Injury Epidemiology: Fourth Edition

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Lulu Books

Chapter 10. HUMAN FACTORS

Most people who are injured are doing something at the time -- driving, riding in a vehicle, ingesting food or drugs, walking, working, or playing. So are people who are infected by microorganisms, but those who study injury place more emphasis on behavior than those who study most infectious diseases. Notable exceptions are infectious diseases transmitted by sex. Ironically, sexual behavior in moving vehicles has been neglected as a topic for research. No relevant studies were found in a search of Google Scholar in early 2015 regarding "sexual behavior and vehicle crashes".

Historically manufacturers of injurious products or products that could be changed to reduce injury severity emphasized behavior as the cause of injury to divert attention from the products (Eastman, 1984). Despite the claims of industry spin-doctors and their apologists in government, injury control has never been a simple choice of changing agents and vehicles of injury versus changing behavior. The issue is: what factors can be changed to reduce harm and how much injury reduction can be achieved by deliberate attempts at changing the factors? Certainly not all injuries are preventable by modifying energy conveyances or modification of environments and behavioral change can be accomplished to some extent. To do so will require a better scientific understanding of behaviors involved, whether they can be modified and how to do so on a large scale.

BEHAVIORAL THEORIES. The construction of behavior change strategies would be easier if behavioral and social scientists could agree on human behaviors that are changeable. For example, historical arguments regarding the best approaches to crime prevention turned on the issue of the extent to which behavior is modifiable at what stages of development (Tremblay and Craig, 1995).

The operant conditioning model prevalent among experimental psychologists portrays human beings as trainable by reward and punishment to do virtually anything, and often ignores biological limitations such as reaction time, as well as cognitions that intervene between the input of rewards and punishments and

the output in behavior. The neoclassic economic model, and that of some cognitive psychologists, views human beings as rational "utility" (goal) optimizers. There is also little room for human physical or psychological limitations in this model (low intelligence, mental illness, and addictions, for example). Rather than being mainly responsive to external stimuli as in the operant conditioning model, the rationalists think that each person weighs each option for behavior as to its probability for accomplishing or experiencing a utility, and discounts the cost in terms of the time between the immediate situation and the ultimate goal. The origin of the "utilities" is often obscure in such theories.

Many sociologists view behavior as largely influenced by the internalized cultural and social environment, including learned social customs and mores, socioeconomic status and peer pressure. Socio- and psycho-biologists emphasize the effects of genetics on the biological factors that contribute to motivations such as rivalry, emotions such as rage, cognitive limitations, and neuronal-motor function. Certain psychologists and psychiatrists look for the major motivations for behavior in the unconscious mind, largely determined by relationships with parents or guardians in infancy and early childhood.

Devotees to any one of these approaches may object to the oversimplification in a one-sentence description of what are often very complex and detailed theories. Also, the list is by no means exhaustive. There are numerous eclectic mixtures. And most of the theories ignore the fact that human beings frequently make mistakes. Human factors researchers who have studied human error rates find them quite high and substantially intractable (Hojjati-Emami, et al., 2015).

Each of the behavioral theories may have some merit for subsets of a population engaged in a given activity at a given time. Human beings are very complicated and, at any one time in the course of a lifetime, several of the factors emphasized by the various schools of thought may influence the behavior of the moment. Therefore, it is not surprising that behavioral or social scientists who have attempted to apply their disparate theories to behaviors that increase or decrease probability of injury have found one or more of their hypotheses supported to some degree by data. In many such instances, the hypothesis has some predictive value, but in others the research "results" are artifacts of research design or invalid assumptions about the data or its interpretation.

In one book of contributed chapters regarding mainly psychological theories and their applications to injury-related behavior, several of the authors refer to “determinants” of behavior (Gielen, et al., 2006). Human behavior, like most other phenomena, is not determined; it is probabilistic. One or another biological, cultural, social, economic or psychological factor, or several in combination, may increase or decrease the probability of a given behavior. No one or combination of them is going to map into a one-to-one determination that a given behavior will occur.

The usefulness of the valid biological, psychological, economic, and social predictors of increased probability of injury depends on the strength of the correlations and the extent to which the factors are subject to change by intervention. A primary concern regarding behavior change is its implementation in large populations. More than six billion people inhabit the earth in a huge variety of societies, cultures, and economies. Even within countries such as the U.S. there are large variances in subcultures based on ethnic background, religion, economic status, age, and sexual orientation to name several.

Some people are organized, formally or informally, around interests that place their adherents at special risk – guns, motorcycles, and turf defense by street gangs among the most prominent. Many thrive on false narratives, such as the need for a loaded gun by ones bed to defend ones home in areas where the risk of home invasion is virtually nil. There is a much greater probability that a child will access the gun and shoot someone or self than that the home will be invaded. The claimed need to defend the home requires an accessible, loaded gun while such availability increases the probability of children's access or use by an adult in a moment of rage (or psychological depression in the case of suicides).

Individuals are often psychologically torn among the mores and expectations of different subcultures in groups to which they belong. Obviously, to reduce injury by behavior change, the effort must be demonstrated to be effective in numerous contexts and directed at the most vulnerable segments of populations.

A complete explication of behavior theories and their implications for injury research would require far more space than is available for a single chapter. Here I briefly discuss the stages of life to indicate the complexity of the problem. Not only do the causal models of different schools of thought look quite different, the relative strength of a given causal path in any causal model of injury must differ dramatically depending on the stage of development of the individual (Kane, 1985). Age is a proxy for a mix of the factors emphasized in behavioral theories as well as differential vulnerability of tissue to energy insults, and the probability of being in situations where energy exchanges are more or less likely.

DEVELOPMENTAL STAGES IN CHILDHOOD. During 1976-77 in the U.S., the motor-vehicle-occupant death rate per population of infants less than one year of age was twice that of those one to two years old. The rate declined, as children grew older until age six, where it leveled, and the rate among 6-12 year olds was about a third that of infants (Baker, 1979). Does this mean that parents were conditioned to love their children more and take better care of them as they grew? Do children increase in utility as they develop? Are the social and economic pressures on new parents so severe that their driving ability deteriorates enormously? Do some new parents have a subconscious hate for

their newborn that is manifested in driving behavior, endangering themselves as well as the infant?

