Application of Behavior Change Theory to Preventing Unintentional Injuries

By David A. Sleet and Andrea Carlson Gielen

Abstract

The use of behavioral and social science theories and methods has been critical to progress made in disease prevention and health promotion; their application to preventing unintentional injury is equally important. Injuries are largely predictable and preventable. Behavioral, psychosocial, and sociocultural factors are known contributors to injuries and can be modified using sound theoretical frameworks. While structural and environmental approaches have traditionally been associated with the greatest potential, it is rarely feasible to achieve injury reduction without some element of behavior change. In this chapter, we describe several individual and community-level theories and models with examples of research that use theory to address injury problems. For practitioners, the use of theory can both improve the effectiveness of interventions and accelerate the diffusion process. Ecological approaches that consider the dynamic interaction between behavior and the environment hold the most promise for reducing injury.

Introduction

Injury is among the most under-recognized public health problems facing the world today. Worldwide, 8 of the 15 leading causes of death for people ages 15 to 29 years are injury-related. Injuries of all types account for 9 percent of global mortality and are a threat to health in every country around the world. For every death, it is estimated that there are dozens of hospitalizations and hundreds of emergency department visits. Injury—which includes unintentional causes, suicides, and homicides—represents 79 percent of all deaths for individuals aged 1-30 in the United States. Approximately one-third of all emergency department visits and 6 percent of all hospital stays are due to injuries. The costs of injuries are staggering; in 2005 alone, injuries from both unintentional and violence-related causes cost the United States $355 billion. This figure includes estimates of $77 billion in medical care costs and $278 billion in work-loss costs. Globally, unintentional injuries—such as those caused by motor vehicle crashes, falls, burns, poisoning, and drowning—account for the largest injury burden, and young people are among the most vulnerable populations. In the 53 countries of the World Health Organization (WHO) European Region, every year intentional and unintentional injuries kill nearly 800,000 people and are the leading cause of death for people under 45 in the developed world.
From 1990-2010, global deaths from road traffic injuries increased by almost 50 percent, and traffic injuries are projected to move from being the ninth leading cause of death in the world to the third leading cause of death by the year 2020. Half of the world's road traffic deaths occur among vulnerable road users—motorcyclists (23 percent), pedestrians (22 percent), and cyclists (5 percent).

In the United States, unintentional injuries are responsible for most deaths of those ages 1-30. Nearly 126,500 lives are lost each year due to unintentional injuries, including car crashes, poisoning, drowning, fires, and falls. Millions more survive but are left with physical, emotional, and financial scars. Because of the significance of unintentional injuries to the overall injury problem in the United States, this chapter focuses on the application of behavioral and social science theory to preventing unintentional injuries.

Science of Injury Prevention and Role of Behavior Change

The science of injury prevention teaches us that injuries are not accidents. Like most diseases, injuries are often both predictable and preventable. Today we know more about the causes and consequences of injury, and the effectiveness of injury prevention strategies, than ever before. Behavioral, psychosocial, and sociocultural factors associated with lifestyle behaviors are known contributors to injury morbidity and mortality, along with characteristics of products and environments.

While the rationale for using structural or environmental interventions to change injury patterns might seem straightforward, there is rarely an environmental change that does not require behavioral adaptation. For every technological advance, there are behavioral components that need to be addressed. Children need to wear helmets while bicycling; parents need to correctly install child safety seats and booster seats; homeowners need to check their smoke alarms and change the batteries; parents with four-sided fences around their backyard pool need to ensure that the gate to the pool is always closed; and occupants alerted by a smoke alarm still need to find their way to safety. Even the more passive approach to poison prevention through the use of child-resistant closures—one of the great successes in injury control—requires active individual effort in replacing lids correctly.

Integrating knowledge about behavioral science into the mainstream of injury prevention research and practice will help avoid the false dichotomy between active and passive strategies and reduce the tendency to choose one over the other. In Haddon's epidemiological approach to injury, the host's role in injury reflects only personal risk at the level of the individual.

