Injury Epidemiology: Fourth Edition

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Chapter 3. RESEARCH OBJECTIVES AND USABLE D*ATA*

Most of the research on forms of energy that injure people and the vulnerability of human tissues has been done. The issue for injury epidemiologists is to find the factors that can be changed to reduce exposure to the energy in rates and amounts that have severe consequences and evaluate the effectiveness of attempts at amelioration. Some scientists argue that their job is to understand phenomena without concern about the consequences of use of their findings. If they wish to pursue that philosophy, that is their right but any use of taxpayer's money for such research is questionable. The public has the right to demand that taxes be used to benefit the common good.

For example, occasionally when I hear or see a news report that attributes a number of deaths to a weather event such as a large snowstorm, I am tempted to research the possibility that storms reduce deaths. Slick roads certainly increase the risk of a crash to those who choose to drive on them. But to the extent that people stay off the roads during a storm, their exposure to risk of a severe injury is obviously reduced. I resist the temptation to do the study because we can't control the weather. The study would likely make no contribution to injury control.

The first step in any research project is to ask a question or state a hypothesis that defines the objective of the study. The objective of the study influences the study design and the data needed. Even in very limited descriptive studies, one may have the opportunity to examine or collect data on various aspects of an injury: the severity of the injury, the energy sources involved, characteristics and behavior of the persons injured or others at the scene, the places of occurrence, the circumstances, the treatment received, and the cost of treatment.

There are numerous variables descriptive of each of these aspects and the possible combinations of potentially measurable categories of the factors are very large. If all the possible combinations of classifications of factors were tabulated, data on an enormous number of cases would be necessary to obtain stable statistics. Obviously, a coherent and practical research project requires great care in choice of a research question, study design and choice of variables to answer the question.

RESEARCH OBJECTIVES, STUDY DESIGNS AND DATA NEEDS. To contribute findings that are useful in the effort to reduce injury, the researcher must have a clear understanding of how the data may be used. Too many research reports describe the cross tabulations of available data, such as the age and sex distribution of injury X, without any discernable objective. Table 3-1 presents a set of research objectives and study designs would likely contribute to efforts to control injuries.

Table 3-1. Objectives of Injury Research and Control with Research Design

Objective	Research Design
1. Select the most important injuries for surveillance.	Tabulate fatalities and hospitalizations by E-codes.
2. Efficiently apply known countermeasures for homogeneous subsets of injury.	Surveillance of who, when, where and how people are severely injured by subsets.
3. Find changeable factors that will reduce injury and quantify measures of the factors and research the reduction expected.	Reliable and valid designs that control for confounding factors.
4. Develop causal models of homogeneous subsets of injury.	Measure all possible risk factors and specify sequential time order of variables.
5. Evaluate the effectiveness of an intervention.	Introduce the intervention in a realistic setting controlling for other factors, preferably with an experimental-control design.
6. Evaluate the cost- of effectiveness of alternative interventions.	Estimate cost of each intervention and degree overlap in effectiveness among them.

The International Classification of Diseases has two types of codes for injury -- so-called N codes and E codes. The N codes are diagnosis codes (e.g., type and anatomical location of a fracture) and may be coded or extractable from hospital records. E codes are codes for broad categories of circumstances (e.g., motor vehicle, poison, fall, gunshot). E codes are available on death certificates, with greater or lesser accuracy depending on type of injury. In hospital records, however, one often cannot tell anything about how an injury occurred. For example, the record of a fracture often does not indicate whether the injury occurred in a motor vehicle crash, a fall, or in an assault. Even less often is there information on where the injury occurred (geographic location such as street address, highway milepost, global positioning). Without such information, specification of the scope of injury problems and the choice of those that need the most attention cannot be adequately done. Clinicians could aid injury control enormously by inclusion of when, where and how an injury occurred in the history. E-codes used to designate circumstances of injuries can be seen at: http://www.cdc.gov/ncipc/whatsnew/matrix2.htm.

To apply known countermeasures efficiently, detailed surveillance of when, to whom, where and how specific types of severe injuries occur is needed (Item 2, Table 3-1). There are two reasons for emphasizing only severe injuries, such as hospitalizations and deaths. First, large numbers of minor cuts, bruises, abrasions, and burns occur in circumstances that are substantially different from severe injuries (Rice and MacKenzie, 1989). Attempts to control the most frequent injuries will misdirect resources from the most severe and costly injuries. Second, including only hospitalized and fatal injuries remarkably reduces the cost of data collection.

