
Methods for Conducting Systematic Reviews of the Evidence of Effectiveness and Economic Efficiency of Interventions to Reduce Injuries to Motor Vehicle Occupants

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Background: Motor vehicle occupant injury prevention is included in the *Guide to Community Preventive Services* because of the enormous health impact of these largely preventable injuries. This article describes the methods for conducting systematic literature reviews of interventions for three key injury prevention strategies: increasing child safety seat use, increasing safety belt use, and decreasing alcohol-impaired driving.

Methods: Systematic review methods follow those established for the *Guide to Community Preventive Services* and include: (1) recruiting a systematic review development team, (2) developing a conceptual approach for selecting interventions and for selecting outcomes that define the success of the interventions, (3) defining and conducting a search for evidence of effectiveness, (4) evaluating and summarizing the body of evidence of effectiveness, (5) evaluating other potential beneficial and harmful effects of the interventions, (6) evaluating economic efficiency, (7) identifying implementation barriers, (8) translating the strength of the evidence into recommendations, and (9) identifying and summarizing research gaps.

Results: The systematic review development team evaluated 13 interventions for the three strategic areas. More than 10,000 titles and abstracts were identified and screened; of these, 277 met the a priori systematic review inclusion criteria. Systematic review findings for each of the 13 interventions are provided in the accompanying articles in this supplement.

Conclusion: The general methods established for conducting systematic reviews for the *Guide to Community Preventive Services* were successfully applied to interventions to reduce injuries to motor vehicle occupants.

Medical Subject Headings (MeSH): accidents, traffic; alcohol drinking; motor vehicles; wounds and injuries; seat belts; community health services; decision making; evidence-based medicine; economics; preventive health services; public health practice (Am J Prev Med 2001;21(4S):23–30)

Introduction

The U.S. Task Force on Community Preventive Services (the Task Force) chose the topic “motor vehicle occupant injury prevention” for inclusion in the *Guide to Community Preventive Services* (the *Community*

Guide) because of the enormous health impact of motor vehicle occupant injuries. In addition, motor vehicle occupant injuries are largely preventable. The Task Force sought evidence of the effectiveness of interventions to prevent these injuries by using systematic review methods.

The *Community Guide*'s methods for conducting systematic reviews and for linking evidence to recommendations have been described elsewhere.^{1,2} In brief, for each *Community Guide* topic, a diverse team representing a range of disciplines, backgrounds, experiences, and work settings conducts a review by:

- developing a conceptual framework for organizing, grouping, and selecting the interventions for the health issues under consideration and for choosing the outcomes used to define success for each intervention;

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- systematically searching for and retrieving evidence;
- assessing the quality of and summarizing the strength of the body of evidence of effectiveness;
- summarizing information about other evidence; and
- identifying and summarizing research gaps.

This report describes the specific methods used in the systematic literature reviews to determine the effectiveness of interventions to reduce motor vehicle occupant injuries.

Systematic Review Development Team

Three groups of individuals served on the systematic review development team:

- The coordination team—consisting of a Task Force member, methodologic experts in systematic reviews and economics from the Community Guide Branch (Epidemiology Program Office, Centers for Disease Control and Prevention [CDC]), and motor vehicle crash injury experts from the National Center for Injury Prevention and Control (CDC) and the National Highway Traffic Safety Administration (NHTSA)—drafted the conceptual framework for the reviews, managed the data collection and review process, and drafted evidence tables, summaries of the evidence, and the reports.
- The consultation team reviewed and commented on materials developed by the coordination team and set priorities for the reviews. The consultants are motor vehicle injury experts in state and local public health settings, academic organizations, federal agencies, and voluntary organizations. These experts have backgrounds in medicine, public health, economics, health promotion intervention design and implementation, health education, health policy, and epidemiology.
- The abstraction team collected and recorded data from studies for possible inclusion in the systematic reviews. (See Evaluating and Summarizing the Studies, below.) This team included some members of the coordination and consultation teams as well as graduate students and preventive medicine residents.

