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ABSTRACT

Injuries are the leading causes of death for non-infant children and adolescents. Motor vehicles, drownings, fires, firearms, and poisons; in that order, are the major categories of fatal injury for the child population as a whole. Recognition that the agents of injury are the major forms of energy (mechanical, thermal, chemical) has led to an increased focus on the characteristics of energy and factors in children's environments that increase exposure to these agents. A wide range of strategies is available to modify such agents and environments. These strategies would reduce the incidence and severity of injuries, including prevention of creation or release of the agents; separation of the agents from children in time, space, or with physical barriers; and modification of qualities of agents, vehicles and hosts. Research relevant to choice of strategies suggest that changes in injurious agents or environments that do not require modification in behavior of those at risk are usually the most effective and less often generate objections from the general public. However, resistance to regulation on economic, political, and ideological grounds may delay or foreclose the use of a given strategy. Therefore, attempts at injury control should be researched in relatively small-scale experiments before being adopted on a large scale. Such experiments could rule out the programs that have unanticipated harmful effects or no effects, and give more credence in the economic, social and political arenas to those programs that are effective. (Author/MP)

MATRIX NO. 13

INJURIES TO CHILDREN AND ADOLESCENTS

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INJURIES TO CHILDREN AND ADOLESCENTS

From a few months after birth until beyond the average midlife, a person in the United States is more at risk to death from injury than any other cause. About 25,000 persons under 20 years old died from unintentional injuries each year in the late 1970s. About half of these occurred in motor vehicle crashes. Drownings, and deaths from fires, firearms, and poisons constituted about 60% of the remainder.[1] Because they are concentrated in the younger half of life, unintentional injuries account for more preretirement years of life lost than either heart disease or cancer — the leading causes of total deaths.[2] Substantial additional gains in average years of life of the population greatly depend on injury control.

Less is known about morbidity and disability from injuries than about deaths because of the poorer quality of the data on nonfatal injuries. More than half a million injuries to persons less than 15 years old from motor vehicles alone were estimated for 1975, and more than 1.5 million occurred in the 15 to 24 age group.[3] Of the approximately 5,000 motor-vehicle related paraplegias and quadriplegias that were first-time hospital admissions in 1974, an estimated 138 were less than 16 years old and 1,514 were less than 26 years old.[4] Since about half of total paraplegia and quadriplegia is related to motor vehicles, the totals from all injuries are about twice as high as the numbers involving motor vehicles. Injuries to various nervous, organ, and muscular-skeletal systems may result in periodic seizures, loss of one or more senses and/or other impaired abilities. More evidence is needed on the incidence and prevalence of these consequences nationally. Evidence on cognitive or emotional impairment to the surviving injured, to those who believe themselves at fault for their or others' injuries, and to those who have lost loved ones or seen them maimed, also is needed but is perhaps incalculable with any precision.

Without adequate data on the full spectrum of the consequences of injury, and because of the inadequacies of dollar estimates of noneconomic losses, any calculations of dollar costs must be considered as minimum. Most cost estimates do not specify differences in costs by age. One recent estimate of the annual minimum costs of all motor vehicle injuries in 1975 dollars is $14.4 billion.[3]

Knowledge of Causation and Ameliorative Strategies

Conceptualization of the injury problem changed substantively in the 1960s, and this change has given a new focus to research. The notion that, to prevent or reduce injuries, one had to prevent the incidence of *accidents* was challenged by recognition that injury does not occur unless there is a transfer of energy (mechanical, thermal, chemical, ionizing)[5] beyond the tolerance of the host individual. It is this energy transfer that is the necessary and specific agent of injury.[6] Some of the myriad individual behaviors as well as social factors that contribute to injurious energy transfers are worth investigating, but the characteristics of the energy and the vehicles that convey it to the host have received increased attention.

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The physics of mechanical energy, common to injuries in motor vehicle crashes, falls, and from gunshot wounds, have been known for 300 years. Host tolerance to mechanical energy is low in the case of infants whose bones are softer and children with hemophilia, but most children escape unharmed if the energy is managed appropriately. Scientific knowledge of children's tolerance and the physics (or chemistry) of the energy is necessary for the fine tuning of choice or design of children's environments. But ordinary knowledge,[7] available for thousands of years, should indicate that children are less likely to be injured if the elements of their physical environment are soft rather than hard, blunted or rounded rather than sharp, nonflammable or slow burning rather than quick blazing, chemically inert rather than toxic, or incapable of being swallowed by a child.

Much more benign environments could be provided our children, often at the same or less cost than at present. To illustrate the point at a recent public health meeting, Susan Baker showed a slide of swings in a park where the only concrete is under the swings.[8] The protruding knobs, hard surfaces and sharp or pointed edges on the interiors and exteriors of motor vehicles, which increase the incidence and severity of injuries to occupants and pedestrians in crashes, are unnecessary in terms of costs or function of the vehicles.