Data on location and how the injuries occurred has led to large reductions in fall, pedestrian and vehicle-occupant injuries in the limited instances in which such data have been collected (Chapter 7). Simple pin maps of types of injury often indicate stretches of roads, intersections, or clusters of housing in which injuries occur. Obvious remedies are often revealed by visits to the sites (e.g., night lighting, sidewalks, moving or uncovering obscured stop signs, properly timed yellow lights, installation of guard rails, and repair of dilapidated stairs).

In those instances where contributing factors or countermeasures are not obvious, well-designed analytic studies may specify how much a changeable factor would contribute to injury reduction if changed (Item 3, Table 3-1). Suppose, for example, that your community has a high rate of severe injuries to children from falls on stairs in or attached to houses. The research question is the extent that changes in stairs would reduce the injuries. One way to answer the question is to do a case-control study comparing characteristics of stairs where children were injured to stairs in randomly selected households with similar-age children where injuries did not occur. Such a study of stairs in houses of the elderly found substantial differences in levelness, horizontal width, step width, absence of hand rails and lighting (Locklear, 1991). A second aspect of the research would compare the factors relevant to falls of children and the elderly to make sure that any recommended modifications of stairs would reduce injuries in both populations.

The development of elaborate causal models of the sequence of factors that lead to injury is the goal of some researchers, but it is the least productive research activity leading to injury control (Item 4, Table 3-1). The point of injury control research is not to specify some original cause in a sequence of factors, but to specify changeable factors that reduce injuries irrespective of other factors. As noted in Chapter 2, an injury cannot occur unless there is an energy exchange with the human anatomy beyond the tolerance of human tissue. Any countermeasure that reduces such energy exchanges will reduce injury severity irrespective of the factors that increased the probability of the event. The more proximate a risk factor to the energy exchanges, the greater the likelihood that changing the risk factor would have an effect on injuries (Chapter 8).

The effectiveness of interventions, where unknown, can best be studied in controlled experiments (Item 5, Table 3-1). That includes medical care interventions, acute care and rehabilitation (Chapter 14) as well as some types of prevention (Chapter 11). In the case of laws and regulations aimed at prevention, random assignment of treatments is usually not possible, so quasi-experimental designs using jurisdictions where the law was not enacted for comparison as well as other study designs are necessary (Chapters 12-13).

If there is more than one countermeasure that reduces substantially the same types of injuries, the degree in overlap of effectiveness and the relative costs of the countermeasures must be considered (Item 6, Table 3-1). The allocation of resources to duplicative efforts consumes the resources available to reduce injuries that are not being addressed (Chapter 15).

Students choosing topics for library research papers, or data for a thesis, often approach an instructor with a vague statement such as "I am interested in children's injuries." A conversation usually follows, the point of which is to get the student to specify the objective of the research and narrow the topic to a researchable question given the time and resources available. What age range is considered childhood? Since the activities of children vary by age, are there specific activities in a specific age range that you think might be related to certain types of injury? How severe are those types of injuries? Would they occur in limited number of settings? What are the energy exposures in those settings that might injure? How is the energy conveyed to the hosts? How many would receive treatment and where? Are you more interested in implications for treatment or in reduction of incidence or severity? What do you think is the most important information needed to improve treatment (or reduce incidence or severity)?

To find out what needs to be known, one must first find out what is known. The best way to choose an original research question is to survey the scientific literature on a topic and make a list of questions that come to mind in reading the literature. A good place to begin a literature search is Google Scholar or PubMed. A search of PubMed may miss important research in the social and policy sciences relevant to injury control. Significant research on topics such as behavioral, social and cultural factors, violence, and the effects of laws and incentives on behavior is often found in the behavioral and social science literature not indexed in PubMed. If unanswered questions remain at the end of the literature survey, and they are researchable questions, the choices of potential topics for research are evident.

Before embarking on a research project in injury epidemiology, training in scientific methodology and statistics is essential. If one does not understand scientific principles of measurement and classification of phenomena, and the use of statistical methods to describe and analyze the data, the production of a publishable or useful study is very unlikely. Indeed, some of the scientific literature is unintelligible to a reader without such understanding, and some of it is easily seen as invalid, or at least highly questionable, when viewed by the informed reader (Riegelman, 1981).

One way of judging the adequacy of a published literature review is the extent to which it is critical of the research reviewed. A review that just lists studies and what they said, without indicating which are the most methodologically valid, is much less useful than a critical review. Other criteria include the dates of the studies covered in the review. If the review's bibliography lists no studies of recent vintage or no studies several decades old, the review is likely incomplete. Occasionally researchers new to injury epidemiology reinvent the wheel, sometimes in the shape of an octagon, apparently because of the lack of knowledge of previous studies.