Unless otherwise noted, in this report and in the articles presenting the results of the reviews^{3–5} the term “team” refers to the coordination and consultation teams only, because the abstraction team’s role was limited to collecting and recording data.

Conceptual Approach

When developing the systematic reviews, the team first created a conceptual framework that included the following elements:

- A graphic illustration of the problem of motor vehicle occupant injuries and the modifiable determi-

- nants of those injuries. In these reports, we refer to this illustration as the logic framework (Figure 1);
- A list of candidate interventions to reduce motor vehicle occupant injuries (Table 1);
- The criteria used to select interventions for review;
- The final list of interventions evaluated; and
- The outcomes for which evidence was to be sought and those that were to be used to define success and result in recommendations.

Logic Framework

To develop the logic framework, the team first illustrated the following pathway by which motor vehicle occupants are injured in crashes:

- People have access to and use vehicles;
- Some are involved in a crash;
- Energy is transferred from the vehicle to its occupants; and
- Injuries may occur if the energy transferred is greater than the physiologic and anatomic capacity of the occupants.

The team then added the modifiable determinants of those injuries on which interventions act. These determinants affect the pathway and each other by the following complex and interrelated mechanisms:

- characteristics of populations (e.g., driving behaviors or specific risk factors such as age);
- characteristics of public health, health care, or legislative systems (including enforcement);
- physical environment factors (e.g., roadways); and
- vehicle factors (e.g., presence of air bags).

Candidate Interventions

Using the logic framework, the team generated a list of candidate interventions for inclusion (Table 1). They listed interventions addressing each of the modifiable determinants (i.e., population factors, systems, physical environment, and vehicles). These interventions were grouped into strategies according to similar behaviors or risk factors. The logic framework and list of candidate interventions were based, in part, on Haddon’s matrix.⁶

Criteria for Selecting Interventions for Review

In these reviews, the team decided to exclude strategies that focus on changing motor vehicles themselves or other aspects of the physical environment. This decision was made because the resources for implementing such interventions might not be readily available to the primarily public health-oriented audience of the *Community Guide*. The team ranked the remaining strategies on the basis of the likelihood that the included inter-