Much of the research on injury behavior change has been on individuals whose behavior puts them at risk, such as the drinking driver or the child pedestrian. However, because so many of the effective injury countermeasures are policy oriented in nature, practitioners may find behavioral change strategies useful to modify injury prevention policy at the community level. Finding effective ways to activate individuals to become advocates for safer products, policies, and environments represents a new opportunity for behavior change to contribute to injury prevention.

Safer products and environments require behavior change, too, on the part of manufacturers (such as toy makers) and environmental designers (such as city planners), as well as policymakers who regulate exposure to hazards and those who mandate and enforce safety behaviors (such as legislators, judges, or police).

Cataldo et al. emphasized this point when they said "Ultimately, injury control must entail some degree of behavior change, requiring the establishment and maintenance of appropriate safety behavior—by parents, legislators, judges and juries, police, health educators, physicians, reporters, and the like" (p. 233).

It is rarely feasible to achieve injury reduction without some element of behavior change. Behavior change is integral to any comprehensive approach to injury prevention. We define behavioral interventions as the development and application of behavioral science theory, knowledge, strategies, and techniques to the understanding and modification of injury risk behaviors and harms. Behavioral science applications have lagged behind other approaches to injury prevention, despite repeated calls for more behavioral science research in injury prevention.
complex than this, and that behavior change strategies cannot rely on information and education alone. Yet many practitioners in public health still approach behavior change with this assumption in mind, rather than taking a more holistic approach, such as that suggested by an ecological model.

Injury Prevention and Ecological Approaches

Researchers and practitioners have begun to recognize the importance of taking an ecological perspective to understand and intervene on contemporary public health problems, such as injury prevention.

In the Institute of Medicine report "Promoting Health," Smedley and Syme summarized the importance of taking an ecological approach this way: "Perhaps the most significant contribution of behavioral and social sciences to health research is the development of strong theoretical models for interventions (p. 9). The committee ...... found an emerging consensus that research and intervention efforts should be based on an ecological model" (p. 2).

The ecological model states that health and well-being are affected by a dynamic interaction among biology, behavior, and the environment, and this interaction changes over the life course. This definition conveys the notion of multiple levels of influence on health and makes clear the importance of both individual level and community level factors in shaping health related behaviors. Reducing the number of motor vehicle deaths is an example of improving population health through interventions at multiple levels of influence. Legislative policies, educational programs, and changes in the physical and social environment all contribute to changes in injury and injury risks.

Thus, an ecological model has utility in both describing influencing factors and developing prevention programs. Ecological approaches have been used in efforts to modify risk factors for tobacco use, obesity, heart disease, diabetes, cancer, and HIV.

A complete discussion of injury prevention and ecological models is beyond the scope of this chapter; however, Simons-Morton, McLeroy, and Wendel have provided rich detail on applying social-ecological perspectives across a variety of topics in public health, and Green and Gielen have provided an in-depth analysis comparing ecological approaches to reductions in motor vehicle crashes and tobacco use in the United States. Their analysis is elaborated further in Gielen and Green in a discussion of policy and environmental interventions to promote health and safety.

Injury Prevention and Behavioral Science

Researchers and practitioners have begun to recognize the value of using behavioral and social science approaches for injury prevention and control.

Behaviors that give rise to injuries are amenable to preventive interventions. Products, practices, and programs are available that can save lives, yet many people have neither heard about them, nor accepted and adopted them. Many people do not see the need to change, do not perceive themselves to be at risk, or do not have access to affordable safety products or programs that could save their lives. Behavioral scientists can help remedy this. Behavioral and social sciences also can help by documenting behavioral and social risk factors, developing and evaluating interventions, influencing social norms, assisting in post-injury recovery from psychological harm, and by shaping individual and community preventive behaviors.

