cost definition is the relevant one for most public policy decisions.

Another perspective issue, and a second definition of external costs, arises when costing illegal acts. From a societal perspective, many economists believe stolen money is an involuntary transfer payment, not a cost. The total money in circulation remains constant, so society does not experience a loss. Taking this reasoning to its extreme, some economists might argue that the sadist gained pleasure from an assault, a gain that offset some of the suffering costs to the victim. Trumbull (1990) suggests a better alternative, stating that lawbreakers lack standing in societal costing. He and Zerbe (1991) both recommend not counting gains criminals get illegally as societal benefits, and not viewing the prevention of criminals from reaping those gains as a loss. In proscribing these actions, legislatures implicitly state that the gains are ill-gotten and ipso facto do not benefit society. Trumbull's rule underpins a definition of external costs used by both Cohen (1998, 2000) and Rajkumar and French (1997) in analyzing substance abuse and related crime costs:

> "An external cost is a cost imposed by one person onto another, where the latter person does not voluntarily accept the negative consequence (through monetary payments or otherwise). For example, the external costs associated with a mugging include stolen property, medical costs, lost wages, and pain and suffering endured by the victim. The victim neither asked for, nor voluntarily accepted, compensation for enduring these losses. Moreover, society has deemed that imposing these external costs is morally wrong and against the law" (Cohen, 2000, p. 272).

In Cohen's work, the definitional line blurs, with the money stolen by the criminal not counted as a cost but the wages that the criminal lost while in jail counted. Again on the cusp, Cohen (1998) counts the money spent on illicit drugs as a cost of substance abuse.

Often one displays costs and benefits (that is, cost savings) from multiple perspectives, as in Figure 1 showing costs and benefits from a sustained compulsory breath testing program in New Zealand. Showing costs and benefits from multiple perspectives provide a more complete representation of the costs and benefits of a program.

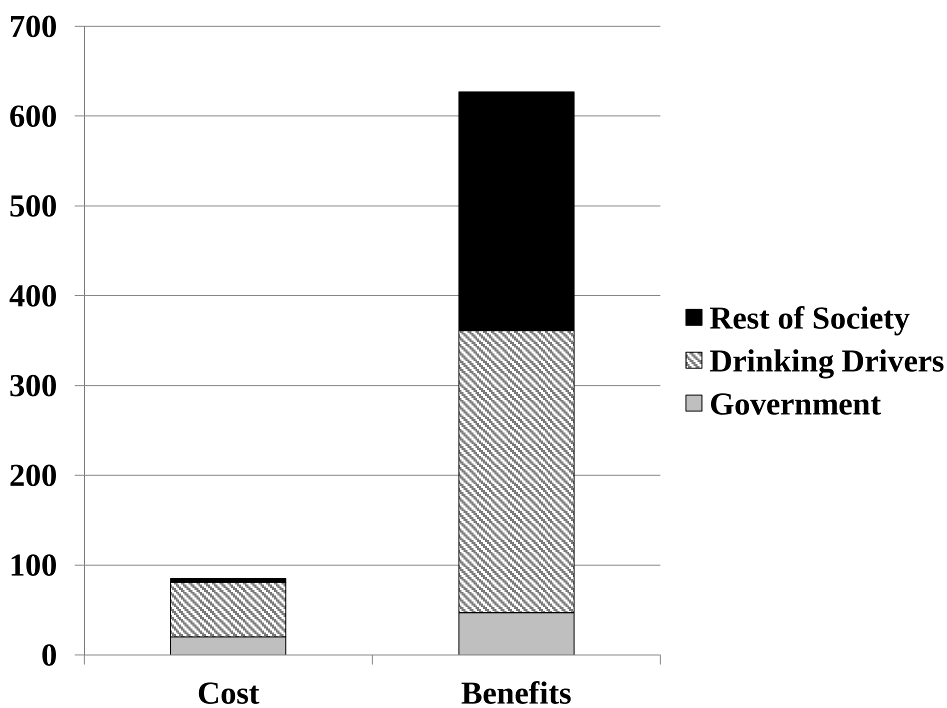


*Figure 1*. Costs and benefits from a sustained compulsory breath testing program in New Zealand by perspective (in millions of 2009 US dollars)
*Source:* Miller and Blewden (2001)

In our motorcycle helmet example, we analyze the investment from two perspectives: (1) a societal perspective, which means that everyone's costs and benefits count, including the motorcyclist, his family, his employer, his insurers, and taxpayers/government, and (2) the individual perspective, examining the decision to voluntarily wear a helmet from the motorcyclist's viewpoint.

### Step 4: Decide How to Adjust for Differential Timing

Costs and benefits of many interventions extend over years. Inflation results in price changing over time even though the amount of resources used (or saved) and their opportunity cost remains the same. An economic evaluation measures all costs and benefits in inflation-free dollars stated in a base year (that is, in 2012 dollars). Costs of an intervention incurred in the future and benefits received in the future, however, are of lesser value than immediate ones, because money can earn interest when invested and the future is uncertain. For example, a motorcyclist could be killed by a drunk driver while strolling about on the day after his helmet allowed him to emerge from a motorcycle crash unscathed. Conversely, a scientific breakthrough three years after he buys his helmet could reduce the consequences and costs of a brain injury. Therefore cost-outcome analyses reduce or *discount* future cost and benefit streams to reflect their present value. The further in the future a cost or benefit will be the less weight discounting gives it in the present.

In our motorcycle helmet example we state all costs and benefits in 2010 dollars. We use the 3% discount rate that the Panel on Cost-Effectiveness in Health and Medicine (Gold et al., 1996) recommends using in analyses of health policy. In a full study, we also would compute estimates at other discount rates to see how sensitive the findings are to the choice of discount rate.

### Step 5: Estimate Costs of Alternative Options

Intervention costs should be comprehensive. They include costs of program start-up and operation. If staff will be involved, one includes their wages, fringe benefits, and overhead expenses. Volunteer time is priced at the amount it would cost to hire someone to do the volunteer's work.

In our helmet example, an Internet search in August 2011 located U.S. Department of Transportation-approved and Snell-certified helmets for $50 including shipping, a good selection below $100 and some priced as high as $750. We analyze a $100 helmet, with sensitivity analysis estimating the savings for a $50 and a $200 helmet. We add an hour's wage of $19 to shop for the helmet (the national average wage according to the 2010 U.S. Current Employment Survey).

### Step 6: Select Relevant Effectiveness Measures

Ideally, effectiveness measures should be final outcomes like impaired driving crashes averted, not measures like reductions in alcohol outlets that sell to minors, or worse, changes in vendor attitudes about the harm caused by selling alcohol to minors. The choice of effectiveness measures often will be driven by available data and the underlying purpose of conducting the economic evaluation. In our example, we estimate how much motorcycle helmets reduce deaths and non-fatal brain injuries.

### Step 7: Estimate Effectiveness

In prospective analyses of regulatory strategies previously evaluated through small-scale experiments or demonstration programs in selected locations, it is wise to assume effectiveness in jurisdiction-wide replication will be 25% lower than the efficacy achieved by a program developer in a focused research trial (see Aos et al., 2004; Caulkins et al., 2002; Miller & Hendrie, 2009). Developers are highly motivated. Their experiments often operate under ideal conditions in terms of fidelity and resources. Replications almost never reach the same level of effectiveness as they move to a broad society-wide scale. On the other hand, if effectiveness was previously estimated in jurisdictions where whole populations in natural settings were exposed to the regulatory strategy, there is no need to reduce the expected magnitude of effect.