A systematic enumeration of 10 logically distinct strategies available to ameliorate the interaction of human beings with hazardous agents has been developed by William Haddon, Jr.[9-11] The strategies and a single illustration of a tactic for each follows: (1) Prevent the creation of the hazard in the first place — do not use flammable materials in dwelling units and children's institutions, furniture and clothing; (2) Reduce the amount of the hazard brought into being — reduce temperatures to below scalding levels in water heaters; (3) Prevent the release of the hazard that already exists — increase road skid resistance; (4) Modify the rate or spatial distribution of release of the hazard from its source — increase the use of child restraints and seat belts in transportation vehicles; (5) Separate, in time or in space, the hazard and that which is to be protected — build pedestrian over- and underpasses on roads, especially in areas with large numbers of children; (6) Separate the hazard and that which is to be protected by interposition of a material barrier — install air bags in new cars; (7) Modify basic qualities of the hazard — use utility and light poles along roads that *break away* when struck by motor vehicles; (8) Make that to be protected more resistant to damage from the hazard — provide blood clotting factors to children with hemophilia; (9) Counter damage already done by the environmental hazard — install smoke detectors in all buildings; (10) Stabilize, repair, and rehabilitate the object of damage — make burn centers accessible to those needing them. A much greater range of tactics under each strategy has been suggested elsewhere.[9-12]

Research Relevant to Choice of Strategies

The existence of knowledge of the necessary and specific cause of injuries, or strategies and tactics to prevent them, does not guarantee that the knowledge will be used or used correctly. If the strategy involves changing the behavior of children or parents, the limits of behavioral change approaches — education, advertising, be-

havior modification, legal and administrative requirements – must be considered. If the strategy is automatic (passive)[13] – requiring no action of the child or family – the limits to the legal and administrative systems involved in implementation must be considered.

Education with respect to hazardous activities must be developed and delivered to the public in such a way that it does not promote more of the hazardous activity rather than reduce the risks associated with the activity. Unfortunately, the proliferation of driver education in the public schools has increased greatly the numbers of drivers under 18 in recent years, with little or no effect on the teenaged drivers' crash risk per licensed driver.[14] The growth of driver education and accompanying licensure contributed to the increases in deaths of teenagers per population in the late 1960s and early 1970s.[15] The spread of alcohol and drug education in schools also may have contributed to those deaths as well as other injury-related deaths. One study found increased use of alcohol and other drugs associated with drug education.[16] And alcohol use is known to be related to fires, drownings, falls, etc.[17]

Attempts to educate parents regarding household hazards[18] and restraint use in motor vehicles[19] has very limited or temporary effects on hazard reduction. There should be *Non Sequitur of the Year* awards with eligibility limited to all scientific papers that point out a particular hazard and then conclude with a "therefore, an educational program should be launched" appeal. Education may be a useful strategy under certain circumstances, but too often it is considered the only strategy.

The more frequently the action must be taken, the more uncomfortable and inconvenient the action; the more the action reduces pleasure, or the more costly the action, the less the proportion of the population that responds to education, advertising, or other attempts at behavioral change.[20-21] If the behavior must occur only once or infrequently to be effective – reducing the temperature in household water heaters, placing covers over electrical outlets, purchasing a more crashworthy vehicle – behavior change approaches are likely to have some effect.

Reaction to coercive behavior modification can nullify effectiveness. In the mid-1970s auto executives talked the government into requiring an interlock system, so that cars wouldn't start unless belts were extended from stowed positions or fastened, rather than require automatic protection. The interlock increased belt use but public reaction reversed the requirement.[22] This result misled some members of Congress into thinking that the public didn't want increased crash protection[23] when actual demand for such protection was high.[24] What the public didn't want was to be hassled.

Requiring certain behaviors by law is usually more effective than education, persuasion, or involuntary behavior modification but, to the extent that the behavior is uncomfortable, inconvenient, costly, or difficult to observe by police, effectiveness is reduced. Laws requiring seat belt or child restraint use are more effective than persuasion, although substantial proportions of the population do not comply with the laws.[25-26] Where enforcement is easier – as is the case with motorcycle helmet use laws – compliance is very high and so is effectiveness.[27] A politically active minority of motorcyclists, however, has persuaded half the state legislatures to

repeal or seriously weaken these laws mainly on ideological grounds.[28] Laws prohibiting blood alcohol concentrations above set levels are difficult to enforce. Compliance is low and periodic *crackdowns* by police and/or courts have, at best, temporary effects.[29-30]

Approaches that automatically reduce hazards without changing the behavior of those at risk are usually the most effective and less often generate objections from the general public. The federal standards that improved the crashworthiness and crash avoidance capabilities of 1968 and subsequent model cars reduced fatalities[31] and severe injuries[32] in the cars by 20% to 25% with no serious public objections. Infants' crib related injuries have been reduced 40% by governmentally required design changes in new cribs and warnings regarding necessary changes in old cribs.[33] Children's falls from windows in multilevel dwellings decreased by 50% when New York City required landlords to install devices on windows that make it difficult for young children to crawl out the windows.[34] Children's fingers and arms are no longer injured in wringers of washing machines as they were before the adoption of drying mechanisms internal to the machine that automatically stop when the door is opened.