Historically, much of the behavioral science applications to injury issues have appeared outside of traditional population health in disciplines such as psychology, anthropology, child development, human ecology, transportation, human factors, geriatrics, and others. These contributions have helped grow interest and relevance to public health applications for injury control.

However, the models, theories and behavior change strategies used to address other public health problems have been sorely underrepresented in the injury literature. A focus on behavior can complement other approaches, since there is rarely an injury that does not have a behavioral component. Many authors have noted the need to improve behavioral interventions by using better empirical data about behavioral determinants and by employing modern health behavior change theories, frameworks, and research methods.
examples that can help facilitate the change process among individuals at risk and among those in a position to influence policy and environmental change.

Theories From Behavioral Science

In recent years, there has been growing national interest in the contributions of theoretical models from the behavioral sciences to public health. However, the limited success of behavioral change efforts in modifying injury-related behaviors can be traced, in part, to failure to apply these theories to develop, implement, and test injury-prevention behavior change interventions. When rigorous research methods are used, theories can not only help us understand causes of problems, but—because they also allow us to identify mechanisms of change—they can also help us determine why programs succeed or fail and help us build better prevention programs. Selecting the most appropriate theory is situation-specific and depends on the particular audience, setting, and characteristics of the behavior to be changed.

Theories influence change across the levels of the ecological model. In translating an ecological model to action programs, Glanz, Rimer, and Viswanath describe three levels of influence for change. One, intra-personal change refers to influencing an individual's knowledge, attitudes, and beliefs on his or her behavior. Theories of cognition, perception and motivation are relevant here. Two, inter-personal change refers to the influence of significant others such as families, friends, and co-workers; relevant here is the modifying effect of social influence and social norms on individual behavior. Three, community-level change includes the influence of organizational settings (such as workplaces, schools, churches) and their influence on behavior. On a larger societal level is the influence of social and health policies (such as those related to welfare reform) and other societal influences (such as poverty and disenfranchisement) that influence injury risk behaviors. Examples of models applied to the community level include community mobilization, organizational change, and inter-sectoral action. Theories and models can help explain community and individual change processes in an ecological context. For example, simple changes in community zoning and urban planning can dramatically impact injuries related to the built environment, such as bicycling and pedestrian safety.

Different intervention strategies and methods are available when working with individuals and with communities. Example, at the individual level, intervention strategies typically include a variety of behavioral, educational, counseling, skills development, and training methods. Innovative new technologies such as computer-tailored messaging and behavioral prescriptions, Web-based learning, and motivational interviewing are promising approaches to strengthen the impact of injury prevention interventions at the individual level. When interventions focus on organizations, communities, and policies, the use of social marketing, mass media, and media advocacy are important, as are coalition building, social planning, and community development.

Application of Theories

A complete enumeration of the theories and their applications in the field of health behavior change is beyond the scope of this chapter, although interested readers are referred to relevant textbooks and reports and recent articles using theory to influence a variety of injury prevention behaviors such as: booster seat use, legislator behavior, terrain vehicle (ATV) helmet use, driver behavior, and smoke alarm maintenance behaviors. Behavior change theories, research methods, and applications in injury prevention have been described previously by Gielen, Sleet and DiClemente. Here, we describe several examples of well-respected behavior change theories or models that have been applied to injury problems.

Individual-Level Theories and Models

The Health Belief Model, Theory of Reasoned Action, and Applied Behavioral Analysis have an extensive literature supporting their utility, and each has been used for understanding injury problem behavior. In this section, we briefly describe the key constructs of each of these models and provide an example of research that utilized them to address an injury problem.
Health Belief Model (HBM). This model says that preventive behaviors are a function of individuals' beliefs about their susceptibility to the health problem, the severity of the health problem, the benefits versus costs of adopting the preventive behavior, and experiencing a cue to action.