Perhaps a few of the behavioral and social scientists extremely dedicated to their respective theories would view such hypotheses as worthy of research, but scientists aware of anatomy and physics considered other hypotheses. The tissues of infants are less tolerant of energy insults and certain positions in the vehicles increase the mechanical forces on them in crashes. Using the formula describing mechanical energy in Chapter 2, it can be shown that an unrestrained ten-pound baby becomes a 300-pound flying object in a 30-mile-per-hour crash. Furthermore, when placed in the lap of an adult, an infant in a frontal crash will be crushed between the interior-front structures of the vehicle and the similarly multiplied weight of an unrestrained adult attempting to hold the infant.

Social and behavioral factors undoubtedly affect the transportation of children in particular types of vehicles, their seating arrangement in the vehicles, and whether or not they are restrained in an appropriate child carrier or booster seat. Children may also distract drivers, but probably no more at one year of age than at six years of age. The relative effects of these factors on injury rates have not been studied in sufficient detail to weight them as contributors to injury.

During 1980-1984 in the U.S., vehicle occupant death rates of children less than 1 year old declined 37 percent and those of 1-4 year olds declined 25 percent as child restraint use laws were adopted (Robertson, 1989). These reductions were associated with increases in observed child restraint use in urban environments that increased from less than 10 percent (Williams, 1976) to 49 percent (National Highway Traffic Safety Administration, 1989). Children seated in the front seat in vehicles in fatal crashes declined from 42 to 31 percent in the 1990s in association with publicized warnings regarding danger of passenger airbags to out-of-position children in front seats (Wittenberg, et al., 2001).

Child development may be modified by brain damage associated with low birth weight, in-uterus alcohol and drug exposure, environmental lead exposure, serotonin deficiency or head trauma in childhood. Such factors associated with later violent behavior led a National Research Council panel on violence to recommend longitudinal studies to better delineate their potential effects (Reiss and Roth, 1993). In the U.S., falls are the leading cause of head trauma to children less than 12 years of age. Assaults on children are strongly correlated with the presence of adults other than biological parents in the household (Reading, 2006).

As children develop motor skills, they become more active. For a time, the motor skills develop more rapidly than perceptual and cognitive skills. Children's injuries reflect the hazards in the environments in which they are placed or find themselves, and the behaviors that expose them to energy exchanges, as well as changing tissue vulnerabilities (Rivara, 1982a). They roll, and later crawl, off beds and from other elevated surfaces. Their heads are larger than their bodies, and hanging sometimes asphyxiates those that squeeze their bodies between crib slats. Children attempt to swallow foods and other objects

that are of a size to block respiration when lodged in the trachea. Toxic chemicals and plants are also swallowed. They wander into swimming pools, hot tubs and spas. They touch hot surfaces, pull over containers of hot liquids and are placed in, or turn on, overheated water. They find loaded guns and occasionally shoot people.

A study of parental actions to reduce injury to toddlers found that attempting to teach the child to avoid hazards was ineffective at best and increased risk in some instances. Hazard removal and parental supervision was more likely to reduce injuries (Morrongiello, et al., 2004).

At given points in development, children apparently learn to largely avoid certain hazards to which they remain exposed in their environments. Head injuries associated with stairs and window or door glass decline by half from age two to three, and those associated with furniture and other household fixtures decline rapidly after age six to seven (Rivara, 1982b). At age 4 to 9, children playing with matches and lighters start fires, disproportionate to their numbers in the population at that age (Cole, et al., 1986). As they develop the ability to run, climb, and operate vehicles such as tricycles, bicycles, guns, skateboards, and motorized vehicles, children's involvement in injuries associated with these activities increase.

A variety of research questions have been raised by these injury distributions (Rivara, 1982a). To what extent does differential understanding of developmental stages by parents account for their children's exposure to hazards? If there are differences in knowledge, does giving information to the less informed result in reduced exposures and injuries? What are the capabilities of children relative to proposed countermeasures? For example, if fencing is the option chosen to reduce children's access to swimming pools, what types of fences or gates can children breach (Rabinovich, et al., 1994)? To know how to modify firearms to prevent child use, what is the limit of children's ability to pull the trigger of extant firearms (Naureckas, et al., 1995)?

The age differences in injuries vary by gender in some cases and not in others. Are the differences in males and females learned, biological, or some combination of the two? What other characteristics of children, if any, are predictive of injury given similar exposure to hazards? Are such characteristics short lived, or do they persist through several developmental stages? How does one distinguish cases of unintentional injury and child abuse (Kemp, et al., 1994)? Are any of the predictive characteristics modifiable, and do attempts at modification result in reduced injury? One review of attempts to reduce antisocial behavior in children indicates that early interventions with prospective and new parents are more effective than later school-based approaches (Tremblay and Craig, 1995). Nevertheless, school and after-school programs have been shown experimentally to reduce aggressive behavior as rated by teachers and parents (Hudley, 2003).

Less often considered are questions regarding stimuli generated outside the home. What influence does advertising have on decisions to purchase hazardous products? How much of such influence is exerted through TV programs and commercials directed at children? How many hazardous products are received as gifts and from whom? How often do the injuries associated with hazardous products occur from products that belong to neighbors, friends, relatives and others outside the home?

The noted references indicate that epidemiologists and others interested in children's injuries have attempted to answer a few of the questions using a variety of methodological approaches. This is not the place for an exhaustive literature review, which should be undertaken before attempting new research.

ADOLESCENTS AND YOUNG ADULTS. The most severe injuries to teenagers and young adults occur in motor vehicles and assaults, particularly assaults on self or others with guns in the United States (Baker, et al., 1992). Assaults, sports and motor vehicles topped the list of mechanisms of teenaged head injuries (Quale, et al, 2014). Males are substantially more involved than females as drivers and assailants, and whites are more often killed in motor vehicles and suicides, while blacks are more often killed in assaults. Females are often involved as "straw purchasers" of guns for males with criminal records and dealers are willing to sell, in some cases even if they know the eventual recipient cannot legally own the gun (Sorenson and Vittes, 2003).