Let's go back to our helmet example. Deutermann (2004) uses 1993-2002 data and a very robust evaluation design to estimate that a motorcycle helmet reduces fatality risk by 37% for motorcycle operators and 41% for passengers. For simplicity, we assume operators never ride as passengers. A meta-analysis (Liu et al., 2008) estimates from six "higher quality studies" that a helmet reduces non-fatal brain injury risk by 69%.

Table 1 uses those effectiveness figures to estimate lives saved by helmets. The first row of data in Table 1 shows a census count of motorcycle operator deaths in crashes in 2008 (National Highway Traffic Safety Administration, 2011). The second row shows the estimated number of deaths if helmets did not exist. The third row shows the formulas used to compute the numbers of deaths that would occur if nobody wore a helmet. For those not wearing a helmet, that simply is the current number of deaths. For those wearing a helmet, we compute the number of deaths without helmets by dividing the number of deaths while helmeted by the percentage of deaths that helmets do not prevent, in this case by 63% (100% - 37% helmet effectiveness). The last column in Table 1 estimates deaths avoided among riders with unknown helmet use. This estimate assumes that helmet use was comparable among cyclist fatalities with unknown and known helmet use. In that case, the number of deaths that would have occurred if no one in this group wore a helmet equals the number of deaths with unknown use times the deaths if none of the riders with known helmet use had worn a helmet divided by the actual number of deaths of riders with known helmet use.

Table 1

*2008 Motorcycle Fatalities in the United States and Predicted Fatalities without Helmet Use*

| Actual and Predicted Scenarios | Helmet Used? | | | Total |
|---|---|---|---|---|
| | Yes | No | Unknown | |
| Actual Operator Deaths | 2,855 | 1,990 | 130 | 4,975 |
| Deaths if Nobody Wore a Helmet | 4,532 | 1,990 | 175 | 6,697 |
| Calculation of Number of Deaths If Nobody Wore a Helmet | 2,855/(1-.37) | | 130* (1,990+4,532)/ (1,990+2,855) | |

Risk is computed as the number of deaths or injuries divided by exposure. To translate the gains from helmet wearing displayed in Table 1 into estimates of risk reduction per helmet, we divide by the number of helmets. To do that, we need to estimate the number of helmets in use. A 2008 survey estimated that 10.4 million motorcycles were in use in the United States with 25 million regular or occasional riders (Motorcycle Industry Council, 2009). If we assume one regular operator per motorcycle, with a helmet shared if a cycle has multiple operators, then 10.4 million helmets were in use. In that case, the annual fatality risk of unhelmeted operation is 6,697 deaths if nobody wore a helmet divided by 10,400,000 helmets. If everyone wore a helmet, helmets would prevent 37% of the deaths so the risk reduction from helmet use is 37%*6,697 /10,400,000 = .000238.

We can make similar estimates for non-fatal brain injuries. Johnson and Walker (1996) reported the ratio of hospitalized non-fatal brain injuries to fatalities 135/132 among unhelmeted motorcyclists in six states during the 1990-1992 time period. Multiplying the fatality count times this ratio suggests 6,849 brain injuries would have occurred if no one used a helmet in 2008 (6,697 * 135/132). Recall that helmets prevent an estimated 69% of non-fatal brain injuries. Thus the annual brain injury risk reduction from wearing a helmet would be 0.000454 (6,849 *

69%/10,400,000). Keep in mind these risk levels are averages and vary with miles ridden, both because exposure increases and because more experienced/regular riders may have lower risks. And a rider who avoids death may be non-fatally injured instead.

**Step 8: Calculate and Value Benefits**

The type of economic evaluation selected for a given study determines how benefits are calculated and valued. In cost-effectiveness analysis, the benefit measure (for example, the gain in health-related outcomes) can be the increase in a final outcome measure (that is, the benefits may be the number of lives, life-years, or QALYs saved) or in an intermediate measure (that is, the percentage of cigarette vendors who refuse to sell to minors or the number of motorcycle riders who begin wearing helmets). The cost-effectiveness measure is computed by dividing the cost of the intervention by this non-monetary benefit measure. When evaluating public health programs, typically some portion of the benefits are reductions in resource costs like medical costs, property damage, police response, or attorney fees in liability lawsuits. For prevention of illegal acts like violence, impaired driving, and serving alcohol to underage patrons, reduced adjudication and sanctioning costs add to the resource-cost-saving benefits. Decision-makers are interested in how much of the cost of the intervention is offset by resource cost reductions, which represent tangible financial benefits. For example, when the Consumer Product Safety Commission estimated baby walkers that had been redesigned to prevent stairway falls cost $4 more than traditional baby walkers and resulted in benefits that included medical cost savings averaging $17 per walker (Rodgers & Leland, 2008), it was easy to understand why the Commission required the redesign. For this reason, it is preferable for a cost-effectiveness analysis to subtract benefits that can be expressed as resource cost savings from the intervention costs before dividing by the non-monetary outcome measure. When conducting a cost-effectiveness analysis, it thus is desirable to separately estimate financial benefits that can be expressed as resource cost reductions as well as measure non-monetary benefits.

In cost-utility analysis, the most commonly used benefit measure is a final outcome, the number of QALYs gained or saved, QALYs are routinely used as benefit measures by many regulatory agencies that incorporate economic evaluation into their decision making processes, and in clinical trials of pharmaceuticals and medical treatment protocols. QALYs are calculated based on two factors: the gain in quality of life and the number of life years over which the gain is sustained (Miller & Hendrie, 2011). Several generic quality of life instruments have been developed to use in measuring quality of life (McDowell, 2006) or alternatively, techniques are available to measure quality of life directly. An alternative comprehensive measure of health outcomes is disability adjusted life years (DALYs), which primarily are a measure of disease burden but are also commonly used in economic evaluation studies. A DALY typically equals one minus a QALY.

Benefit-cost analysis expresses health outcomes in monetary values, so the overall analysis of the costs and benefits of an intervention can be conducted in dollars or other currency values. The generally preferred method to place monetary values on health gains in benefit-cost analysis is called *willingness to pay*. The willingness to pay approach involves assessing what people actually pay or say they would pay for changes in their health status or for small changes in the risk of injury or death. Thus, it values the fatality risk reduction resulting from passage or enforcement of a public health law, not the preservation of a known life. If one makes an unrealistic assumption that the value of a QALY is independent of a person's age (that is, that the loss of six months of quality of life is valued the same at age 18 and age 88) and independent of the type of risk involved (for example, cancer versus heart attack), one can monetize the QALY gains so that they can be treated as benefits in a benefit-cost analysis. The QALY includes health-related work loss, but it may be preferable to value that wage-related loss separately and explicitly in a benefit-cost analysis -- the approach we take in our examples in this monograph. Doing so reduces the impact of the age-independence assumption because the wage loss can be tailored by age. This monograph presents both monetized QALY gains for use in the benefit-cost analysis and non-monetized gains for use in the cost-effectiveness analysis. (For details on QALY measurement and valuation methods, see Drummond et al., 2005; Miller & Hendrie, 2011).