In recent years, the concept of self-efficacy was added to the model. Self-efficacy, a concept originally from Bandura's work, refers to one's confidence in his or her ability to perform a specific behavior. An illustration of this model in injury prevention comes from the study by Peterson and colleagues' study of the beliefs and safety practices of 198 parents with children aged 8 to 17. They used the HBM to predict how parents' attitudes might influence their injury prevention teaching and environmental modifications. Parents generally were not very worried about injuries to their children (i.e., low perceived susceptibility). The HBM constructs most strongly associated with parental safety efforts were beliefs that their actions would be effective (i.e., benefits), a realistic appraisal of the costs of action (i.e., costs), and feeling knowledgeable and competent to perform the behaviors (i.e., efficacy). In this case, the authors suggest that practitioners use interventions influencing parents' beliefs about their child's susceptibility to injury through education, while simultaneously increasing parents' competency to intervene through specific behavior change strategies. Health education methods and strategies might include direct communications to address susceptibility and skills training and improved access to safety products to address competence.

Theory of Reasoned Action (TRA) and Theory of Planned Behavior (TPB). This model describes behavior as a function of behavioral intention, subjective norms, and attitudes. The model focuses on the individuals' intention to perform a behavior as predictive of their actual behavior. Intention is a function of attitudes and subjective norms. Ajzen later modified the TRA to be called the Theory of Planned Behavior and included the concept of perceived behavioral control, which reflects how easy or difficult the individual perceives the behavior to be. The TPB has been used to study safe swimming practices, storage of household firearms, the use of safety gear by in-line skaters, and drinking and driving.

In practical use, the TRA was used as the conceptual framework for a survey of parents' beliefs and practices regarding use of car safety seats. Attitude toward car seat use was found to be the single best variable for distinguishing between car seat users and non-users. This variable consisted of responses to six items measuring beliefs about the consequences of the behavior (e.g., using a car seat would be a hassle; your child would be better behaved in a car seat). Respondents who believed that their spouse would approve of using a car seat (a measure of subjective norm) were also more likely to report using one. These results can help practitioners develop public and patient education materials using salient messages with credible spokespersons. For example, media messages might communicate the ease with which car seat use becomes a habit with positive consequences such as child comfort and spouse approval.

The HBM and TPB were compared, along with the Locus of Control Theory (LCT), in a study of 965 Finnish youth ages 12-19. Structural equation modeling was used to examine these youth's intentions to use bicycle helmets, and the authors found that both the TPB and the LCT offered good fit models for the data. Lower intention to use a helmet was associated with perceived negative peer opinions, inconvenience, not having a helmet, and believing that a helmet could not improve their safety.

Applied Behavior Analysis (ABA). ABA is a specific subfield within psychology that uses the technology of behavior modification and operant conditioning to facilitate change. Behavior is viewed as learned, and principles of stimulus control, feedback, reinforcement, and punishment shape the acquisition, maintenance, and extinction of behavior.

Applied behavioral analysis or behavioral safety addresses the "ABCs" of behavior by manipulating the Antecedents, Behaviors, and Consequences associated with behavior. Antecedents occur before the behavior (such as cues in the environment), behaviors include the context in which the behavior occurs, and consequences are what follow the behavior.

Understanding the ABCs that control a behavior can help the practitioner intervene by shaping the behavior and the environment to bring about change. Removing roadside billboards that remind drivers of drinking, increasing prompts and cues in the drinking environment that discourage drinking and driving, and selecting a designated driver can all be ways to modify the antecedents of drinking and driving. Slowing the rate of alcohol consumption, learning drinking or binge drinking refusal skills, server interventions in the drinking environment, and feedback from blood alcohol detection...
devices can be used to modify the drinking behavior. Social and peer support for not drinking and driving, positive feedback, incentives or rewards from bartenders or friends, and fines, license suspension, and jail time can all be used to modify consequences in a positive or negative way.