Descriptive studies may be devoted to the identification of all injuries in a population, based on some minimum severity criteria, or may be focused on place of occurrence (e.g., roads), particular types of disability (e.g., spinal cord), a subset of the population (e.g., children), those associated with a given activity (e.g., swimming), or any number of other categories.

Decisions about what data are needed can be greatly facilitated by thinking at the outset how the data are to be used. Which of the objectives noted in Table 3-1 is a general objective of the study? How can that objective be refined into specific aims? What specific statistical distributions of what variables are needed to reach decisions based on the conclusions? Actually constructing statistical tables that one intends to fill with data will force the identification of variables that must be measured, reveal definitional problems, and identify relevant categorizations.

FINDING USABLE DATA. Often one does not have the resources to collect original data and must find a data set that includes the variables and categories needed to answer a particular question. Many of the classification schemes used by organizations devoted to the compilation of injury statistics were developed before the application of epidemiologic concepts and scientific principles. This does not mean that all of them are useless, but the uses to which the data are put are sometimes illogical and counterproductive to injury control, at least partly due to poor classification schemes.

As noted in chapter 2, injury classifications are often a mixture of vehicle, host or circumstantial characteristics. For example, the National Safety Council for decades attempted to assemble data on "accidents" as well as injuries and reported its estimates in Accident Facts, an annual publication now called Injury Facts. The broad categories used include: work, motor vehicle, public, home, farm, and school. These categories are inconsistent with one of the fundamental principles of classification; classes should be mutually exclusive, that is, a case should be classifiable in one and only one category.

Most farmers would consider their occupational activities as work and increasing numbers of persons in non-farm occupations work at home. Some people are injured in or by motor vehicles while engaged in their occupations. The National Safety Council is not alone in use of categories that are not mutually exclusive. In the National Health Interview Survey, conducted by the National Center for Health Statistics, similar categories were used, although in both systems the motor-vehicle cases that occur while working or in the home driveway were classed systematically as motor-vehicle rather than work or home (National Center for Health Statistics, 1986). The 2004 report from the survey on child health hardly mentions injury and combines injury and illness in statistics on days lost from school: If one wanted to use the data to target the primary health-related causes of school absenteeism, the data are useless.

Total numbers of deaths from injury of those who die soon after injury are probably counted in total with reasonable accuracy excepting some, such as electrocutions classified as "heart attacks", or pneumonia in the elderly bedridden because of a fall. People whose disabilities from injury shorten their lives later, such as those with spinal cord injury that die from infection, usually do not have their deaths counted as injury deaths.

Categorization problems, along with differences in data sources, can produce remarkable differences in estimates of numbers of injuries, or even deaths, the most easily countable injuries. The National Safety Council estimated 11,700 worker deaths from injury in 1984 compared to 3,740 counted by the Bureau of Labor Statistics (BLS) in its annual survey of businesses. Some of this difference is due to the fact that certain small businesses and farms were excluded from the BLS survey, but that cannot possibly account for such a large difference in the estimates (Panel on Occupational Safety and Health Statistics, 1987). More recently, the National Safety Council indicates that it relies on BLS data (National Safety Council, 2013) but, in contrast to the earlier discrepancy mentioned, its numbers are consistently several hundred less per year than BLS numbers (BLS, 2013). In India, the national railway reported 1000 railway-related fatalities compared to more than 10,000 estimated from police reports. The railway only reports cases where a railway employee or equipment was judged at fault (Berger and Mohan, 1996). In February, 2015, a query of the CDC WISQARS fatal injury files indicated that 9,948 motor vehicle occupant deaths, exclusive of motorcyclists, occurred in 2012 (CDC, 2015) compared to 22,912 counted in the National Traffic Safety Administration's Fatality Analysis Reporting System (NHTSA, 2015). The latter is the more accurate number. Apparently thousands of death certificates, on which the CDC data are based, do not specify that the death was to a vehicle occupant. Obviously, the researcher relying on any data source must be aware of who is doing the counting and the definitions they use.

A second principle of classification is that the classes are exhaustive, that is, there should be a category for every case. Again looking at the National Safety Council categories, where would one classify an injury to a child playing touch football in the field of a neighbor's farm? It would be misleading to call it a farm injury, and it didn't happen anywhere in or near the child's or neighbor's home, at school, or in a public place.