The major objections to automatic approaches usually come from designers, manufacturers or suppliers when there are suggestions or proposed requirements for changes in the products with which they deal. Most often these objections are based on cost, despite the fact that additional costs often may be absorbed as part of redesigns that would occur with new models and manufacturing processes. Surveys of the public have indicated that it desires and is willing to pay for reduced hazards.[24, 35] The designers, producers, and suppliers of hazardous products may, in some cases, be unaware of these desires or may have other motives for resisting any interference in their command over their businesses.

Needed Research

The future research that is most likely to contribute to reduction in harm to children will take into account the characteristics of the agents and vehicles involved in injury, the strategies available to reduce the hazards, the relative effectiveness of the strategies, and the potential support for and resistance to specific strategies. While the agents of injury are known, much remains to be learned about the processes that contribute to their exposure to children. Current epidemiologic research on children's injuries too often is confined to relatively unchangeable characteristics of the injured or their parents (e.g., age, sex, race, socioeconomic status). Not enough is known about incidence and severity of nonfatal injuries, where hazardous agents are found in the child's environment, how agents reached injured children and in what quantities, what were the lengths of exposure, and what strategies in what combinations would have prevented the harm. Information, on whether children are more often drowning in bathtubs, swimming pools, oceans, rivers or ponds, and whether such drownings are concentrated in particular areas, is more relevant to choice of preventive strategies than information on the educational status of the drowned children's parents.

Injury control strategies and tactics should be researched as to whether they comply with criteria for efficacy without harmful consequences. It is evident from the experience with increased licensure from high school driver education, and with carcinogens used in flame retardant sleepwear, that unintended harmful consequences can accompany behavioral or environmental change. Fortunately, the carcinogens in the flame retardants were discovered quickly and removed from the marketplace. High school driver education, in contrast, has remained in place far longer. It is supported by the unjustified belief that education can solve any problem and by a lobby of producers of educational materials, consultants, administrators, and teachers who stand to lose from its discontinuance.

Although often not the case, it should be obvious that research on the effectiveness or potential harm of any public health strategy or tactic should be done by persons who stand neither to gain nor lose (other than shared risk) as a consequence of the findings. The study of educational, rehabilitational, and legal approaches is difficult, but these approaches are not impossible to research in controlled or quasicontrolled experiments on a relatively small scale. Because they tend to be labor-intensive when proliferated, they are certainly easier to stop when found ineffective or harmful on a small scale than after they have become an integral part of the social and economic fabric.

More difficult to research, but no less important questions, relate to why there is often a long delay between reasonably proven efficacy of injury prevention strategies and their actual use. When the cost of designing or manufacturing a product is the same or less if its hazardous characteristics were changed, what are the attributes of decision makers or the decision processes that lead to lack of consideration of the potential hazards of a product? Is education of such decision makers any more effective in reducing hazards than education of parents and children who will use the products?

Where modification of a process or product would increase costs and thus give competitors an advantage if all did not make the change, what are the characteristics of regulatory processes that most effectively and efficiently reduce hazards? Under what conditions are design rules versus performance rules preferable? Under what conditions are incentive systems versus command and control regulations preferable? The answers to such questions must consider who is threatened economically, politically, or ideologically by the choices, and how potential opponents are arrayed in the economic and political landscape.

And, finally, there are those navel-gazing questions that the research community should address. Are we asking the right questions? Are we seeking answers from the best data? Are we anticipating use or misuse of our research and how can we minimize the latter?

Summary

Injuries are the leading causes of death to noninfant children and adolescents. Motor vehicles, drownings, fires, firearms and poisons, in that order, are the major categories of fatal injury for the child population as a whole. Recognition that the agents

of injury are major forms of energy (mechanical, thermal, chemical) has led to an increased focus on the characteristics of energy and factors in children's environments that increase exposure to these agents. A wide range of strategies is available to modify agents and environments that would reduce incidence and severity of injuries – prevention of creation or release of the agents; modification of rates of distribution of the agents; separation of the agents from children in time, space, or with physical barriers; modification of qualities of agents, vehicles and hosts.

A number of principles have emerged from research on behavioral, legal, and administrative systems that must be considered in choice of strategies. Education regarding a hazardous activity can increase the frequency of the activity and thus be harmful. Various forms of persuasion have little or no effect on behavior, if the proposed behavioral change involves increased discomfort, inconvenience, cost, or loss of a pleasurable activity. Persuasion is most effective for behaviors that must occur only once or infrequently to be effective; e.g., reducing temperatures in household water heaters to prevent scalds. Requiring the behavior by law is more effective if the behavior is observed and enforced easily by police. However, reaction to zealous enforcement sometimes results in repeal of the law as happened with motorcycle helmet laws in many states.

Changes in injurious agents or environments that do not require modification in behavior of the individuals to be protected are usually the most successful strategies for injury reduction. More crashworthy motor vehicles and nonflammable clothing, housing, etc., are examples. However, resistance to regulation on economic, political, and ideological grounds may delay or foreclose the use of a given strategy. Attempts at injury control should be researched in relatively small-scale experiments before being adopted on a large scale. Such experiments could rule out the programs that have unanticipated harmful effects or no effects, and give more credence in the economic, social and political arenas to those programs that are effective.

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