Applications of ABA in road safety have effectively increased the use of safety belts and child restraints, reduced vehicle speeding, and improved bicycle helmet use. In other areas of injury prevention, applied behavior analysis has been used to reduce children's fall-related behavior on playgrounds and change safety behaviors in a fire in public buildings.

Behavioral safety approaches have had a long history of use in promoting occupational health and safety and have been employed more recently to increase the use of personal protection devices, such as hard hats and ear protection, to reduce injuries on the job and to increase worker productivity and morale.

Applying behavioral safety to the design of a "culture of safety" is a new approach at the organizational level. This is a recent understudied research area with different theoretical perspectives taken, suggesting that human factors engineering with behavioral monitoring can play an important role in injury reduction on the job.

Integrating Individual-Level Models

In 1991, the National Institute of Mental Health convened a theorists' workshop to bring together creators of behavioral theory to develop a unifying framework to facilitate health behavior change. Their discussions led to an enumeration of five theories that, taken together, contain virtually all the variables that have been used in attempts to understand and change human behaviors: the Health Belief Model, Social Cognitive Theory, Theory of Reasoned Action, Theory of Self-regulation and Self-control, and the Theory of Subjective Culture and Interpersonal Relations.

Considering all five theories and their many variables, eight variables appear to account for most of the variations in health-related behaviors: (1) intentions, (2) environmental barriers, (3) skills, (4) outcome expectancies (or attitudes), (5) social norms, (6) self-standards, (7) emotional reactions, and (8) self-efficacy. It is likely that these same eight variables might also regulate and predict change in injury risk behavior (Dr. Martin Fishbein, Personal Communication, January 23, 2003).

In translating this guidance to action, Fishbein and colleagues concluded that, generally speaking, for a person to perform a given behavior, one or more of the following conditions must be met:

1. The person forms a strong positive intention or makes a commitment to perform the behavior.
2. There are no environmental barriers that make it impossible to perform the behavior.
3. The person possesses the skills necessary to perform the behavior.
4. The person believes that the advantages of performing the behavior outweigh the disadvantages.
5. The person perceives more normative pressure to perform than not to perform the behavior.
6. The person perceives that performance of the behavior is consistent with his or her self-image or values.
7. The person's emotional reaction to performing the behavior is more positive than negative.
8. The person perceives that he or she has the capabilities to perform the behavior under different circumstances.

The first three factors are viewed as necessary and sufficient for producing any behavior, while the remaining five are viewed as modifying variables, influencing the strength and direction of intentions. By way of a hypothetical example, we can apply these notions to the injury control behavior of testing the functionality of a residential smoke alarm. If a homeowner is committed to testing the smoke alarm every month, has access to the alarms in the home, and has the skills necessary to successfully test the alarm, we would predict that there is a high probability he or she will perform the behavior. The probability that the individual will test his or her smoke alarm monthly would be predicted to increase even more if the homeowner also believes that testing is worth the time and trouble, knows that neighbors all test their alarms, believes that testing is consistent with his or her values as a responsible homeowner, has no negative emotional reaction to testing, and can test the alarms under different conditions in the home. According to this notion, the probability of testing monthly would be predicted to reach nearly 100 percent under these conditions. In practice, this integrated model has not been applied to this or any other injury-related behavior, but it holds promise as an innovative approach to injury prevention.
program development, at least until such time as sufficient research is available on specific theories as they relate to injury prevention.

Community-Level Theories and Models

Community-based injury prevention occurs when people and organizations collaborate as communities to design and implement strategies to keep citizens safe. A community can be defined either geographically or on the basis of common interests. Community organization and mobilization and community-based participatory research focus on the active participation and development of the community to enable community members to better evaluate and solve their own health and social problems.