Four ethical issues arise in valuing fatality risk, work losses, and QALY losses averted by public health laws. All are fraught with significant political hazard. They require delicate handling in economic analyses of public health laws and regulations. First, although wages, household work, and lifespan vary by age, sex, and race, these are differences resulting, in part, from discrimination. White males earn more than women or minority males, but that does not mean government should place a higher value on the life of a white male than on another citizen. The U.S. Department of Transportation, for example, decided against placing a higher value on the lives of air travelers than drivers, because the value difference results from an income difference. Government, they reasoned, should not place a higher value on a wealthy citizen than a pauper (Ackerman & Heinzerling, 2004; McCormick Jr. & Shane, 1993; Sunstein, 2004; Viscusi, 1994). Remaining lifespan varies with age simply as a result of basic biology, not discrimination. Analysts, therefore, often use a constant value per life year, which implicitly places lower values on elderly than young lives (Johansson-Stenman & Martinsson, 2008). Nevertheless, a firestorm erupted when the US Environmental Protection Agency (EPA), at the U.S. Office of Management and Budget's (OMB) urging, made that relationship explicit in analyzing a regulation that would avoid respiratory deaths of elderly people (Seelye, 2003; Viscusi, 2009). The public reaction forced EPA to return to using the same value for the life of any adult citizen, regardless of age.

The second ethical issue arises from the discounting of future costs and benefits. Because death and permanent disability create a lifetime's worth of work and QALY losses, these losses are reported as present values. Discounting reduces the value of future losses below the value of current losses. An environmental regulation that addresses global climate change is concerned with outcomes over the centuries. At a 3% discount rate, the present value of losses a century from now is 5.35% of the actual loss. The ethical question is whether we have the right to significantly harm future generations in order to avoid making small sacrifices now. In analyzing public health laws and actions with lasting consequences, a number of authors suggest that the discounting clock start as those affected are born (Cowen, 1992; Cowen & Parfit, 1992; Schelling, 1995). Cowen (2001) argued convincingly that intragenerational and intergenerational discount rates should be the same. In other words, just because they are further out into the future, the health and well-being of future generations should not be discounted more than future benefits that accrue to those currently alive.

The third ethical issue is related to the role of national borders. People disagree on responsibility to illegal immigrants and people living in other countries than their own. They debate whether illegal immigrants who pay taxes should be entitled to government services including medical care and education. Environmental regulatory analyses often include separate estimates of the domestic and world impacts (Interagency Working Group on Social Cost of Carbon & Government, 2010). When the U.S. tightens a workplace toluene exposure law, for example, it may merely shift the exposure to an Asian or Mexican worker rather than achieving a net worker health gain. Regulatory analyses in the U.S. typically ignore this risk migration.

Finally, valuation inherently involves a mix of science and ethical judgment. No clear line divides better regulatory analysis values from advocacy-driven values. EPA, for example, always has chosen a higher willingness-to-pay value than other agencies for fatal risk reduction. It is unclear to what extent this reflects better science versus enthusiasm for justifying environmental regulation. Or, people may object more to risk of disability from ambient air pollution they feel they cannot control, compared to risk of disability from a car crash they feel they can control. Some analysts suggest valuing the risk reduction of death from dreaded causes more than other causes, with nuclear accidents and terrorism leading candidates. In this vein, EPA suggested doubling the value of fatal risk reduction for cancer (Interagency Working Group on Social Cost of Carbon & Government, 2010). This decision would greatly reduce allowable levels of toxic pollutants. John Graham, who headed OMB's regulatory oversight during the Bush administration, questioned the wisdom of the "cancer premium … in light of the reluctance of citizens to monitor for radon in their homes, enroll in cancer screening programs, and eat their fruits and vegetables on a daily basis" (Borenstein, 2011).

Now we'll return to our helmet example. We tabulated costs and QALY losses per motorcycle death from the data base underlying Miller and colleagues (2011). Similar estimates for a hospitalized brain injury came from Miller and colleagues (2009); we adjusted the costs to 2010 dollars using the Consumer Price Index (CPI) – Medical Care and All-Items and the Employment Cost Index – Total Compensation – Total Private; these three price indexes are published monthly by the U.S. Bureau of Labor Statistics. For example, the medical cost per critical brain injury = $249,356 * CPImedical2010/CPImedical2002 = 249,356 * 388.25/260.8 =$371,213. Table 2 shows the estimated costs by cost category.

Table 2

*Estimated Costs and QALY Losses due to a Fatality and a Hospitalized Brain Injury in a Motorcycle Crash, Annual Risk Reduction from Riding Helmeted, and Average Benefits (Costs Avoided) and QALY Gains per Year by Riding Helmeted from Varied Perspectives (in 2010 dollars)*

| | Medical | Other Resource | Work | Quality of Life | Total | QALYs | Risk Reduction |
|---|---|---|---|---|---|---|---|
| Fatal | $36,786 | $208,119 | $1,202,809 | $2,685,269 | $4,132,983 | 20.98 | .000238259 |
| Hospitalized | $135,087 | $71,985 | $111,595 | $409,102 | $727,769 | 3.20 | .000454423 |
| Societal Perspective | $70 | $82 | $337 | $826 | $1,315 | 0.0065 | |
| Internal Perspective | $10 | $0 | $160 | $826 | $996 | 0.0065 | |
| External Perspective | $60 | $82 | $177 | $0 | $319 | 0 | |
| Government Perspective | $17 | $1 | $33 | $0 | $51 | 0 | |

Based on these costs of death and brain injury and the annual risk reduction estimates, the average motorcycle operator's helmet was estimated to avert $1,315 in injury costs annually. We computed the benefits from internal, external and government perspectives using payer matrices (Blincoe et al., 2002; Miller et al., 2011). A rationale for a public health law mandating helmet use is that citizens other than the rider together pay $319 per year in medical, other resource, and wage replacement costs for the average rider who does not wear a helmet (Miller, 1994, March 3).

Earlier we assumed a helmet has a five-year life. Statistical tables are available that provide the present value factors of a given monetary amount received each year. A present value factor is the 'multiplier' that when multiplied by the amount received each year gives the present value of the cash flows. The present value factor for five years at a discount rate of 3% is $1 + 1/1.03 + 1/1.03^2 + 1/1.03^3 + 1/1.03^4 = 4.717$. The average present value of the benefits stream from using a motorcycle helmet thus is $6,161.

### Step 9: Compute the Cost-Outcome Measure

Cost-outcome measures are the metric used in economic evaluation to compare benefits of an intervention such as a public health law with its costs. In calculating cost-outcome measures, an incremental approach is typical; with the additional net costs that one alternative imposes over another compared with the additional benefits provided. The ratio of the additional costs over the additional benefits is termed the incremental cost-effectiveness ratio (ICER). For example, results of a cost-effectiveness analysis evaluating the introduction of a law reducing the times of sale of alcohol could be reported as the additional net cost (that is, the intervention costs minus the financial benefits resulting from resource cost reductions) per additional injury averted. If QALYs were being used as the health outcome measure, then the ICER would be reported as the additional net cost per additional QALY gained. If the financial benefits from resource cost reductions following the introduction of the law exceed the costs involved in implementing and enforcing the law, no ICER needs to be calculated and the *net cost savings* (that is, the costs minus the financial benefits) and injuries averted or QALYs gained can be reported separately.