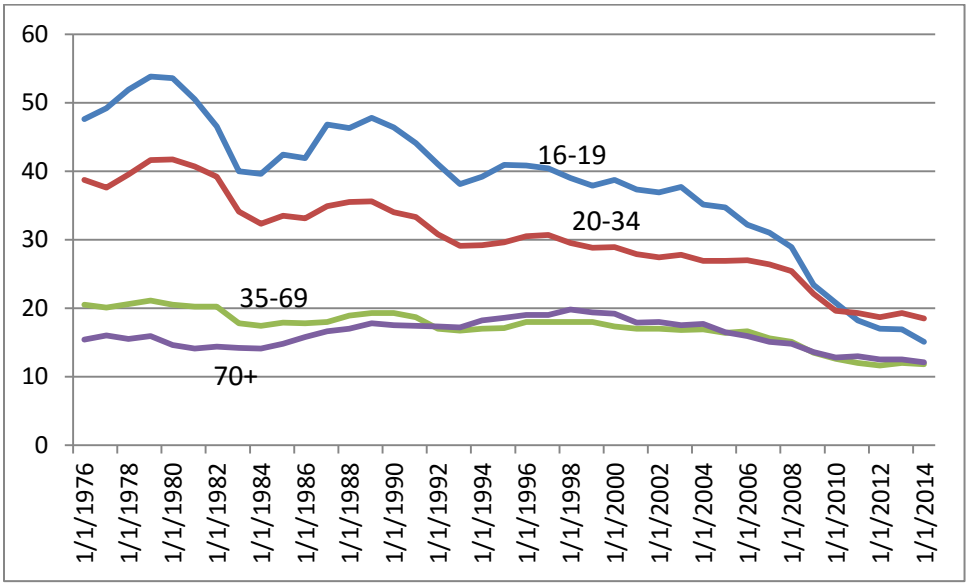

Figure 10-1. **Age of drivers in fatal crashes per 100,000 of the age group in the population.** Source:
http://www.iihs.org/iihs/topics/t/teenagers/fatalityfacts/teenagers

The involvement of teenaged drivers in fatal motor vehicle crashes per number of teenagers in the population has declined by about two-thirds since the Fatality Analysis Reporting System was initiated in 1975 (Figure 10-1). In recent years teenaged drivers have been less involved per capita than 20-34 year olds. When corrected for miles driven, however, teenaged drivers have the highest involvement rates relative to drivers up to age 79 (Figure 10-2). Therefore, the major reason for the decline in Figure 10-1 is that fewer teenagers are driving.

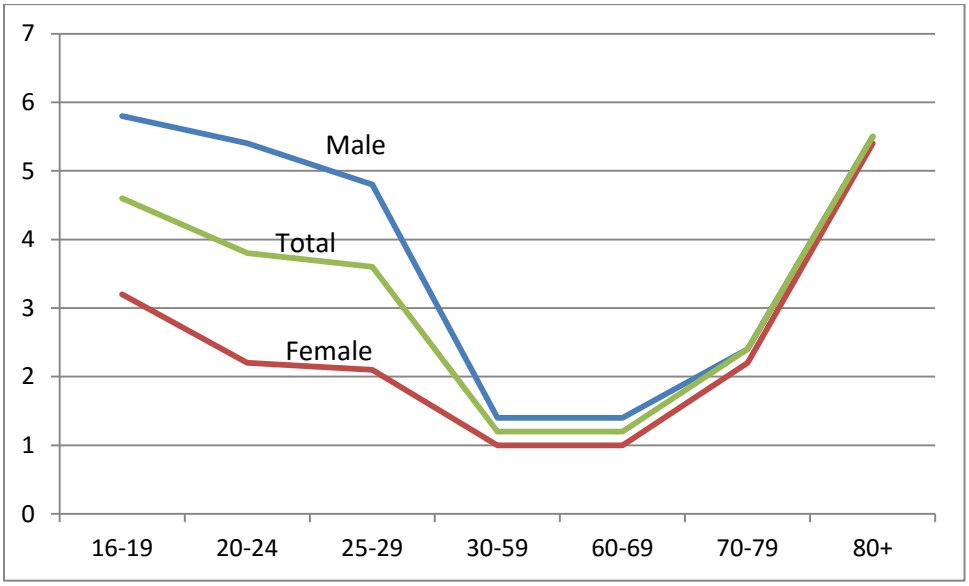

Figure 10-2. Fatal crash involvement per 100 million miles driven by age and gender. Source: http://www.iihs.org/iihs/topics/t/teenagers/fatalityfacts/teenagers

The effects of driver education and graduated driver licenses on teenaged driving respectively are discussed in the next two chapters. The cost of insuring teenage drivers may also contribute to the decline in teen driving. Car ownership is lower in relation to higher insurance rates among U.S. states (Raphael and Rice, 2002) and teen insurance rates can be as much as double adult rates in several states. The gender differences among drivers less than 30 years old seen in Figure 10-2 are larger than the age differences but gender gets much less attention than age.

Behavioral theories contain all sorts of hypotheses as potential explanations of teen and young adult behavior, but the research in support of many of them is inadequate or nonexistent. Adolescence and young adulthood is a period of accelerated separation from parental influence, sexual maturity and establishment of sexual relationships, struggle for economic independence, and adaptation to changing expectations from peers and adults (Gilula and Daniels, 1969). Terms such as inexperience, risk-taking, sensation-seeking, impulsiveness,

and alcohol and drug "abuse" are some of the terms used to describe the behaviors of adolescents and young adults that may contribute to injury.

One study in Canada found that motor-vehicle crash rates of newly licensed drivers at age 17, 18 and 19 were similar to drivers of the same age who had been licensed one, two or three years (Pierce, 1977). Therefore, driving experience did not seem to be a major factor in the substantial decline in crash rates from age 16 to 19. A study of Michigan drivers found the opposite among 18-20 year-olds. Those with two-years driving experience had lower crash rates than those with one year of experience but the age effect persisted in addition to experience. Younger teenage drivers with the same experience as older drivers had higher crash rates (Eby, 1995). In such studies of nonfatal crashes based on police reports, differences in reporting crashes to police, which can be a function of insurance rating and other factors, may bias the results. A study of prior driving experience of licensed drivers in fatal crashes compared to a sample of same-aged licensed drivers would be more convincing. A case-control study of motorcyclists where the cases were identified from hospital ER cases and coroners indicated little effect of riding experience but familiarity with the motorcycle made some difference (Mullin, et al., 2000).