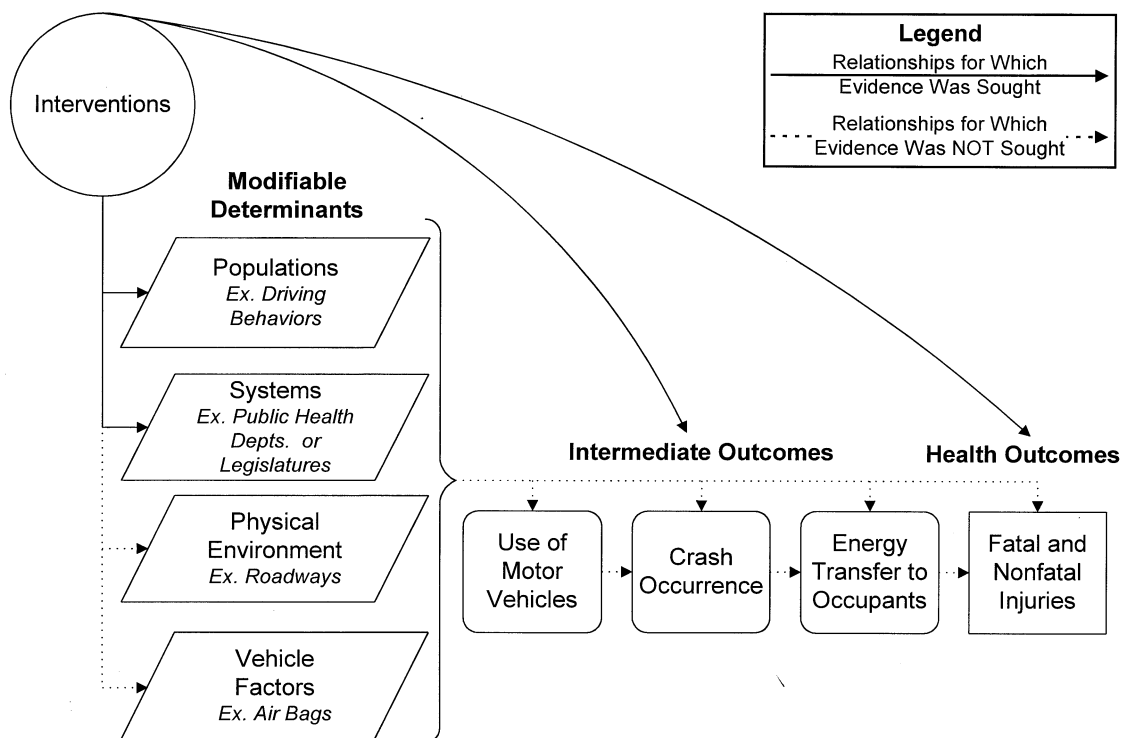


Figure 1. Logic framework illustrating the links among interventions, modifiable determinants of motor vehicle crash injuries, and intermediate and health outcomes.

ventions could reduce the injury burden. On the basis of the team's recommendations, the Task Force selected for review three strategies: to promote use of child safety seats, to promote use of safety belts, and to deter alcohol-impaired driving. These strategies were chosen because (1) use of child safety seats and use of safety belts are below national goals⁷; (2) 38% of traffic deaths involve alcohol⁸; and (3) not using child safety seats, not using safety belts, and alcohol-impaired driving are among the most important contributors to motor vehicle occupant injuries.

Within each of these three strategies, the development team generated a comprehensive list of interventions. From this list, they created a priority list of interventions for review after polling consultants and other experts about their perception of the importance and practicality of the various interventions. Interventions reviewed were either single component (i.e., using only one activity to achieve desired outcomes) or multicomponent (i.e., using more than one related activity). The specific interventions chosen for review are described in each of the accompanying evidence review articles.³⁻⁵

Analytic Frameworks

An analytic framework was designed for each of the interventions in the three strategies chosen for review to illustrate the key health and other outcomes that

might result from the intervention (and on which the literature search was to concentrate), the potential effect measures for each of those outcomes, and the likely target populations and settings for the intervention. These analytic frameworks helped to define the study questions of interest for the intervention, the key terms to be used in searching for evidence, and the criteria for studies to be included in the evidence base for the intervention.

Specific outcome and effect measures used for determining effectiveness are described in each of the accompanying evidence review articles.³⁻⁵ For all three strategies, the outcomes that were chosen to indicate effectiveness included reductions in injury rates (both fatal and nonfatal) and improvements in behavioral outcomes (i.e., use of child safety seats, use of safety belts, and alcohol-impaired driving). Improvements in behavioral outcomes were deemed acceptable by the team because of the following reasons:

- Child safety seats are 55% to 70% effective in preventing deaths⁹;
- Safety belts are 45% to 60% effective in preventing deaths and 50% to 65% effective in reducing moderate-to-critical injury¹⁰; and
- The risk of involvement in a single-vehicle fatal crash nearly doubles with each 0.02 g/dL increase in blood alcohol concentration (e.g., from 0.08% to 0.10%).¹¹

Table 1. List of candidate interventions to reduce motor vehicle occupant injuries