In the case of benefit-cost analysis, a choice of measures can be used to determine which option provides the best value for money. The first measure, the benefit-cost ratio equals the benefits divided by the costs. It shows the return per dollar invested. For example, the All Stars substance abuse education program for middle schools has a benefit-cost ratio of 34, while its competitor Project Northland has a benefit-cost ratio of 17 (Miller & Hendrie, 2009). Thus All Stars returns twice as many benefits per dollar spent. The second measure, net benefits, equals the benefits minus the costs. This measure is important to consider in conjunction with the benefit-cost ratio when using an economic analysis to guide a choice among alternatives. In our example, All Stars costs $140 per pupil and returns $4,760 in benefits for a net benefit of $4,620 per pupil. Project Northwood costs $400 per pupil and yields $6,800 in benefits for a net benefit of $6,400.

All Stars offers the largest return per dollar invested, but Project Northland produces a larger reduction in youth substance abuse and yields a larger net benefit per person. If a school system can afford Project Northland, it will yield a larger reduction in the underlying problem and greater net benefits.

A benefit-cost ratio or net benefit calculation needs to value quality of life gains in dollar terms (Gold et al., 1996). These gains measure the good health preserved. Ignoring them provides a distorted underestimate of the return on investment that should never be used in allocating resources between competing interventions. For example, suppose the government is deciding whether to mandate bumpers that will withstand higher speed impacts without damage. Those bumpers will reduce vehicle repair costs but will increase injury severity when cars hit pedestrians. To justify the mandate, the analysis must show the repair cost reduction is larger than the quality of life losses as well as the more tangible injury costs.

In our helmet example, we compute the discounted cost-outcome measures from the helmet cost of $25.33 per year for five years ($119/4.717) and the benefits per helmet per year from Table 2. Table 3 shows formulas used to compute the cost-outcome measures and the associated estimates. From a societal perspective, the net cost of a helmet is less than zero. The financial benefits from reduced medical and other resource costs save society more than the helmet costs; the helmet offers a net cost savings. Moreover, from the internal perspective of the helmet user, the cost per QALY gained is only $2,286, and thus only a small fraction of the estimated $127,989 monetary value of a QALY. This figure is inflated to 2010 dollars, and used when valuing quality of life in the crash costs in Table 2.

Table 3

*Cost-Outcome Estimates for Voluntary Motorcycle Helmet Use from Various Perspectives*

| Measure | Benefit-Cost Ratio (Benefits/Costs) | Net Benefit (Benefits – Costs) | Cost per QALY Saved (Costs – Medical Savings – Other Resource Savings) / QALYs Gained |
|---|---|---|---|
| Societal Perspective | $1,315/$25.33 = 51.9 | $1,315-$25.33 = $1,290 | $25.33-$70-$82 is less than $0; net cost savings |
| Internal Perspective | $996/$25.33 = 39.3 | $996 - $25.33 = $971 | ($25.33 - $10)/ 0.0065 = $2,286 |
| With Perceived Risk | $319/$25.33 = 24.1 | $319 - $25.33 = $584 | ($25.33 - .612 * $10) / (0.0065 * .612) = $4,827 |

Society saved money when a motorcyclist rode helmeted. The rider also realized an excellent return on investment in the helmet. Note that on average, people underestimate their risks of crash injuries. Blomquist (1982) estimated that perceived risk is only 61.2% of the actual risk, so motorcyclists will perceive a smaller benefit from wearing a helmet than they actually get. From the last row of Table 3, a benefit-cost ratio of 24 based on perceived risk means that the average rider will perceive that voluntarily wearing a helmet will return more than $24 per dollar invested, while the actual benefit ratio (from the second row of Table 3) is 39.

**Step 10: Conduct a sensitivity analysis**

Every economic evaluation suffers from uncertainty. Cost estimates, effectiveness estimates, and benefit values are imprecise. More importantly, cost-outcome analyses involve assumptions (for example, we choose to use a 3% discount rate) and controversial methods with alternative approaches (for example, the way to value QALYs). Sensitivity analysis deals with uncertainty; it tests whether plausible changes in selected estimates or assumptions affect results of the analysis.

Sometimes cost-effectiveness analysts also use statistical bootstrapping methods to estimate a confidence interval around cost-effectiveness measures (Drummond et al., 2005).

Sensitivity analysis is especially important in analyses assessing proposed public health laws. Effectiveness of legislated interventions varies with enforcement and media coverage; however, effects can decay over time or slowly ramp up. A U.S. law requiring that cars sense when tire inflation was low, for example, yielded no benefits until the Federal government developed implementing regulations, allowed public comment on them, issued them, and allowed auto manufacturers more than a year to implement them. Even when implemented, the auto fleet's safety only improved as vehicles turned over. The turnover rate was affected by the economy, as was the number of miles driven per vehicle-year. When driving intensity changed, the rate of benefit accrual changed too. Finally, changes in medical care and in other safety features (for example, addition of side airbags) reduced the frequency and consequences of the crashes that the sensors were projected to prevent.

In our helmet example, we tested sensitivity of the results to helmet costs. Excluding time spent buying a helmet from the costs raised the benefit-cost ratio from 51.6 to 61.6. Assuming a four-year helmet life lowered the ratio to 41.8.

## Special Issues in Economic Evaluation of Public Health Laws

Economic evaluations of public health laws involve decisions and challenges that rarely arise in economic analyses of health care programs and practices. They include methods to value a variety of subtle intangible costs that a law imposes on people by shaping their behavior directly, costs of passing and implementing a law, costs of adjudication and sanctioning, unanticipated benefits and costs, and mixing of health benefits with employment or educational benefits.

**Intangible Costs**

Laws shape or restrict personal choices. They put the common good above individual desires. Public health laws sometimes impose discomfort and inconvenience. They can reduce mobility, increase travel time, impinge on freedom of choice, or deny access to accustomed pleasures. These largely intangible effects count as societal costs. Some are easier to value than others.

**Inconvenience and Discomfort**. Inconvenience tends to be either extra expense or extra time spent in completing a task. For example, it can be the four seconds spent putting on a safety belt, or the time and money spent on a way to securely store a motorcycle helmet when parking a cycle away from home. The value of time has been widely studied, so these savings can be valued. In particular, around the world, the value of travel time is deemed to be 50%-60% of the wage rate and of unplanned delay time to be 60%-90% of the wage rate (Kruesi, 1997; Waters, 1996). Thus one can value most inconveniences in dollar terms. Seemingly irrational choices to not use safety devices with benefits that exceed the purchase price result from the failure to value discomfort and inconvenience, meaning these intangibles can be valued by analyzing usage decisions.

In terms of our helmet example, many motorcyclists do not wear helmets even though the individual benefits they think they will get from a helmet (based on their perceived risk levels) show a helmet would clearly save them money or quality of life. This seemingly irrational behavior results because the analysis has not priced the intangibles, the costs of discomfort, inconvenience, and loss of freedom associated with helmet use. We estimated values for the intangibles from an existing analysis of usage decisions (Blomquist et al., 1996). They estimate the inconvenience costs of putting on and taking off a helmet each trip equal $48/year (1.3481 hours/year * $22.23/hour in 1991 dollars * 1.601 inflator to 2010 dollars). Blomquist and colleagues developed a formula to combine with survey interview data to support an estimate of the combined value of discomfort and inconvenience costs. With the current 48% probability that a rider wears a helmet in states without helmet laws (National Highway Traffic Safety Administration, 2010), the combined value is $540.