Distracted driving has been studied by use of vehicles equipped to record behaviors and near misses as well as crashes. The association of distracted driving and the outcomes were stronger among teenaged drivers than among adults but the confidence intervals on the magnitude of the effects were very large because of the small samples studied (Klauer, et al., 2014; Foss and Goodwin, 2014). A much larger study using on-board cameras estimated that 70 percent of teenaged crashes were attributable to inattention to driving, 58 percent while talking on the phone or to others in the vehicle, texting while driving, etc. The analyzed cases excluded crashes at less than 1 g of force, vehicles hit from the rear, and animal collisions (Carney, et al., 2015). Contrary to estimates of sleepiness being a major factor in teen crashes based on self-reports (e.g., Pizza, et al., 2010), the camera study observed “drowsiness” in less than 1 percent of the crashes. The male/female ratio (52 percent male) was much less than is found in fatal crashes. There may be selection bias in the estimates because the cameras were installed by parents. The motive for the installations is unknown but may have been partly due to parental knowledge that the their teens were easily distractible. No comparisons to adult crashes or teen driver behavior when not in crashes were included in the study so precise calculation of relative risk of the behaviors is unspecified.

The term "risk-taker" implies that the person knows the risk and deliberately behaves in such a way as to increase risk to self. Certainly some suicide attempts and assaults are the result of deliberate choices, but the extent to which perception of risk is actually associated with various types of risky behavior is difficult to research because of the questionable validity of self-reports of perceptions and behavior (e.g., DeJoy, 1992, Rhodes and Pivik, 2011). The

involvement of alcohol, other drugs, and mental illness in many cases of presumed deliberate assaults on self and others raises doubt about the pre-injury state of mind of the persons regarding perception of risk (Graham, 2003). In addition to or in combination with alcohol use, marijuana use is associated with hospitalization for a variety of injuries perhaps indicative of impaired assessment of risk (Gerberich, et al., 2003).

The hypothesis that risk-denial or belief in personal invulnerability is a factor is at least as plausible as the "risk-taker" hypothesis. Studies of perceived risk in motor vehicles indicate that younger drivers more often think their peers at higher risk than themselves, compared to such perceptions among older drivers (Bragg and Finn, 1982; Matthews and Moran, 1986), yet the authors of those studies persisted in calling the risk denying young drivers "risk-takers".

Motor vehicle injuries are common enough in the adolescent years such that prospective cohort studies could be undertaken to measure the extent to which genetic and hormonal differences, knowledge of risk, beliefs about personal vulnerability, impulsiveness, mental illness, conflicts with parents and lovers or peers, challenges from peers, and economic difficulties are predictive of becoming a driver in a crash causing injury. Becoming the assailant or the injured in an assault may be subject to study by similar methods, although identification of cases not reported to police would be difficult given the potential for reluctance to report involvement.

Unwarranted conclusions have been drawn from the examination of patients after injury and inference of pre-injury psychopathology. For example, one study of patients in a trauma center, excluding two-thirds (those with a Glascow Coma Score less than 15 as well as children less than 18 and those receiving narcotics for pain), claimed that the patients had higher than normal "pre-injury psychopathology". The measure of "psychopathology" consisted of a questionnaire with items such as "I feel isolated", "I have low/very low spirits" (Whetsell, et al., 1989). Administered to people in a hospital after trauma, it should have been obvious to the researchers that these are not necessarily measures of pre-hospital states of mind. No attempt was made to correlate the responses to the behavior of the respondents at the time of injury, i.e., did the respondents' behavior contribute to the injury or not? Prospective studies of questionnaire measures of psychological traits and car crashes do not indicate a correlation (e.g., Schuster and Guilford, 1964), but temporary psychological states are not captured by such methods (Robertson, 1983).

The literature on assaults and homicides is mainly limited to descriptive studies. Some correlations among relationship of assailant and victim, weapon if any, and biological, psychological, social, and demographic characteristics have been reported, but there is substantial disagreement regarding causation, partly resulting from numerous methodological issues (Rosenberg, et al., 1986). Characteristics of assailants and interactions among couples in domestic assaults have been described (Shupe, et al., 1987), but no data were collected on couples

not involved to be able to say that the alleged causal factors were less prevalent in those who do not have such problems. Comparison of domestic homicides vs. other homicides (Joudis, et al., 2014) or gender differences in firearm suicides (Kaplan, et al., 2009) are of dubious value. They are all dead and without knowledge of the prevalence in the population of the factors identified, the relative risks remain unknown.

Race is emphasized in many studies of homicide because of the very high rates among young black males. Studies of domestic homicide indicate, however, that the correlation with race disappears when household crowding is controlled statistically (Centerwell, 1995). Rates of assaults and other crimes of mostly black juveniles with single parents plunge when they move from poverty neighborhoods to more middle class environments in random housing assignments (Ludwig, et al., 2001). It is the socioeconomic consequences of the way races have been treated historically and the criminal cultures that have historically accompanied poverty among a variety of ethnic groups that explains the differences in violence, not the genetics of race. In some cases, poverty is mitigated by cultural factors. It has been claimed that recent Mexican immigrants to the U.S. have substantially lower involvement in violence than would be expected from their economic status (Sampson, et al., 2005), but the claims are based on self-reports which are less reliable than counts of fatal cases. Some immigrants to the United States apparently adapt to the gun culture quickly. Although suicide rates are lower, homicides rates are higher among many immigrant groups than among their counterparts of similar ethnic origin (Sorenson, Sorenson and Shen, 1999).

Aggression has been studied extensively in controlled laboratory experiments under a wide variety of experimental conditions (Mattson, 2003; Siegel, 2005). The relevance of these studies to assaults in homes, streets and bars, or to aggressive driving, is open to debate. One well-designed study of alcohol and aggression in college students, for example, randomly divided the students into four groups: 1. alcohol and threatened 2. alcohol and not threatened, 3. placebo and threatened, 4. placebo and not threatened. Strong flavoring masked the alcohol and placebo. The subjects were placed in a situation where they were supposedly competing with a person in another room on a reaction-time task in which each subject could deliver an electric shock to the other. The situation was presumed as threatening, but those in the "non-threatened" condition heard their "opponent" object to hurting someone. There was no difference in intensity of shock delivered to "opponents" between those with and without alcohol in the non-threatened groups. Those in the threatened group delivered more intense shocks to their "opponents" and, if they had also consumed alcohol, they delivered very strong shocks to their "opponents" (Taylor, et al., 1976).