Population Interventions			
<p><u>Alcohol-specific education</u></p> <ul style="list-style-type: none"> • Police department campaigns (e.g., putting a wrecked vehicle in front of a school) • Prom night campaigns/drug-free pledges • Designated driver programs 	<p><u>Restraint use interventions</u></p> <ul style="list-style-type: none"> • Child–restraint device distribution programs • Prenatal counseling or education programs (e.g., in birthing or breastfeeding classes) • Mass-media campaigns 	<p><u>Interventions aimed at teenaged drivers</u></p> <ul style="list-style-type: none"> • Education for risk recognition • Education for risk reduction • Graduated licensing • Older minimum driving age • Organized competitions for rational driving skills • Curfews • Required drivers' education for licensing 	<p><u>Interventions aimed at elderly drivers</u></p> <ul style="list-style-type: none"> • Recognition of risk of failing eyesight with education to decrease nighttime driving and speed • Yearly license renewal with eye exam and driving test <p><u>Speed control interventions</u></p> <ul style="list-style-type: none"> • Individual feedback for speed reduction • Speed reduction education campaigns
System Interventions			
<p><u>Alcohol-specific regulation</u></p> <ul style="list-style-type: none"> • License revocation after DUI • Sobriety checkpoints • Sales restrictions • Mandatory treatment for DUI • Lower blood alcohol limit • Targeted, highly visible enforcement • Brief interventions for alcohol use in trauma centers • Increase BAC testing in trauma centers • Tow-away of vehicles for convicted DUI offenders 	<p><u>Restraint use regulation</u></p> <ul style="list-style-type: none"> • Mandatory seat belt laws • Mandatory child restraint laws • Mandatory prenatal class education • Targeted, highly visible enforcement 	<p><u>Community mobilization/social marketing to lobby and gain acceptance for any other intervention</u></p> <p><u>Speed control interventions</u></p> <ul style="list-style-type: none"> • Speed limits • Video camera surveillance and ticketing 	<p><u>EMS, trauma, and hospital</u></p> <ul style="list-style-type: none"> • Reduce response and transport times • Enforcement of laws requiring yield to emergency vehicles • Increase EMS training levels • Increase funding for EMS and trauma at the local level • Community volunteerism for Bystander Care programs through local EMS providers (e.g., first aid)
Physical Environment Interventions		Vehicle Factor Interventions	
<p><u>Increase availability and acceptability of public transportation</u></p> <ul style="list-style-type: none"> • Free or reduced evening fares • Increase the number of facilities • Ensure safety at facilities 	<p><u>Roadway modifications</u></p> <ul style="list-style-type: none"> • Removal of immobile objects from roadsides • Speed bumps • Traffic circles 	<p><u>Vehicle modifications</u></p> <ul style="list-style-type: none"> • Built-in restraints • Ignition interlock • Raised brake lights • Antilock brakes • Air bags • Passive restraints • Side impact protection 	

BAC, blood alcohol concentration; DUI, driving under the influence; EMS, emergency medical services

Search Strategy

The reviews of interventions to reduce motor vehicle occupant injury reflect systematic searches of multiple databases as well as reviews of reference lists and consultations with experts in the field. Specific search strategies and inclusion criteria are provided in each of the accompanying evidence review articles.^{3–5} The team searched six computerized databases (MEDLINE, Embase, Psyclit, Sociological Abstracts, EI Compendex, and Transportation Research Information Services [TRIS]), which yielded 10,958 titles and abstracts for screening. Studies were eligible for inclusion if:

- they were published from the originating date of the database through June 2000 (March 1998 for child safety seat interventions);
- they involved primary studies, not guidelines or reviews;
- they were published in English;

- they were relevant to the interventions selected for review;
- the evaluation included a comparison to an unexposed or less-exposed population; and
- the evaluation measured outcomes defined by the analytic framework for the intervention.

After screening titles and abstracts, 3653 papers were collected for further screening and 277 of these papers ultimately met the inclusion criteria.

Individual studies were grouped together on the basis of the similarity of the interventions being evaluated and were analyzed as a group. Some studies provided evidence for more than one intervention. In those cases, the studies were reviewed for each applicable intervention. Interventions and outcome measures were classified according to definitions developed as part of the review process. The classification and nomenclature used in the systematic reviews sometimes differs from that used in the original studies.

Evaluating and Summarizing the Studies

Each study that met the inclusion criteria was evaluated by using a standardized abstraction form (available at www.thecommunityguide.org) and was assessed for suitability of the study design and threats to validity.¹ On the basis of the number of threats to validity, studies were characterized as having good, fair, or limited execution.^{1,12} Studies with limited execution were not included in the summary of the effect of the intervention. The remaining studies (i.e., those with good or fair execution) were considered “qualifying studies.” Estimates of effectiveness are based on those studies.