The calculations involved are quite complex. Blomquist's estimate is (willingness to pay of $1,333,000 per death averted * .0002264 lives saved/helmet/year -.05 * $355.18 net benefit from helmet use) * 1.601 inflator to 2010 dollars), where the coefficient -.05 is the probit score that corresponds to a 48% probability). As a check on these costs, our estimates in Table 3 ignored the costs of discomfort and inconvenience associated with a helmet that someone wore voluntarily. A rational rider would not wear a helmet if those costs exceeded the benefits. Since 52% of riders travel unhelmeted in states without helmet laws, the $584 in perceived net benefits of helmet use should closely approximate the median discomfort and inconvenience costs. And indeed, they are reasonably close to our $540 estimate of these costs. Blomquist and colleagues (1996) also provide a way to value the freedom lost when helmet use is mandated. From the helmet use choices of motorcyclists, it estimates they value fatality risk at $1,333,000 per death (in 1991 dollars). It estimates motorists choices about safety belt use suggest a higher value of $2,213,000 per death. If we assume motorcyclists value their lives as highly as anyone else, the difference between these values results from the value motorcyclists place on the discomfort, inconvenience, and loss of freedom when a law mandates helmet use. The annual loss is valued at $915 per person who a law forces to wear a helmet (estimated with the formula above and the higher value of life). Thus, the inconvenience is an estimated $48, the discomfort cost $492 ($540-$48), and the value of lost freedom $375 ($915-$540).

An unresolved issue about these estimates is their duration in that inconvenience costs will persist. Conversely, the discomfort costs are likely to decline over time. Most drivers become so accustomed to a safety belt that they eventually feel uncomfortable driving without its light pressure. Similarly, the discomfort of a motorcycle helmet on a hot day may be offset by the warmth and protection it provides on a cold or breezy day. In the analyses below, we assume that a new user's helmet discomfort costs fall by 25 percentage points per year to a stable level equal to 25% of the initial loss. We treat loss of freedom resulting from a law as a one-time loss due to a legislated change in standing.

**Mobility**. Mobility is much easier to value than inconvenience or discomfort. We could value the miles foregone at the Federal reimbursement rate per mile driven in a personal vehicle inclusive of vehicle maintenance and amortization. In valuing the cost of raising the age for a driver's license, for example, we first could estimate what portion of travel would be foregone and what portion would be provided by older family and friends. We could value transportation by others by assuming average suburban travel speeds and pricing driver time at the average value for household work (Grosse et al., 2009). That approach represents a lower bound. If failing an eye exam at license renewal forces an elderly person to stop driving, the person loses not only mobility but independence. As another example, single trip mobility losses for when an intoxicated person does not drive home are generally priced at the cost of alternative transportation including the trip to retrieve the car.

**Joy of Intoxication**. A particularly difficult, yet important intangible loss is the loss of the joy of intoxication. Alcohol is the only legal intoxicant. Because no similar legal goods exist, forced reductions in alcohol consumption can cause far larger consumer losses than restricting consumer access to goods where close substitutes exist (Jonathan Caulkins, personal communication with Ted Miller, January 15, 2011). Raising alcohol taxes or limiting promotion pricing or volume pricing like happy hours shifts the price of alcohol and shifts the supply curve. Consumers incur virtually the same expense as before but get to consume less alcohol. Economics has relatively straightforward ways to estimate the resulting loss in consumer surplus if one can estimate the shape of the supply and demand curves.

The situation is different if one artificially restricts supply by limiting sales hours, outlet density or alcohol advertising. In that case, consumers buy less alcohol than they want to at the offered price. Unlike interventions that raise prices, these restrictions leave money in consumers' pockets. They spend that money on second-best substitute goods or buy their alcohol at less convenient times and places. To the extent that they buy less alcohol, the loss is the difference in utility of alcohol versus the substitute good. The question then becomes how much of the enjoyment from drinking alcohol cannot be replaced by instead eating an ice cream cone or watching a movie or playing with a puppy. Because alcohol is the only readily available legal intoxicant, we conservatively suggest assuming that the loss is quite high, 50% of the retail price of the alcohol they did not buy (in the U.S., a loss of $0.60 per drink foregone in 2010 dollars). The choice of 50% has political appeal. Half of the retail sales price of a drink equals the profits realized above production costs by producers, wholesalers, and retailers (Miller Brewing Company, 2000). Using this value assures that the cost estimate used for the law accounts for all profits foregone by the alcohol industry. This value is an overestimate of producer and seller losses because it ignores the increased profits of the industries that sell the substitute goods. The 50% estimate probably is high, and thus conservative, from the consumer's perspective as well. If the reduction results from constraints on alcohol outlet density, for example, then the consumer chose to forego the alcohol purchase rather than travel to a less convenient outlet. The value of the alcohol foregone was less than the added travel cost.

**Child Discomfort and Inconvenience**. As parents, we are quite comfortable ignoring child comfort and convenience when regulating child welfare. Unlike restrictions on adult choices, therefore, laws that regulate child behavior tend to be viewed as cost-free protection of those not mature enough to make wise choices. We put health and safety first. For example, almost all bicycle helmet laws and many motorcycle helmet laws only apply to children and youth. In costing a child car safety seat, one would consider shopping time, purchase price, the time spent putting the child into and out of the seat, the safety gained and possibly the greater ease of driving without a child crawling around the car. One would not consider whether the child would be happier if unrestrained, and count that loss in happiness as a cost of the law requiring child restraints.

**Costs of Passage and Implementation**

Analysis of the passage of a law requires choosing a *counterfactual*. The counterfactual is the scenario that is compared with the scenario if the law passes. It may simply be the status quo, but it could be a non-legislative approach to problem reduction. In the latter case, the analysis needs to consider the probability that the law will pass and how long it will take before it becomes effective. Regardless of the counterfactual, the analysis should include passage and implementation costs.

Downing (1981) estimated the costs of passing a law and issuing any required implementing regulations. The estimated costs of approving mandates are 2.9%-7.1% of the first-year direct costs imposed on the public. Variation within this range depends on how many vertical legislative and administrative levels must act on the program, how controversial the program is and how many groups it will adversely affect. These same factors affect probability of passage and delay before the law is enacted and implemented. If one takes a national perspective, the cumulative adoption rate of a model law is likely to resemble an s-shaped or cumulative normal curve (Gray, 1973; Rogers, 1962). Initially a few states will pass the law; then passage will gather speed; finally it will taper off, with some states possibly never passing the law. Discussions with legislators, government legislative liaisons, and lobbyists can yield reasonable estimates of adoption likelihood and timing. Their judgment can be supplemented with data on the delay involved in passing or rejecting other legislation. The best comparison would be a legislative proposal on related subject matter, or roughly equal in scale and controversy, and likely to bring forth the same pro and con coalitions.

Downing (1981) estimated public implementation and administration cost another 4.2%-4.6%. Miller and colleagues (1985) assessed the actual public implementation and administrative costs to mandate high-mounted center rear brake lights on cars to reduce rear-end crashes. They enumerated 15 work tasks and 72 comments to the regulatory docket involved in implementing this $90 million regulation and estimated the cost was $3.7-$4.0 million or 4.1%-4.4%. Expected costs could be substantially higher if the law or regulation were challenged in court (for example, mandatory health insurance). Implementation costs for laws often are available in budget estimates provided to the legislature. When an estimate is not readily available, Downing's percentages offer a convenient and efficient way to estimate passage and implementation costs.

And now, we revisit our helmet example. Recall we estimated the first-year costs of buying and riding in a motorcycle helmet at $940 including $25 in out-of-pocket costs and $915 in intangible costs. The large intangible costs suggest the costs of passing a helmet law will be at the high end of Downing's range; conversely, implementation should be relatively easy and inexpensive. This suggests costs of passage and implementation might be 11% of first-year usage costs or $101. Table 4 shows the total costs of a helmet law from several perspectives including the intangible and public costs and the associated savings.