Given knowledge of such results, an injury epidemiologist wants to know how much of the variation in assaults can be explained by alcohol and threatening situations. How does a researcher obtain unbiased samples of assailants and

potential assailants in which alcohol can be measured? What constitutes a threat? Is there a relatively small set of threats that can be identified in large numbers of assault cases? Is the assault directed toward someone perceived as threatening or a scapegoat such as a child, spouse, or lover?

If the set of factors that are threatening to persons who are potential assailants were limited to a few, such as unemployment or fear of unemployment, harassment by peers, and degradation of self-esteem by spouses or lovers, then it may be possible to find ways to help people cope with such threats. If the threats are so diverse that none accounts for a substantial part of the problem, then the probable success of changing threats to reduce assault is diminished.

Among the most publicized claims about causation of spouse and child battering is that the batterer was abused as a child. While being abused as a child may increase the risk of becoming an abusing adult, the majority of abusers were not abused as children (Rosenberg, et al., 1986). Therefore, as desirable as reduction in child abuse would be, it would not reduce battering in the next generation as much as the publicized claims would have us believe.

Intimate partner homicide is substantially related to mental illness (Farooque, et al., 2005**).** One way of studying these issues in a population would be to identify from police records a sample of households that had one or more domestic disputes reported within the past year. Controls for comparison could be selected by identifying residents of other households in the same residential block and randomly choosing one or more that had no domestic disputes reported to police in the past year. Interviews with family members, preferably augmented by validity checks where possible -- such as employment history, might reveal a set of threats, mental illness or other factors that, separately or in combination with alcohol, are amenable to change. Self-reports of violent sexual aggression did not involve alcohol use disproportionately, but did involve resistance to alcohol use by the victim (Racket, et al, 2004**).**

The advantage of police-reported cases is the potential for obtaining objective data on alcohol. A small pilot study could be undertaken to see whether cases and controls would cooperate with a request for breath alcohol, the controls at the same time of day and day of week as the dispute was reported in the cases.

The study design would be subject to criticism because it would not identify the set of battered women and children that do not come to the attention of police. Protocols for identifying such cases have been developed (Stark, et al., 1981), and researchers with clinical affiliations should be able to identify many such cases in that setting, but objective measurement of alcohol in the batterer in those circumstances probably would not be feasible. Great care must be exercised in such research to avoid placing the battered person at greater jeopardy for having revealed the batterer, however inadvertently.

Descriptive studies of suicides of teenagers and young adults indicate clusters of types of problems (legal, interpersonal, history of mental illness), method used (firearm, hanging, drugs, gas), and age group (Gerberich, et al., 1985). Case-

control studies, such as the Houston study (Silverman and Simon, 2001), are needed to determine which from among the identified factors are risk factors or can be used to identify persons at higher risk. One such finding from the Houston study is that attempters had changed residence more often than controls within the last 12 months. Another design would select cases from each cluster and controls with similar problems to reveal the extent to which suicides within a given cluster are correlated to the misfit of personality and social environment, availability of method used, and other variables in theories of suicide.

Little research has been conducted on attempts to change exposure to potential injury hazards by offering programs to youth that keep them from hazardous environments. In the United States, programs to open schools and other facilities for "midnight basketball" for low-income youth was treated as a joke by political opponents of any government involvement, rather than taken seriously as a program to be studied (Hartman, 2001). Claims of success based on simple trends in crime rates in cities that have the programs are inadequate (Farrell, et al., 1996). Controls on changes in other factors, such as influx of recent immigrants, are needed to rule out those factors as explanations. In Brazil, some 370 programs to engage so-called "street children" in productive activities were initiated, but the effect on injuries and other problems of these children has apparently not been evaluated (Berger and Mohan, 1996).

A neglected area of research in adolescent and young adult injuries is the extent of recruitment to danger. To what extent is the use of cars and guns in hazardous ways a function of nightly doses of television portrayals of such behavior? To what extent do organized clubs for hazardous activities recruit new participants? What is the involvement of the industries that sell equipment for hazardous activities (e.g, hang gliding, scuba diving, sky diving, motorcycling, gun use, fast cars) involved in promoting the activity through clubs and magazines? How many of the injured were led to the activity by such promotion?

For example, members of the Sports Car Club of America, matched by age and gender to nonmembers, were found to have higher crash rates and speeding violations (Williams and O'Neill, 1974). The unanswered question is whether those who are wont to drive fast join such clubs or are recruited into the club and adopt the speeding culture after joining.

ADULTHOOD. Until recent years, injury rates in the adult pre-retirement years of life were lower than among children and adolescents for most types of injuries. Injuries to workers in certain occupations were major exceptions (Baker, et al., 1992). The generally lower rate of most types of injuries as people proceed through adulthood could be partly from greater knowledge of risks and partly from changes in exposure, such as reduced driving at night and reduced "partying" on weekends. An exception to lower injury rates among adults is

poisoning from prescription drugs. In the 21st Century, death rates due to prescription painkillers have soared and the increase was mainly among the 25-64 year age group (Figure 10-3).

Following studies claiming that pain was under medicated, in the 1990s the standard of medical care for use of opium-based drugs was altered to recommend larger doses. These drugs are addictive and addicts often become desperate to obtain the drugs. A study of 275 cases of opioid caused deaths in West Virginia, among the states with the highest drug caused death rates, less than half had been obtained by prescriptions (Hall, et al., 2008). Doctor shopping for physicians who would prescribe an opioid was found among 30 percent of women and 17 percent of men. The remainder was obtained from others who were prescribed the drugs or through illegal drug dealers. Similar studies in lower prevalence states are needed to see if the percentages in this study are generalizable.