Gielen and Collins and McLoughlin et al described the difference between 'community-wide' interventions and 'community-based' programs, highlighting the importance of treating the community as the source and not simply the site of prevention programs. Green and Kreuter have described the necessary components of community interventions this way: "Given reasonable resources, the chances are that a community intervention will succeed if the practitioner (1) builds from a base of community ownership of the problems and the solution; (2) plans carefully; (3) uses sound theory, meaningful data, and local experience as a basis for problem decisions; (4) knows what types of interventions work best for specific populations and circumstances; and (5) has an organizational and advocacy plan to orchestrate multiple intervention strategies into a complementary cohesive program" (p. 261).

The application of community-level theories and models in injury prevention can be seen in the World Health Organization (WHO) "Safe Communities" movement, initiated in Sweden in the 1980s, and as of June, 2014, 336 designated international safe communities were in operation worldwide. The program, which combines top-down with bottom-up strategies, was developed in eight steps: (1) epidemiological mapping, (2) selection of risk groups and hazardous environments, (3) formation of coalitions or interdisciplinary workgroups, (4) joint action planning involving many sectors, (5) implementation, (6) evaluation, (7) program modification from feedback, and (8) transfer of program success to others. It is structured around a broad coalition of community partners, involving business, civic organizations, local government, non-profit groups and organizations, and local residents. In the United States, the Safe Community Model has been applied mostly to the traffic safety sector by the National Safety Council and has been adopted by the National Highway Traffic Safety Administration as a part of its support to the Governor's Offices of Highway Safety Programs in many parts of the country. While the model presents a unique approach to community injury prevention, research findings on its impact on reducing injury rates have been equivocal.

In the United States, Hingson et al describe a community-based program to reduce drinking and driving in which intervention cities reduced fatal crashes by 25 percent and fatal crashes involving alcohol by 42 percent, relative to the rest of the State of Massachusetts, during the 5 years of the program, compared with the previous 5 years without the program. This community-level approach to drinking and driving prevention has appeal among many communities struggling to reduce their injury burden.

Implications for Practice

For practitioners, the use of theory can both improve the effectiveness of interventions and accelerate the diffusion process. At both the individual and community levels, using theory can help clarify assumptions on which interventions are selected and, when used in conjunction with thorough needs assessments, can contribute to more successful injury prevention programs.

In the Community Trials Project to reduce alcohol-involved trauma, a research-in-practice partnership was formed to focus on changes in the social and structural contexts of alcohol use. The researchers worked to implement prevention policies and activities that were evidence-based and asked communities to customize and prioritize their initiatives based on local concerns and interests. Specific components of the mobilization effort were directed toward responsible beverage service, drinking and driving, underage drinking, and alcohol access. Coalitions, task forces, and media advocacy were used to raise awareness and support for effective policies with the public and decisionmakers. Researchers conducted an 899091 9293 94,95 96,97 98 99 100
Evaluation of the impact of these efforts and demonstrated significant reductions of 6 percent in the reported quantity of alcohol consumed, 51 percent in driving over the legal alcohol limit, 10 percent in nighttime injury crashes, 6 percent in alcohol-related crashes, and 43 percent in alcohol-related assault injuries seen in emergency departments.

Effective injury prevention will require involvement by multiple stakeholders. We need to involve engineers, social workers, pediatricians, and developmental psychologists to help uncover everyday problems and solutions that can be implemented in the community and in clinical practice. Manufacturers of consumer products that carry the risk of an injury need to help us understand the hazards that might lead to an injury; in the process, they also will help to protect themselves from recalls and costly product liability litigation.

While the goal of most individual and community-based interventions is a reduction in injury, they can also serve intermediate goals, such as increasing knowledge and awareness of safe practices (e.g. replacing batteries in smoke alarms), changing behaviors that reduce risk (e.g. wearing helmets), and improving skills (improving the installation of child safety seats).

Implications for Future Research

Behavioral sciences applications to injury prevention must rest on a solid foundation of rigorous research methods. Some of the challenges faced in past injury research are related to research design and sample size. Often, sample sizes are too small to test population effects. A related problem is that some of the interventions are not intensive enough, lack penetration in the community, or are too expensive to implement at the population level.