Table 4

*Costs and Cost-Outcome Estimates per Newly Helmeted Rider for a Motorcycle Helmet Law (in 2010 dollars)*

| Measure | Cost per New User (over 5 years) | Benefit-Cost Estimate | Net Benefit | Cost/QALY Saved |
|---|---|---|---|---|
| Societal Perspective | $2,125 | 2.9 | $4,080 | $46,203 |
| Ignoring Loss of Freedom | $1,750 | 3.5 | $4,455 | $33,879 |
| Internal Perspective | $2,024 | 2.3 | $2,676 | $64,946 |
| Based on Perceived Risk | $2,024 | 1.4 | $853 | $107,075 |
| External Perspective | $101 | 14.9 | $1,404 | Net Saving |
| Government Perspective | $101 | 2.4 | $140 | $2,480 |

Table 4 shows that the motorcycle law is quite appealing from the perspective of government and of those who do not ride motorcycles. It costs them relatively little (just $101 per new helmet user) and allows them to escape paying large bills associated with motorcyclist brain injuries (benefit-cost ratios of 2.4 and 14.9). From the viewpoint of the motorcyclists who the law forces to wear helmets, the law is at best marginally beneficial with a benefit-cost ratio of 1.4 based on the injury risk levels that motorcyclists perceive and a cost per QALY gained of more than $100,000. Given these figures, it is not surprising that many states have repealed their helmet laws despite the life-saving benefits and taxpayer savings that these laws offer.

**Enforcement and Sanctioning Costs**

A public health law's cost and effectiveness also are functions of enforcement and publicity. Those efforts tend to be fairly level across laws, except possibly for laws passed in response to Federal incentives. Perhaps as a result, laws requiring use of safety devices – child seats, seat belts, helmets –

fairly predictably increase use by 30-40 percentage points (Blomquist et al., 1996; National Highway Traffic Safety Administration, 2010).

A further issue in analyses of safety device mandates is the possibility of misuse. Civil disobedience and legal loopholes, for example, led to motorcycle helmets worn on knees. Discomfort leads some people to put the shoulder harness behind them or hold it away from their body. Misuse also can be unintentional. For example, child safety seats often are installed incorrectly; a decade of misuse campaigns and misuse-oriented seat design improvements resulted in a rise from 52% to 82% effectiveness in rear seating positions (Zaloshnja & Miller, 2007). The effectiveness estimates underlying the analysis may need to be reduced to account for misuse.

With Trumbull's rules on standing, gains from the illegal acts foregone because of enforcement unequivocally are not costs to wrongdoers. Many criminologists view the purpose of incarceration and probation as prevention, not punishment. Both fear of sanctioning and supervision of past offenders deter crime. Even if sanctioning costs borne by the government are costs of prevention rather than costs of a specific criminal incident, they count in the cost-outcome analysis. But what about sanctioning costs borne by criminals? Does the criminal's lack of standing mean that if a fine covers court costs or the drunk driver pays for the ignition interlock on his car, these payments are not costs to society? If so, they should be omitted from the cost-outcome analysis. We agree with Cohen (1998, 2000) that these costs are societal costs. Productivity would increase if government did not have to process citations and levy fines.

Whether to count the wage losses that a criminal experiences while incarcerated is less clear. Cohen counts them as costs of crime, but we suspect he errs. Because the economy rarely is at full employment, the criminal will be replaced by another worker. While the criminal's family has less income, the family of the replacement has more. The criminal's employer will experience some costs in the process, primarily costs related to hiring and training a replacement worker. Gramlich's

(1981) classic work on the return on investment in government programs suggests employer costs will ripple, with a series of people getting better jobs and a low-skilled person ultimately escaping unemployment. Friction costs value the employer costs and typically are around 30% of the associated wage loss (Berger et al., 2001; Koopmanschapp et al., 1995; Lofland et al., 2004). Because friction costs are difficult to estimate, a simpler second-best approach is to estimate the costs of hiring someone to replace the criminal.

**Unexpected Costs and Benefits**

Laws can have unforeseen or unevaluated consequences. Economists call these *spillover costs and benefits*. For example, bicycling dropped in Australia following implementation of a helmet law (Robinson, 2006). In several places, mandatory motorcycle helmet laws reduced motorcycle theft; thieves who wanted to joy-ride rarely had a helmet handy and were likely to be apprehended if they rode without one (Insurance Institute for Highway Safety, 2011). At a minimum, limitations sections of economic analyses need to consider these spillover costs and benefits. Highway safety laws are especially prone to have unevaluated spillover effects. Does reducing the maximum legal driver blood alcohol content to 0.08 or 0.05, for example, shift drinking locations, in the process reducing barroom brawls but increasing domestic violence? Voas and Kelley-Baker (2008) describe a broad range of unevaluated benefits that might result from the youth driving curfews in graduated licensing laws, such as reduced drinking, drug use, risky sex, and violence.

**Non-health Benefits of Public Health Laws**

Recall that the denominator used in computing net cost per QALY gained subtracts those financial benefits that can be valued in dollars from the intervention costs. The literature makes one important exception (Gold et al., 1996). Medical treatment and preventive health services result in improved physical and mental health that allows people to work more and earn more. The QALY gain values their improvements not only in physical and mental functioning but in role functioning, in ability to work, play, and socialize. That means the health-related wage gains resulting from a public health law are included in the QALY gain; they are not separate benefits. They should not be subtracted from the intervention costs when computing cost per QALY gained. Subtracting them would double count the QALY gain (Gold et al., 1996).

Not all wage gains resulting from public health programs, however, are health-related. Unlike medical treatment, "social policies often have effects that spill over from one domain to another, such as education and health investments that affect human capital and work effort" (Vining & Weimer, 2010, p.4). For example, school financial assistance to orphans in Zimbabwe is designed to reduce early marriage and associated HIV transmission, but it also increases schooling and raises lifetime incomes (Hallfors et al., 2011). Similarly, the Nurse Family Partnership intensive home visitation program to low-income mothers bearing their first child is designed primarily to improve child health outcomes (Olds, 2006). The program also provides job counseling that may increase maternal employment and earnings levels. Basing cost-effectiveness on QALYs includes the health-related earnings gains, but does not include the wage gains from improved education or employment coaching. The handful of cost-effectiveness articles that have dealt with wage gains like this appropriately treat these benefits as gains over and above the QALY gains (Cheng et al., 2000; Frick et al., 2004; Miller et al., 2011). In computing cost per QALY saved, these wage gains should be treated as benefits that are subtracted from the intervention costs.