For studies that reported multiple measures of a given outcome, consistently applied rules were used to select the “best” measure with respect to validity and precision. Measures that were adjusted for the effects of potential confounders were used in preference to crude effect measures. For studies with concurrent comparison groups, net effects were derived when possible by calculating the difference between the changes observed in the intervention and comparison groups. A median was calculated as a summary effect measure for each outcome of interest. For reporting bodies of evidence consisting of seven or more studies, an interquartile range is presented as an index of variability; otherwise a simple range is reported.

Bodies of evidence of effectiveness were characterized as strong, sufficient, or insufficient on the basis of the number of available studies, the suitability of study designs for evaluating effectiveness, the quality of execution of the studies, the consistency of the results, and the effect size.¹

Other Effects

The *Community Guide* systematic reviews of interventions to reduce motor vehicle occupant injury routinely sought information on other effects (i.e., positive and negative health or nonhealth “side effects”). Evidence of potential harms of these interventions was sought if they were mentioned in the effectiveness literature or if the team thought they were important. For example, in the reviews of child safety seat interventions, the team specifically sought information about the effect of the interventions reviewed on the incorrect use of the devices. Likewise, for reviews of legislative interventions to increase safety belt use, the team sought information about compensating behaviors that might increase risk and thereby negate the protective effects of the intervention (e.g., speeding, following distance). And, in interventions to reduce alcohol-impaired driving, the team sought information about potential infringement on civil rights.

Evaluating Economic Efficiency

For all interventions that are recommended or strongly recommended by the Task Force, the team conducted systematic reviews of the evidence of economic efficiency (see Appendix).^{1,2} These reviews are provided to help decision makers choose among recommended interventions.

The general methods for conducting systematic reviews of economic efficiency have been previously reported² and are summarized here as they were adapted for the review of interventions to prevent motor vehicle occupant injury. The four basic steps are the following:

- searching for and retrieving evidence,
- abstracting and adjusting the economic data,
- assessing the quality of the identified economic evidence, and
- summarizing and interpreting the evidence of economic efficiency.

Searching for and Retrieving Economic Evidence

The databases MEDLINE, TRIS, CHID, NTIS, Embase, EI Compendex, PsycINFO, Social Science Search, Sociological Abstracts, ECONLIT, and Dissertation Abstracts were searched for the period 1970–1998. In addition, the references listed in all retrieved articles were reviewed and experts were consulted. Most of the included studies were either government reports or were published in journals. To be included in the review a study had to:

- be a primary study rather than, for example, a guideline or review;
- take place in an Established Market Economy^a;
- be written in English;
- meet the team’s definitions of the recommended and strongly recommended interventions;
- use economic analytical methods such as cost analysis, cost–effectiveness analysis, cost–utility, or cost–benefit analysis (see Appendix); and
- itemize program costs and costs of illness or injury averted.

Abstracting and Adjusting the Economic Data

Two reviewers read each study that met the inclusion criteria. Any disagreements between the reviewers were reconciled by consensus of the team members. A standardized abstraction form (available at [^a Established Market Economics as defined by the World Bank include Andorra, Australia, Austria, Belgium, Bermuda, Canada, Channel Islands, Denmark, Faeroe Islands, Finland, France, Germany, Gibraltar, Greece, Greenland, Holy See, Iceland, Ireland, Isle of Man, Italy, Japan, Liechtenstein, Luxembourg, Monaco, The Netherlands, New Zealand, Norway, Portugal, San Marino, Spain, St. Pierre and Miquelon, Sweden, Switzerland, the United Kingdom, and the United States.](http://www.the</p></div><div data-bbox=)