The point here is not to pick on organizations that employ scientifically inadequate or non-useful categories. The point is to avoid using categories that are not mutually exclusive, exhaustive, and meaningful relative to the uses to which the data might be put. Injury researchers choose their projects for all sorts of reasons -- personal experience with or concern about a particular type of injury, intellectual curiosity, or the need to identify a problem that will attract grant support perhaps being the most common. Whatever the motivation, consideration of the usefulness of the data to be collected would perhaps accelerate the use of categories that enhance the linkage between injury epidemiology and injury control. The definition of what constitutes a case and precision and accuracy of severity measurements are crucial.

Usually the most useful injury categories are those that are relatively homogeneous as to energy source and vehicle or vector of the energy. For example, if one is interested in burns, the place of injury -- home, school, restaurant, or hotel -- may or may not be important. The same energy source may be the major culprit at each of these sites. Burns from heated liquids spilled from unstable cups or other containers may occur in all of these places. To control the damage, knowledge of the extent to which the burns and other injuries (e.g., lung damage from smoke) occur from fires (specified by ignition source and material ignited), tap water, hot drinks spilled from specific types of containers, space heaters by specific types, is the information that is the most useful (McLoughlin and Crawford, 1985).

Broad categories of injuries do not capture important differences among relatively homogeneous subsets of the category nor a basis of inference of their causes. For example, in 2014 the American Journal of Public Health editors foolishly published an article and editorial by a former General Motors employee who compared fatal motor vehicle death trends among countries. He inferred from the differences that the U.S. had inferior motor vehicle safety efforts compared to countries with larger reductions in fatalities. Among several factors that he ignored was the difference in trends occurring in relatively homogeneous subsets of the data (Robertson, 2014). Figure 3-1 shows the difference in trends in occupants of closed vehicles compared to motorcyclists and pedestrians. Occupant deaths declined by almost a third while motorcyclist deaths doubled and pedestrian deaths changed little in the 21st Century through 2012.

Motorcyclist death rates per vehicle or per mile are far higher than those of other road vehicles and are concentrated among more recently sold vehicles (Paulozzi, 2005). Motorcycle sales in the U.S. more than doubled from 1999 to 2006 and motorcyclist deaths almost doubled.

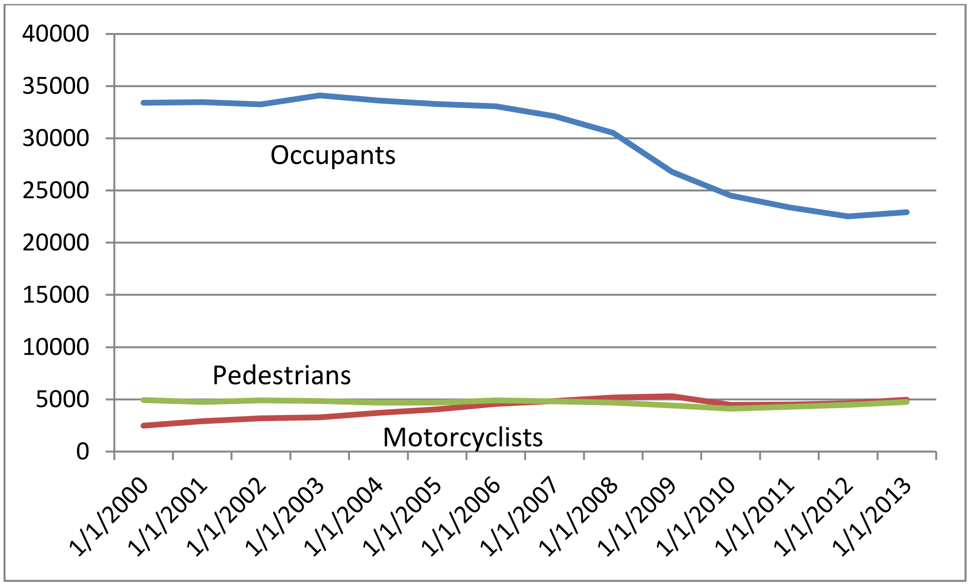

Figure 3-1. Trends in Relatively Homogeneous Subsets of Motor Vehicle Deaths
(Source: National Highway Traffic Safety Administration, Fatal Analysis Reporting system -- http://www-fars.nhtsa.dot.gov/Main/index.aspx.