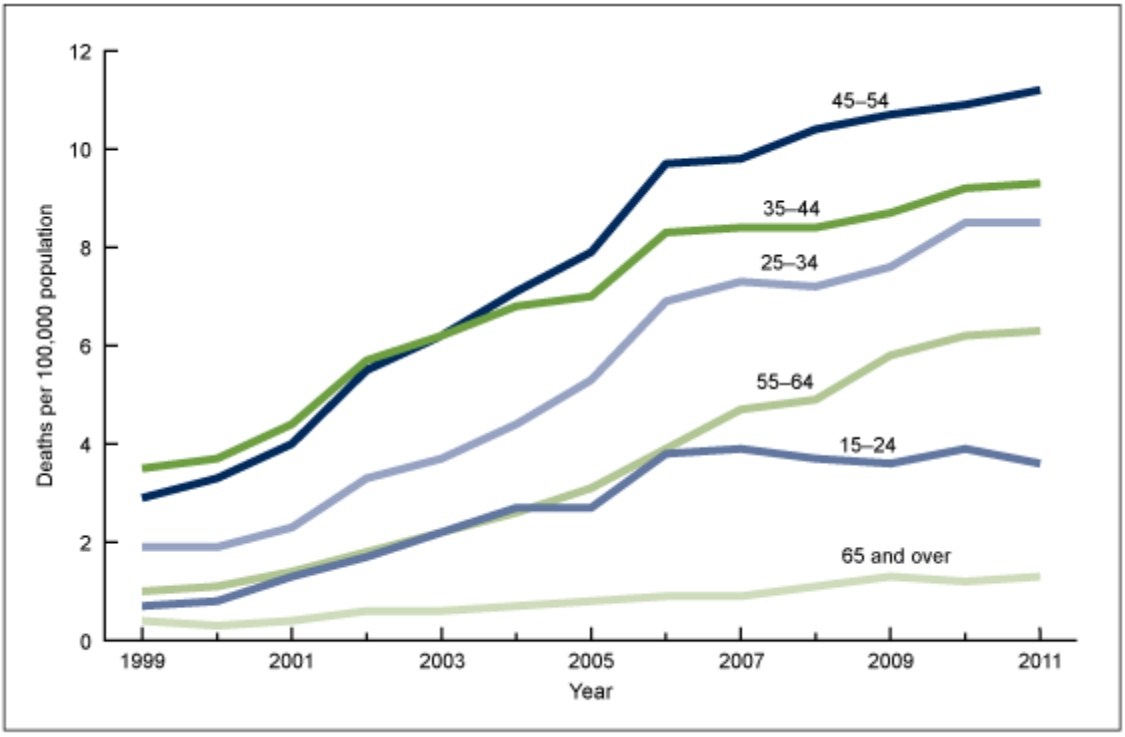

Figure 10-3. Opioid-analgesic poisoning death rates, by age group: United States, 1999–2011. Source: http://www.cdc.gov/nchs/data/databriefs/db166.htm

In a study of death certificate data nationally in the U.S., drugs indicative of treatment for mental disorders were found in significant numbers in combination with opioids -- 30 percent benzodiazepine (a sedative and muscle relaxant) and 13 percent antidepressants (Jones, et al., 2013). Risk of death is also associated with higher prescribed dosages except among dying patients in palliative care (Bohnert, et al, 2011). Some "overdose" deaths may be partly attributable to drug

interaction effects. A comparison of patients prescribed opioid analgesics in combination with benzodiazepine and patients prescribed only opioid found that the risk of death attributed to overdose more than doubled with the addition of benzodiazepine (Park, et al, 2015).

A big question raised by the trends in the age-related opioid poisoning is why the relatively low rate of increase among the elderly? Pain for which the drugs are prescribed is more frequent and severe among the elderly than among younger people because of arthritis and deteriorating bone structure. Do physicians consider these pains less worthy of opioid prescriptions? Are the elderly less susceptible to addiction? Are the elderly less willing to doctor shop or obtain drugs illegally? Or are drug deaths among the elderly more likely to be attributed to other causes?

There is little evidence that personality traits are related to injury risk or perceived risk. Psychometric methods are found inadequate to explain differences between actual and perceived risk (Sjoberg, 2000). Injury risk is higher among the mentally ill. Repeated hospitalizations for unintentional injury was more than twice as frequent among the mentally ill as among other patients treated for injury in one study (Wan et al., 2006). Suicide risk is 20-30 times higher among victims of bipolar disorder than those without the disease (Pompili, et al., 2013). Failure to take prescribed drugs and self-medication with alcohol and other substances is associated with violence of the mentally ill (Swartz, et al., 1998).

A major factor in changing behavior is overcoming denial that one is susceptible to a known or perceived risk. After presenting the risks of gassing, hand burns, and child poisonings from household cleansers to a sample of consumers, they were asked how much more or less likely than average such injuries were in their homes. Only 2-3 percent said more likely and 40-65 percent said less likely (Viscusi and Magat, 1987). These results are similar to those obtained when a random sample of new-car buyers were asked whether their chances of being injured or killed in a car crash were greater than, the same as, or less than "people like yourself." Six percent said greater and 40 percent said less. Denial was not related to claimed willingness to pay for improved crash protection in motor vehicles, however (Robertson, 1977). An interesting research project would be to see if denial of risk is associated with actual probability of injury but the study would have to be done prospectively because denial may be influenced by injury experience.

Race and gender differences that persist in particular types of injury rates are often cited, but race and gender are no more modifiable than age. They are of interest only as identifiers of groups in which causal factors differ in kind or magnitude, or as identifiers for targeting programs to modify risk factors.

Too often conclusions about race and gender are based on stereotypes. In the 1980s when I told colleagues I was reviewing the literature on injuries to Native Americans, virtually every one stated with conviction that alcohol accounted for

the higher injury rates in that population. The literature indicated that, while alcohol is a problem among several Native American groups, it probably does not account for nearly the variation in injury rates that stereotypical thinking suggests. The only study found in which blood alcohol was measured among injured Native Americans indicated that more Native Americans were tested in the same jurisdiction relative to whites, 63 percent versus 45 percent (Westermeyer and Brantner, 1972). Therefore, the involvement of alcohol measured objectively was not available in a sample without potential selection bias. A later study of Native Americans and others in fatal motor vehicle crashes in Arizona relied on invalid police reports for the majority of assessments of alcohol in Native Americans (Campos-Outcalt, et al., 1997). Although the article claimed that there was no difference in the proportion chemically tested for alcohol concentration, recalculation of the numbers in the article indicates that 33 percent of Native Americans were tested and 56 percent of others were tested. If the police were more oriented to expecting alcohol in Native Americans, the estimate of alcohol involvement would be biased.