Table 2. Example of economics summary table

-Authors -Authors Affiliation -Funding Source -Pub. Date, -Study Period	-Method -Reported or Calculated Summary Measure	-Study Location, -Setting Type, -Population Description, -Follow-up Period	-Interventions Studied -Comparisons	-Reported Currency and Base Year -Costs Included -Benefits Included -Reported Summary Measure -Reported Effect Size	-Adjusted Currency and Base Year -Adjusted Value Summary Measure -Benefit/cost ratio -Notes	-Quality Category -Quality Score -Notes
Sobriety Checkpoints - Selective Breath Testing						
-Miller, TR -Children's Safety Network Economics & Insurance Resource Center -Not reported -1998 -Not reported	-Cost benefit analysis -Net benefit (annual)	-United States -Hypothetical community -100,000 licensed drivers -Not reported	-A hypothetical one-year campaign of intensive, four-hour sobriety checkpoints, 156 checkpoints per year, at a staffing level of 10 officers per checkpoint (BAC>.10%) -No comparison group	-1993 US dollars -Costs included personnel, equipment, travel delay, trial and punishment, mobility loss. -Benefits included averted medical care costs, property damage, future earnings, and quality of life -Benefits: \$7.90 million Costs: \$1.37 million Net benefit: \$6.52 million -Effect size ^a : 15% reduction in alcohol-attributable crashes	-1997 US dollars (annual) -Benefits: \$9.2 million Costs: \$1.6 million Net benefit: \$7.6 million -Benefit/cost ratio ^b : \$6	-Very good -94 -Note: This study uses survival value from 50 willingness-to-pay studies.

^a This effect size is an estimate by the authors based on a literature review, which suggested that a generously funded, intensive checkpoint program can be expected to reduce alcohol-attributable crashes by about 15%.

^b Benefit/cost ratios are provided as a stand-alone piece of information and should not be used to rank interventions unless (1) there is a known budget constraint; (2) the interventions are mutually independent; and (3) interventions exhibit constant returns to scale (an increase in intervention inputs yields an equivalent increase in output).

communityguide.org) was used for abstracting data. For those studies conducting cost-effectiveness and cost-utility analysis, results were adjusted to approximate the analysis to the reference case suggested by the Panel on Cost-effectiveness in Health and Medicine.¹³ Results from cost-benefit analyses were adjusted for currency and base-year only. When feasible, results were recalculated if the discount rate used in the study was other than 3%.

Assessing the Quality of the Evidence

Quality of study design and execution was systematically assessed across five categories: study design, cost data, outcome measure, effects, and analysis. By subtracting points for each limitation from a perfect score of 100, study quality was characterized as very good (90-100), good (80-89), satisfactory (60-79), or unsatisfactory (less than 60). Results from unsatisfactory studies were not presented.

Summarizing the Body of Evidence

The findings about the economic efficiency of interventions are presented in summary tables. The summary tables include information on seven aspects of each included study. Table 2 provides an example of a summary table.

Ratios or net present values (i.e., the discounted net benefit or net cost obtained from cost-benefit analysis) are pooled in ranges in those cases in which the intervention definition, population at risk, and comparator match across studies.

Barriers

Information about barriers to implementation of the interventions was abstracted from reviewed studies, evaluated on the suggestion of the team, or both. Information on barriers did not affect recommendations of the Task Force but is provided to assist readers contemplating implementation of the interventions.

Translating Strength of Evidence into Recommendations

The Task Force recommendations presented in the accompanying article¹⁴ are based on the evidence gleaned from the systematic reviews conducted in accordance with these methods. The strength of each recommendation is based on the strength of the evidence of effectiveness (e.g., an intervention is "strongly recommended" when there is strong evidence of effectiveness, and an intervention is "recommended" when there is sufficient evidence).¹ Other types of evidence can also affect a recommendation. For example, evidence of harms resulting from an intervention might lead to a recommendation that the intervention not be used if adverse effects outweigh improved outcomes. In general, the Task Force does not use economic information to modify recommendations.

A finding of insufficient evidence of effectiveness should not be seen as evidence of ineffectiveness. It is important for identifying areas of uncertainty that require additional research. In contrast, adequate evidence of ineffectiveness leads to a recommendation that the intervention not be used.