Closed vehicle occupant deaths, pedestrian deaths and motorcyclist deaths are substantially different in causation and methods of prevention. Linda DeGutis, the only injury expert to be President of the American Public Health Association, tells the story of testifying before a legislative committee on motorcyclist injuries where a legislator said something to the effect that "Motorcycles have seat belts don't they?" No, seat belts without an energy absorbing exterior structure would be worthless. By the way, pedestrians don't have seat belts or exterior structure either. A study that lumps all motor vehicle deaths together in relation to injury control efforts is fatally flawed.

CASE FINDING. Once one has decided the set of injuries that are to be investigated and meaningful categories to describe them, a means of finding cases must be identified and implemented. Various people and organizations, public and private, are potential sources for case identification and data on particular sets of injuries -- the person injured and witnesses, private physicians and clinics, police, emergency medical responders, hospital emergency rooms, hospital inpatient personnel, rehabilitation facilities, medical examiners and coroners. Each data source has biases that must be understood and made explicit to avoid misinterpretation of the data.

Figure 3-2 presents the paths through which the vast majority of injury cases flow. Once an individual is exposed to energy sufficient to cause pain or perceptible tissue damage, that person or someone in proximity makes a decision whether to seek medical or other help. Most cases are relatively trivial cuts and bruises and are self-treated or ignored. The person who seeks help may go directly to a private physician or, if police or emergency medical personnel are called, the person may be examined and released or taken to a private physician, hospital emergency room or the morgue. If admitted to a hospital, the injured person may subsequently be released, or sent to another hospital, a rehabilitation facility, or the morgue.

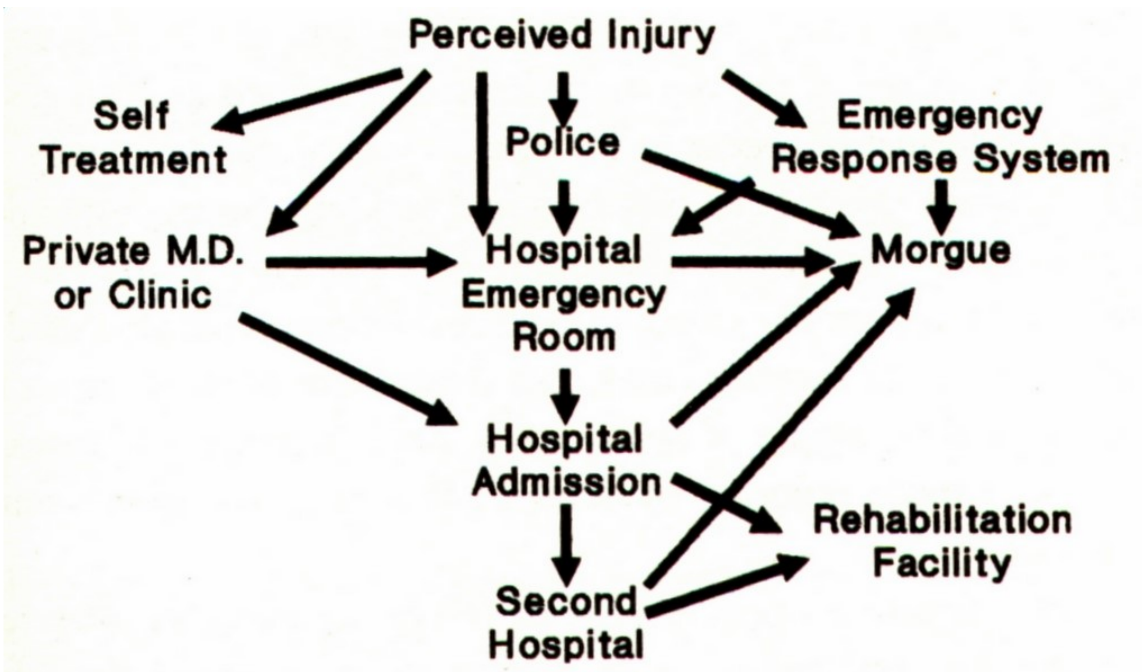

Figure 3-2. Paths of the Injured

Each of the arrows in Figure 3-2 is a potential path that has a probability of occurrence that is related to several factors, including the circumstances of the injury and its severity. A person may not seek help because of embarrassment, threat from an assailant, knowledge of how to treat an injury, inability to pay for services, geographic remoteness from services, or attitudes regarding the services available. Private physicians and clinics, police, emergency personnel and hospitals usually have protocols for handling or referring cases, but these are not always followed.