Methods used to evaluate outcomes of injury-related interventions often do not take into account the unique attributes of the community or are not designed with community input. For example, behavioral interventions can contribute to the success of community-based participatory research (CBPR)—a collaborative approach to research that equitably involves all partners in the research process. CBPR begins with a research topic of importance to the community with the aim of combining knowledge and action for social change to improve community health and eliminate health disparities.

Although participatory research can be effective in addressing multiple public health problems, it is perhaps especially important for problems that relate to individual behaviors influencing injury.

Greater use of an array of quantitative and qualitative methods is justified, including analytical approaches such as randomized control trials, quasi-experimental designs, cohort studies, case-control and case cross-over designs, ecological studies, and mixed methods designs, all of which will strengthen the evidence base for injury prevention effectiveness. The use of modern analytic methods such as video data analysis, multilevel modeling, spatial regression, geographic information system (GIS) analysis, and social network analysis can improve the precision of injury data.

Injury prevention research can continue to advance our understanding of injury causes, mechanisms, risk factors, and outcomes through efforts to improve surveillance systems at the State and local levels. Improved surveillance capacity will also enable us to uncover new and emerging threats, such as the recent rise in prescription drug overdose deaths or sports-related concussion.

Research designed to evaluate the impact of policies and programs on personal behavior will require extreme sensitivity to the ethical issues surrounding the protection of individual autonomy. Identifying priority injury problems in community settings can be facilitated using needs assessment strategies. Decisionmaking about program design and evaluation and intervention strategy selection is a shared responsibility, and it will be embraced when it remains consistent with the core values of the community.

Finally, cost benefit, cost utility, and cost-effectiveness studies will be needed to assess the return on investment for implementing injury prevention practices and policies and to support the value of injury prevention as a public health strategy.

Conclusions

The use of behavioral theories and methods has been critical to progress in improving public health and injury prevention.
Behavioral interventions, in conjunction with structural approaches and environmental change, can enable and reinforce efforts to prevent injuries in ways that can ultimately protect whole populations. The application of behavior change theory to unintentional injury prevention should enable practitioners and researchers to more easily identify potentially useful strategies for many injury problems. Researchers and policymakers have highlighted the need for more effective educational and behavioral approaches to injury control. Educational approaches must focus not only on awareness, but also on skill development and training that leads to measurable behavior change and risk reduction.

Because of the wide range of types of injury, preventive behaviors, and various target groups and community characteristics, there remains a strong need for additional research using accepted behavioral theories and models. Wider application of interventions using rigorous study designs, health promotion and policy change theory, multifaceted community-based interventions with community input, intervention tailoring, economic evaluations, and implementation and dissemination research is needed. More attention is also needed to the issues of training researchers and community practitioners in the application of relevant theories.

Training more behavioral scientists in the epidemiology of injury and the science of injury control is an urgent first step. Likewise, enhancing the behavioral and social science training of injury practitioners and researchers is necessary. Theoretical research is needed to clarify the mechanisms by which change occurs across levels of ecological models. Applied research can help us understand and modify risk perceptions, social norms, and other psychosocial factors associated with behavior and behavior change. Child developmental research is needed to tailor interventions to accommodate differences in patterns of physical and cognitive growth. Community-level research is necessary to understand mechanisms for influencing large populations through behavioral and environmental strategies.

While evidence from a single study can provide useful information about program efficacy, the study must be repeated and replicated in different populations and in different settings. Ultimately, what is needed is substantial research on both the determinants of behavior and the efficacy and effectiveness of programs, so that recommendations can be made to practitioners about best practices. Noticeably absent from injury/behavior literature are longitudinal study designs and mediator models of analysis, both of which would aid in understanding behavior over time and the influencing factors that account for any changes.

We believe these are important steps for strengthening the application of behavioral science to injury control, which in turn can contribute to changing individual behaviors, environmental conditions, and social structures in ways that prevent injuries and improve population health.

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