There was a 29-fold difference in deaths attributed to "alcoholism", cirrhosis, or alcohol poisoning among different groups of Native Americans in Oklahoma (Stratton, et al., 1978). Age-adjusted alcoholism death rates among Native Americans declined about 40 percent in the early 1980s (Howard, et al., 2000). Self-reported total abstinence from alcohol is twice as high among Native Americans as among whites. In groups where intoxication is frowned upon, drinking is done alone and in secret. In groups with a tradition of the seeking of visions and endurance dancing, heavy alcohol consumption in public is more acceptable, particularly among young males (Levy and Kunitz, 1974; Kunitz, 1976; May, 1982). The stereotype apparently evolved from historical accounts of "Indians and firewater" and the very noticeable public drinking in certain groups, particularly in towns near reservations.

The social factors that influence if, when, and where drinking occurs undoubtedly influence the risk of particular types of injuries, such as the high rate of deaths from cold and exposure among Native Americans in New Mexico (Sewell, et al., 1989). Prior to declines associated with injury control programs for Native Americans (Smith and Robertson, 2000), Native Americans who obtained medical care from the Indian health Service had about three times the injury death rates of the United States population as a whole. When I compared total injury death rates of Native Americans with those of rural isolated populations generally, however, the differences were small (Robertson, 1985).

Among U.S. Navy personnel, Native Americans were hospitalized for "alcoholism" three times more often per capita than whites or blacks, yet their hospitalizations for injury per capita were 13 percent less than those for whites and blacks (Hoiberg, et al., 1981). The point is that injury rates are similar among races whose living and working conditions are similar. The major explanations for racial differences in injury rates are more likely to be found in the vehicles

and environments to which they are exposed rather than in biological and personality theories, or racial stereotypes. According to a CDC WISQARS death certificate search, the age adjusted Native American injury death rate declined to 1.1 times higher than the all-U.S. rate by 2013. The rates among those who are served by the Indian health Service are higher but have declined more rapidly than among the U.S. population generally in association with surveillance activities and evidence-based injury control programs (Chapter 7).

The extent to which gender differences in injury rates can be attributed to biological factors, social factors, or interaction among biological and social factors, probably differs by type of injury. Women usually experience fewer severe injuries of most types as teenagers and adults, but there are exceptions. In domestic violence that does not involve weapons, women often strike men as well as vice versa, but the severe injuries from violence in homes are most often to women and children (Rosenberg, et al, 1986), probably because men are physically stronger, on average, than women and children. Most of the studies of dominance behavior, hormones, alcohol and other potential factors in aggressive behavior have not included women (Mazur and Robertson, 1972).

GROWING OLD. Severe injury rates tend to increase among the elderly for several types of injury (Rice and MacKenzie, 1989). Although some exposures are decreased among the elderly (e.g., miles driven, driving at night), and injury incidence is lower, the consequences when injury occurs in length of hospital stays and mortality are more severe because of decreased resilience to trauma. Decreases in visual acuity, hearing, mental alertness, as well as multiple prescription drug use probably increase risk of incidence, but reduced exposure to driving, industrial machines, and farm equipment probably results in lower incidence. Certain exposures, such as use of stairs or walking on other surfaces that are conducive to falls, are not changed or may even increase after retirement. The elderly have particularly high injury rates from falls. In social environments where the young prey on or abuse the elderly, they are the victims of assault, and some resort to suicide to escape social circumstances or physical debilitation that they are no longer willing to tolerate.

Elderly people suffer various types of losses including friends, spouse, occasionally a child, job, status, income, power, self-esteem, self-confidence, hearing, sight, other aspects of personal control or competence, and health, all of which are thought to contribute to suicide (Osgood, 1985). In a case-control study in Sweden, suicide risk was substantially higher in persons with visual impairment, neurological disorders and malignancies (Waern, et al., 2002). Many among the elderly support the availability of physician-assisted suicide for the terminally ill, such as that first allowed by law in Oregon and now several other U.S. states as well as countries elsewhere. Combined homicide-suicide among the elderly, where the involvement of guns predominates, has also been studied by case-control methods (Malphurs and Cohen, 2005).

The exact contribution of exposure to energy exchanges by degree of energy generated versus tissue vulnerability to particular types of energy among the elderly has not been specified. Certainly the injured elderly person with the same degree of severity as a younger person is more likely to die than the younger person (Baker, et al., 1974) which probably accounts for much of their high involvement in fatal crashes per mile driven (Figure 10-3).

Attention to risk of falls in the elderly has increased. Among the factors related to falls potentially amenable to change are leg extension strength and gait (Graafmans, et al., 1996; Tinetti, et al., 1995a) and modifiable environmental factors, such as characteristics of stairs (Tinetti, et al, 1995b), which have been found markedly different between the homes of fallers and controls in a case-control study on an Indian reservation (Locklear, 1991). Use of video footage in elder care facilities can further specify the circumstances of falls (Rabinovitch, et al., 2013). Studies of falls refer to relatively strong correlates (multiple pharmaceutical use, visual acuity and fear of falling) as "predictors" (Delbaere, et al, 2006) but do not consider how many false positives and false negatives occur in such predictions. That information is important to apply countermeasures efficiently.

POST-TRAUMA BEHAVIOR. Combat veterans have higher injury rates than other military veterans. Various hypotheses have been advanced to explain this finding but none have been tested adequately (Bell, et al., 2001). There are many studies of posttraumatic stress disorder among combat veterans compared to veterans and others not in combat but the sample sizes are too small to detect subsequent injury risk (e.g., Koren, et al., 2005). Self-reports of combat experience are correlated to self-reports of alcohol use known to increase risk of injury (Wilk, et al., 2010).

Obviously, the lives of persons with non-corrected disabilities are changed -- drastically in the case of severe spinal-cord and brain injury. Documentation of the extent of these effects is important to understand the total, often non-quantifiable, costs of injury. Comparison of injured and non-injured controls would better specify the effect of war experiences.

Other effects of injury may be subtler or not appear immediately. How many people change their behavior as a result of injury? What is the effect on subsequent fear and anxiety of trauma to oneself or to relatives and friends? To what extent does neighborhood violence change the behavior patterns of people in the neighborhood? Does fear of falling result in less mobility among the elderly (Tinetti, et al., 1994), further contributing to the risk? Does subtle brain injury contribute to intellectual or emotional deficits, or increase risk of brain diseases such as dementia and epilepsy?