## Comparing Cost-Outcome Estimates

In evaluating public health laws from an economic perspective, a comparison of benefit-cost ratios or incremental cost-effectiveness per QALY gained is a valuable aid in deciding which options represent optimum value for money invested (Miller & Hendrie, 2011). A table of comparable cost-outcome estimates is called a *league table*. Its side-by-side comparisons of economic evaluation results are most useful if the cost-effectiveness analyses have been undertaken specifically to facilitate between-treatment comparisons using standardized methods or if results of economic evaluations of treatments have been adjusted and standardized to make comparisons meaningful. This is not YPERLINK \l "_ENREF_31" \o "Koopmanschapp, 1995 #516" ¶ Koopmanschapp et al., 1995⊥ ; ‼ HYPERLINK \l "_ENREF_35" \o "Lofland, 2004 #517" ¶ Lofland et al., 2004⊥ )⊥ . Because friction costs are difficult to efectiveness ratios in a league table non-comparable. A notable exception is a league table maintained for injury and substance abuse (Miller & Hendrie, 2009). Their tables currently include more than 160 interventions with estimates of cost per QALY saved and benefit-cost ratios computed at a 3% discount rate with consistently computed costs for injury, illness, and other societal ills. A notable feature of these tables is the assumption that replications of demonstration programs and randomized trials will achieve 25% less effectiveness than the original programs. Table 5 is a league table of estimates for public health legislation and enforcement. All the values in this table were drawn from Miller and Hendrie (2009, 2011) or were computed for this monograph using their benefit estimates. Many of the estimates were developed using Downing's (1981) factors to cost law passage and implementation. Because intangible costs figure prominently in the estimates for laws governing adult behavior, we show them explicitly. In the table, <$0 means that the financial benefits from reduced medical and other resource costs exceed the costs of the intervention; the intervention yields a net cost savings.

Table 5

*League Table of Costs, Savings, Benefit-Cost Ratio and Cost per QALY Gained for Public Health Laws, Enforcement, and Sanctioning (in 2010 dollars)*

| | Cost | Unit Studied | Medical | Other Resource | Work | Quality of Life | Total | Benefit-Cost Ratio | Cost per QALY |
|---|---|---|---|---|---|---|---|---|---|
| **Substance Use/Abuse Interventions** | | | | | | | | | |
| 20% Alcohol Tax | $11 | drinker/year | $5 | $8 | $28 | $63 | $104 | 9.5 | <$0 |
| 30% Alcohol Tax | $22 | drinker/year | $6 | $11 | $36 | $83 | $136 | 6.2 | $8,213 |
| 21 Minimum Legal Drinking Age | $207 | youth 18-20 | $45 | $83 | $150 | $457 | $734 | 3.5 | $22,256 |
| Mandatory Server Training | $59 | driver | $12 | $22 | $46 | $119 | $199 | 3.4 | $27,540 |
| Enforce Serving Intoxicated Patron Law | $0 | driver | $3 | $4 | $8 | $17 | $31 | 68.8 | <$0 |
| TV Alcohol Advertising Ban | $6,253 | M population | $5,316 | $3,196 | $13,975 | $34,719 | $57,205 | 9.1 | <$0 |
| 10% Outlet Density Reduction | $1,607 | M population | $1,329 | $799 | $3,494 | $8,680 | $14,301 | 8.9 | <$0 |
| 10 Fewer Sales Hours/Week | $3,933 | M population | $3,322 | $1,997 | $8,734 | $21,699 | $35,753 | 9.1 | <$0 |
| Retain State Stores as Sole Sellers of Beer & Wine in PA | $0.46 | drink not consumed | $0.52 | $0.31 | $1.37 | $3.39 | $5.59 | 12.1 | <$0 |
| Workplace Peer Support + Drug Testing[1] | $77 | employee | | | | | $1,824 | 23.7 | <$0 |
| Add Alcohol Testing to Peer Support[1] | $13 | employee | | | | | $786 | 60.5 | <$0 |
| **Crime Adjudication and Sanctioning** | | | | | | | | | |
| **Youth Offender Programs** | | | | | | | | | |
| Sentence Youth to Multi-Systemic Therapy | $6,684 | client | $6,809 | $0 | $136,065 | $115,938 | $258,812 | 38.7 | <$0 |
| Sentence Youth to Functional Family Therapy | $3,045 | client | $2,535 | $0 | $50,663 | $43,169 | $96,367 | 31.6 | <$0 |
| Lansing Adolescent Diversion | $2,223 | client | $2,011 | $0 | $47,041 | $37,923 | $86,975 | 39.1 | <$0 |
| Intensive Probation Supervision, Youth | $2,211 | client | $263 | $0 | $5,066 | $4,473 | $9,802 | 4.4 | <$0 |
| Young Offender Boot Camp | $2,891 | client | -$837 | $0 | -$16,735 | -$14,260 | -$31,833 | -11.0 | Infinite |
| **Adult Offender Programs** | | | | | | | | | |
| Drug Courts | $2,947 | client | $271 | $0 | $7,041 | $4,716 | $12,029 | 4.1 | <$0 |
| Optimized Sentencing of Drug Dealers | $16,920 | client | $1,412 | $0 | $5,751 | $29,699 | $36,863 | 2.2 | $63,498 |
| 3 Strikes & You're Out Sentencing | $22,806 | client | $1,412 | $0 | $5,751 | $29,699 | $36,863 | 1.6 | $88,376 |
| Sentence Adults to Moral Reconation Therapy | $421 | client | $374 | $0 | $6,187 | $6,322 | $12,882 | 30.6 | <$0 |
| Sentence Adults to Reasoning & Rehabilitation | $436 | client | $106 | $0 | $2,200 | $1,783 | $4,089 | 9.4 | <$0 |
| Intensive Probation Supervision, Adult | $4,925 | client | $166 | $0 | $3,791 | $2,714 | $6,671 | 1.4 | $47,904 |