Summarizing Research Gaps

Systematic reviews in the *Community Guide* identify existing information on which to base public health decisions about implementing interventions. An important additional benefit of these reviews is identification of areas in which information is lacking or of poor quality. To summarize these research gaps, remaining research questions for each intervention evaluated were first identified. Where evidence of effectiveness of an intervention was sufficient or strong, remaining questions about effectiveness, applicability, other effects, economic consequences, and barriers were summarized. Where evidence of effectiveness of an intervention was insufficient, remaining questions about only effectiveness and other effects were summarized. Applicability issues were summarized only if they affected the assessment of effectiveness. The team decided that it would be premature to identify research gaps in economic evaluations or barriers before effectiveness was demonstrated.

For each category of evidence, issues that had emerged from the review were identified, based on the informed judgment of the team. Several factors influenced that judgment. When a conclusion was drawn about evidence, the team decided if additional issues remained. Specifically,

- If effectiveness was demonstrated by using some but not all outcomes, all other possible outcomes were not necessarily listed as research gaps.
- If the available evidence was thought to be generalizable, all subpopulations or settings where studies had not been done were not necessarily identified as research gaps.
- Within each body of evidence, the team considered whether there were general methods issues that would improve future studies in that area.

The Reviews of Evidence

This article describes the general methodologic approach used in the systematic reviews of interventions to reduce motor vehicle occupant injury. The accompanying articles^{3–5} present the supporting evidence on which the Task Force based its recommendations about these interventions.¹⁴ Each article describes the scope

and extent of the problem studied, discusses the conceptual approach to the review of evidence for the interventions studied, and presents additional information about methodology specific to the review of those interventions, in addition to giving a detailed report on the findings for each intervention.

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Appendix

Economic Efficiency

The *Community Guide* provides information on two kinds of economic efficiency: allocative and productive. In simplified terms, allocative efficiency deals with decisions about what mix of outputs (goods or services) maximizes societal welfare. In the public health arena, these decisions often involve making choices about which program to pursue. For example, assuming fixed resources, a police department may have to make choices between assigning personnel to sobriety checkpoints or to other duties. If new personnel cannot be hired, the costs and benefits of the options must be contrasted. Cost-benefit analysis provides information on the balance between a program's costs and its net societal benefit and can inform these decisions.

Considerations in achieving productive efficiency involve decisions about the best mix of inputs (resources) to use to produce the desired good or service in an efficient manner. Choices must be made because of limited resources. For example, once the decision to implement sobriety checkpoints (the desired service) has been made, different alternatives about how many officers to assign to this work (the best mix of inputs) may need to be considered. The choice may be between using many officers working at multiple checkpoints all over the city and using a few officers in critical locations. Although the first alternative may be highly effective, the second may be less costly. Cost-effectiveness analysis is used to answer the question, "Given a desired goal, what is the cost-effectiveness of the various approaches to reaching that goal?"

Types of Economic Analysis

Cost analysis is the valuation of all the resources consumed by the intervention. Summary measures of a cost

analysis include total cost, average cost, and cost per outcome. Total cost is the sum of resource costs of the intervention. Average cost is the total cost of the intervention per person reached by the intervention. Cost per outcome is the total cost of the intervention divided by an intermediate outcome such as additional children using safety seats. Those studies reporting ratios such as program cost per quality-adjusted life year (QALY) were also classified as cost analyses because the numerator included only the program costs and did not include the cost saving from averted illness or injury.

Cost-effectiveness analysis always involves the comparison of two interventions, a proposed intervention "A" and a comparator, intervention "B." The comparator can be an alternative intervention or the status quo (which could be doing nothing). The cost-effectiveness ratio is the net cost of A compared with B, divided by a measure of the effectiveness, such as illness or injury averted. Net cost is the difference of net intervention costs minus cost savings from averted illness or injury. Net program cost is the difference of the costs of A minus the costs of B. Cost savings from averted disease or injury is the cost of illness or injury within intervention A minus the cost of illness or injury within intervention B.

Cost-utility analysis is a variation of cost-effectiveness analysis, in which the health outcome measure is QALYs.

Cost-benefit analysis compares the costs and benefits of two programs in monetary terms. The net benefit ratio is the difference between program cost (of intervention A when compared with intervention B) and benefits (dollar value of the outcome from intervention A when compared with dollar value of the outcome from intervention B).

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