Some of these questions raise thorny methodological issues. To the extent that the hypothesized effect of trauma could also contribute to the incidence, post-trauma measurement may overstate the effect of trauma. For example, one

research project measured intelligence quotients of persons who had been injured and correlated them to the injured persons' scores on the Glascow Coma Scale and the Injury Severity Score. Persons who were more severely injured had lower IQs (Gensemer, et al., 1989). However, if lower IQ contributes to the probability of severe injury, the inference of a causal effect of trauma on IQ would be overstated. A correlation of lower pre-crash IQs (measured at army induction) and fatal motor vehicle injury has been found (O'Toole, 1990).

Where pre-injury measures are available, such as IQ scores from school, military or other records, researchers interested in post-trauma effects should attempt to obtain the records. Where such measures are not available, the IQ of a sample of siblings or childhood friends of the injured could be used for comparison. To the extent that IQ is predictive; the issue of limits to modifiability of IQ are relevant to choice of injury control methods..

Case-control studies of Alzheimers's disease consistently find a history of head trauma more frequent in persons with the disease -- 24 percent of cases and 8 percent of genetically unrelated relatives and friends matched by gender and approximate age in one study (Graves, et al., 1990). The odds ratios were higher for those whose head injury did not result in loss of consciousness and among those with more recent head trauma. Although there are reasonable biological explanations for head trauma contributing to the disease and the average period between the head trauma and onset of symptoms minus one year was long -- 21.3 years for cases -- it is not possible to exclude the disease or some correlate of the disease as a precursor to trauma rather than exclusively a post-trauma effect.

A study of recalled loss of consciousness from injury found no association with dementia while following elderly participants every two years. Those with a claimed history of loss of consciousness did experience more injuries during the study period (Dams-O'connor, et al., 2013). A review of recent research is available online (Smith, et al., 2013). It would be useful to compare cases in which the behavior of the person did or did not contribute to the injury, but recall of spouses or others regarding long past incidents is a major methodological problem.

Appendix 10-1. Prior Risky Behavior as a Predictor of Future Behavior

A lot of behavior is habitual. Most people have routines that they follow daily to fulfill the needs of daily life (sleeping, eating, cleaning, child care, shopping, commuting and working) with substantial variation on days that they are not working or attending school. We go to bed and arise at about the same time, eat at about the same times of day, drive or walk our workday commutes, work or attend classes during specified hours, etc. This raises the question of the extent to which we habitually behave in ways that increase or decrease our risk of injury. We can reduce risk of severity of injury by developing habits such as putting infants and young children in appropriate restraints while traveling in motor vehicles and buckling up ourselves (Aarts, et al., 1998). More research on habit formation with respect to injury-related behavior might be useful.

From what we know, a reasonable hypothesis is that people who habitually act in risky ways would have greater frequency of incidents such as vehicle crashes. However, the correlation of crashes sequenced in time is surprisingly weak. The notion that crash incidence could be efficiently predicted by crash histories (i.e., some people are "accident prone") was repeatedly shown to be false (Forbes, 1939; Peck, et al., 1967; Stewart and Campbell, 1972). For example, in their study of California crash records, Peck, et al (1967) stated, " … the accident population is largely a changing one from year to year. Of those drivers who were accident involved in both 1961 and 1962, 86.8 percent were accident free in 1963. Conversely, the previously accident-free drivers accounted for the vast majority of accidents in 1963."

Certain behaviors, such as excess use of alcohol, are more related to severity of injury than incidence (Haddon, et al., 1968). Based on that premise, Susan P. Baker and I searched the Maryland police reports and DMV records for prior violations and crash involvements of drivers in 1447 fatal crashes compared to a random sample of 2525 drivers who survived during the same period of time (Robertson and Baker, 1974).

We found that the more convictions a driver had within the prior three years, the greater the probability that the driver would be involved in a fatal crash (Figure 10-4). The darker bar represents the fatally involved and the lighter bar drivers in the sample of all drivers. The emphasis here is on "probability". Fifty-two percent of the drivers in fatal crashes had no prior violations. Any screening of drivers with even one violation would miss half of those who would be involved (the false negatives discussed in Chapter 9). And 16 percent of all drivers would be identified as high risk (false positives). That may not seem very high until you consider that there are about 250,000,000 drivers in the U.S. Sixteen percent would be 40,000,000. If you start a program to rehabilitate or deter the behavior of 40 million drivers, you had better be sure that the program is substantially effective or you will waste a ton of money and a lot of peoples' time.

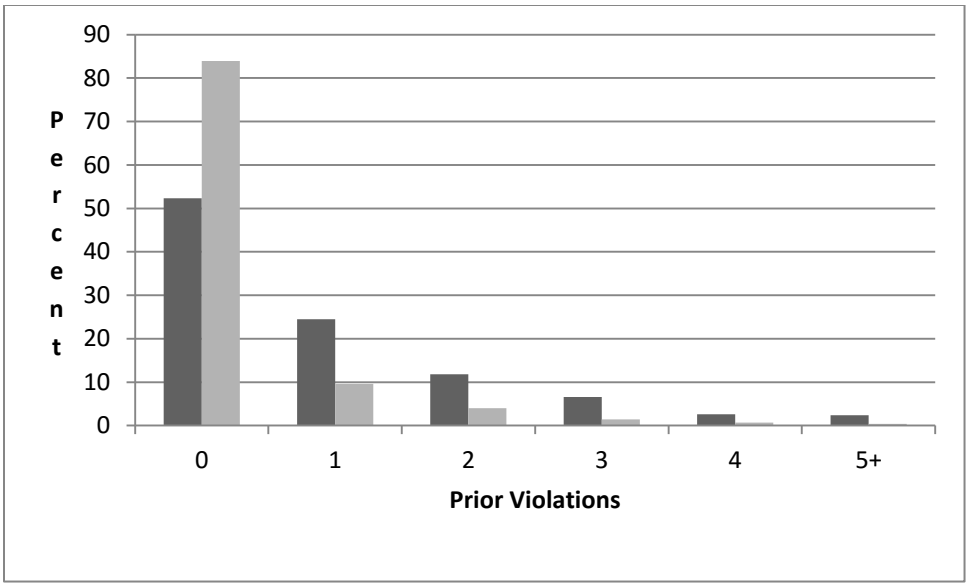

Figure 10-4 Percent Prior Violations of Fatally Involved and All Drivers

References – Chapter 10

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