| | Cost | Unit Studied | Medical | Other Resource | Work | Quality of Life | Total | Benefit-Cost Ratio | Cost per QALY |
|---|---|---|---|---|---|---|---|---|---|
| **Driving Laws, Enforcement & Sanctions** | | | | | | | | | |
| .08% Driver Blood Alcohol Limit | $4 | driver | $3 | $6 | $13 | $33 | $55 | 13.8 | <$0 |
| Zero Alcohol Tolerance, Drivers Under 21 | $39 | driver | $63 | $98 | $207 | $601 | $969 | 24.8 | <$0 |
| Sobriety Checkpoints | $12,309 | checkpoint | $5,555 | $7,033 | $14,899 | $55,700 | $83,187 | 6.8 | <$0 |
| Administrative License Revocation (ALR) | $3,604 | ALR | $3,861 | $5,173 | $10,958 | $40,748 | $60,740 | 16.9 | <$0 |
| ALR with Per Se Law | $3,384 | ALR | $4,615 | $6,141 | $13,010 | $48,471 | $72,237 | 21.3 | <$0 |
| Alcohol-Testing Ignition Interlock | $1,200 | Interlock | $309 | $596 | $1,213 | $4,879 | $6,997 | 5.8 | $7,753 |
| DWI Offender Auto Impoundment | $1,027 | impoundment | $423 | $613 | $1,248 | $3,296 | $5,579 | 5.4 | <$0 |
| DWI Offender Electronic House Arrest | $1,797 | house arrest | $251 | $3,026 | $763 | $2,017 | $6,058 | 3.4 | <$0 |
| DWI Intensive Probation + Treatment | $1,612 | probation | $496 | $1,322 | $1,181 | $3,122 | $6,121 | 3.8 | <$0 |
| Provisional Licensing + Midnight Driving Curfew | $86 | driver | $45 | $112 | $129 | $398 | $683 | 7.9 | <$0 |
| Change Driving Curfew to 10 PM | $164 | driver | $26 | $67 | $78 | $239 | $410 | 2.5 | $37,765 |
| **Occupant Protection Laws** | | | | | | | | | |
| Pass Child Safety Seat Law, Ages 0-4 | $59 | new user | $161 | $152 | $390 | $1,547 | $2,250 | 38.1 | <$0 |
| Pass Booster Seat Law, Ages 4-7 | $40 | new user | $368 | $225 | $579 | $1,375 | $2,548 | 63.7 | <$0 |
| Pass Safety Belt Law | $351 | new user | $296 | $530 | $1,363 | $4,010 | $6,199 | 17.7 | <$0 |
| Upgrade Secondary Belt Law to Primary | $351 | new user | $296 | $530 | $1,363 | $4,010 | $6,199 | 17.7 | <$0 |
| Enhanced Belt Law Enforcement | $363 | new user | $296 | $530 | $1,363 | $4,010 | $6,199 | 17.1 | <$0 |
| Require Driver Airbag | $437 | vehicle | $142 | $162 | $416 | $1,220 | $1,940 | 4.4 | $13,925 |
| Require Passenger Airbag | $226 | vehicle | $38 | $38 | $97 | $285 | $459 | 2.0 | $67,307 |
| Pass Motorcycle Helmet Law | $2,125 | new user | $257 | $311 | $1,301 | $3,229 | $5,098 | 2.9 | $46,203 |
| Pass Bicycle Helmet Law, Ages 3-14 | $14 | new user | $61 | $59 | $152 | $318 | $591 | 42.2 | <$0 |
| Pass Bicycle Helmet Law, Ages 15 & Over | $112 | new user | $37 | $24 | $62 | $164 | $287 | 2.6 | $39,854 |
| **Fire Prevention/Harm Reduction** | | | | | | | | | |
| Childproof Cigarette Lighter Mandate | $0.05 | lighter | $0.41 | $0.54 | $0.81 | $1.84 | $3.61 | 78.1 | <$0 |
| Less Porous Cigarette Paper Mandate | $0.00014 | pack | $0.006 | $0.003 | $0.005 | $0.062 | $0.076 | 559.2 | <$0 |
| Pass Smoke Alarm Law | $49 | new user | $10 | $40 | $111 | $670 | $827 | 17.0 | <$0 |
| Require Sprinkler System, New Colonial House | $2,502 | new home | $80 | $373 | $755 | $4,539 | $5,747 | 2.3 | $57,770 |
| Require Sprinkler System, New Townhouse | $2,285 | new home | $80 | $373 | $755 | $4,539 | $5,747 | 2.5 | $51,650 |
| Require Sprinkler System, New Ranch House | $999 | new home | $80 | $373 | $755 | $4,539 | $5,747 | 5.8 | $15,385 |
| Mattress Flammability Standard | $27 | mattress | $0.67 | $2.82 | $10 | $61 | $75 | 2.8 | $49,146 |
| **Other** | | | | | | | | | |
| Tetanus-Diphtheria-Pertussis Vaccination, Ages 0-6 | $93 | child | $498 | $0 | $1,817 | $0 | $2,315 | 24.9 | <$0 |
| Baby Walker Redesign Mandate to Prevent Stairway Falls | $4 | walker | $17 | $1 | $17 | $154 | $190 | 47.5 | <$0 |
| Impact-Absorbing Playground Surfacing | $14,588 | playground | $3,442 | $5,603 | $100 | $19,847 | $28,992 | 2.0 | $35,750 |

*Source:* Miller & Hendrie, 2009; Miller & Hendrie, in press. All estimates were computed at the same discount rate and with comparably estimated benefit values.

<$0 means that the financial benefits from reduced medical and other resource costs exceed the costs of the intervention. The intervention yields a net cost saving.

[1]Benefits and costs to the employer rather than to society.

## Complexity in Communicating Economic Evaluation Results

It is essential to make sure champions of a proposed law understand which savings they can spend and which costs they must fund. Intangible costs tend to dominate the costs of many laws. While information about those costs provides insight into political acceptability, they are not out-of-pocket costs. It seems important to explicitly differentiate them from the tangible costs of the law. That avoids misleading the policy debate. Similarly, only financial benefits represent immediate out-of-pocket savings in resource costs. The rhetoric of the debate needs to avoid the impression that reduced work and quality of life losses will result in immediate economic gains.

Although economic analysis can help guide decisions about public health laws, these laws rarely are economic panaceas. Other than sin taxes that generate revenue, public health laws are unlikely to ease a budget crisis in the short run. Government, especially state government, pays only a small fraction of the health and safety bill.

Table 6 shows our estimates of the societal benefit-cost ratio (with costs restricted to government investments) required for the U.S. Federal government and state governments to recover their costs. Governments rarely will save much money by passing road safety laws (Miller et al., 2011) or laws that reduce tobacco use. They will save more on interventions that prevent crime, reducing adjudication and sanctioning costs (which all directly accrue to the government). The return also will be greater for programs targeted to specific populations such as Medicaid recipients, because government garners virtually all of the medical care savings and may save on other related safety net payments.

Table 6

*Minimum Societal Ratio of Benefits to Government Costs Required for Government to Break Even on a Public Health Law or Program, by Public Health Problem Addressed and Level of Government*

| Problem Addressed | Government | Federal | State/Local | Source |
|---|---|---|---|---|
| Violent Crime | 5.9 | 39 | 6.9 | Miller et al., 1996 |
| Property Crime | 1.4 | 14 | 1.5 | Miller et al., 1996 |
| Road Crash | 15.1 | 26.7 | 34.5 | Miller et al., 2011 |
| Alcohol Abuse | 12.7 | 34.9 | 20.0 | Miller & Hendrie, 2009 |
| Underage Drinking | 12.7 | 36.9 | 21.0 | Miller & Hendrie, 2009 |
| Drug Abuse | 5.8 | 31.5 | 7.0 | Miller & Hendrie, 2009 |
| Smoking | 5.6 | 7.2 | 25.9 | Guilfoyle, 2011 |

*Note:* Computed from societal cost estimates or payer matrices in the sources shown. The cited estimates of costs of smoking to government excluded foregone taxes, which we computed from the societal wage loss and Census Bureau data on the percentage of earnings paid as taxes.

The job of the state is to protect and enhance the welfare of its citizens. Government invests in medical treatment of illness to save lives and improve quality of life. Like medical care, preventive health and safety efforts are designed to save lives and increase quality of life. Public health laws and prevention programs save life-years and quality of life at a small cost to government compared to most medical treatments. They should not be held to a higher standard of cost-effectiveness.

## Conclusion

The role of economic evaluation is to assess costs and benefits of alternative options for meeting an objective. In many fields, this involves a relatively straightforward exercise of comparing the costs of alternative options and their benefits measured using an appropriate outcome measure. Steps involved in a typical economic evaluation were outlined in the first section of this monograph, which presented an example of an economic evaluation of voluntary use of a motorcycle helmet. As the subsequent sections illustrated, evaluating costs and benefits of public health laws is more complex than evaluation of personal or infrastructure decisions, with additional issues to be considered. Several factors contribute to the added complications of conducting economic evaluation of public health laws. These include the trade-offs involved between protecting individual freedom and serving the common good, uncertainty in the magnitude of several of the parameters included in analyses, and spillover costs and benefits of public health regulation.

Despite complexities, careful economic evaluation of public health laws has an important role to play in informing policy decisions, by providing more accurate, explicit and transparent estimates of costs and benefits of regulatory alternatives. While decisions regarding legal measures to safeguard the health of populations are inherently political—not just technical questions weighing up costs and benefits—economic evaluation of public health laws quantifies many of the trade-offs involved in safeguarding the health of the public. Economic evaluations also guide closely related decisions regarding implementing regulations, enforcement strategies and appropriate sanctions.

## List of Figures and Tables

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