The flow of cases suggests various points at which data may be obtained. An epidemiologist may survey a sample of the population about injuries experienced, or use the records of private physicians, emergency medical services, police, hospitals, rehabilitation facilities, and coroners or medical examiners. Each data source has potential biases that must be considered in using the data. The use of combined data sources sometimes allows an estimate of cases missing from any one and also provides data on several aspects of injury that no one source provides. Since the same injured person may have contact with more than one data source or more than one contact with the same data source, care must be taken not to count the same injury more than once.

The only way to obtain data on injuries that are not brought to medical or official attention is to contact people and question them about injury experience. There is substantial potential for bias in such surveys due to unreliable memory, embarrassment regarding certain types of injury, and differences among people in perceptions of seriousness. The National Health Interview Survey, conducted by the National Center for Health Statistics, sometimes includes a few questions about injuries in its ongoing random sample survey of the population. To be included, an injury must have received medical attention or required a day of restricted activity. In one such survey, the rate of these self-reported injuries per population among persons 65 years and older was 19 percent compared to 38 percent of those less than 45 years old (National Center for Health Statistics, 1986). The elderly may have that many fewer injuries, or their rate could be biased by memory failure or other factors. One analysis of data from the survey found that people who are obese or who say they sleep less than seven hours per night were more likely to report work-related injuries (Lombardi, et al., 2012). That may be so or the sleep deprived and the obese may be employed in workplaces that expose them to more energy. There is no such exposure data in the National Health Survey, only broad categories such as health care, education and manufacturing.

A general population survey is an inefficient way to identify severe injuries. The sample size would have to be huge to include significant numbers of deaths or permanently impairing spinal cord or head injuries.

The method of collecting data as well as the perception by the respondent of the persons or organizations soliciting the data may also affect the probability of the respondent's reporting an injury. For example, an annual survey of cervical spine injuries to high school football players was conducted by mailed questionnaire to high school principals and team trainers to identify cases. On the basis of identified cases, the researchers claimed that a decline in such injuries occurred from warnings to coaches about teaching players to not use the head in blocking and tackling (Torg, et al., 1985). These data are inadequate because only a few percent of the questionnaires are returned and the respondents may withhold information because the researchers were previously active in issuing the warnings about head blocking and tackling. Some respondents may be reluctant to report injuries in which they may perceive themselves or members of their staffs as partially culpable. The researchers have also used newspaper-clipping services to identify cases, but these were obtained from a limited and non-representative sample of newspapers. To my knowledge, no comparison of cases reported in newspapers to those reported by school officials in the same communities has been reported.

One way of estimating completeness of injury reporting in interviews is to interview more than one person with probable knowledge of the injury. In a study of injuries to football players in Pop Warner leagues, coaches were asked to report injuries that required restricted participation for more than one week. At the end of the season, two players and two coaches, randomly selected from each team, were interviewed and asked to provide the names of anyone on the team who had such an injury. Of the total injuries identified, the coaches were the best source (82 percent of injuries reported), but an additional 18 percent were reported by the other respondents that would not have been found by sole reliance on coaches (Goldberg, et al., 1988).

Reporting biases have also been found in official records. A substantial underreporting, despite legal requirements to do so, has been found comparing police reports of certain motor-vehicle injuries and hospital records. In the United States, state governments require that motor-vehicle injuries be reported to police. Yet, in 45 percent of emergency room cases of motor-vehicle injuries in five northeastern Ohio counties, no police report could be found (Barancik and Fife, 1985). The cases lost by relying on police records may be even larger in low-income countries, particularly in remote areas where police presence is minimal (Berger and Mohan, 1996).

Furthermore, in Ohio the lack of police reports was correlated with other factors. Police reports were missing for two-thirds to three quarters of patients less than 16 years old, those who were passengers of vehicles other than passenger cars, and Medicaid recipients. Missing cases in police reports raise serious doubts about studies of effectiveness of seat belts, air bags and other crash protection based on nonfatal injury data (Appendix 5-1).

Medical records, augmented by death certificates, coroner or medical examiner records of the fatally injured, are the best sources for case identification for most studies (e.g., Kraus, et al., 1975; Kraus, et al., 1984). Although many such records do not contain data on the circumstances of injury and other variables, they usually provide information on characteristics of the injury and its severity. If the injury can be disabling, the disability may not be recorded in the data from acute care hospitals. For example, some cases of spinal cord injury not identified in acute care records in one surveillance system were found in records of rehabilitation facilities (Thurman, et al., 1994).

Once the case has been identified, other data can be obtained by matching to other records, if available, or by contacting the person injured or witnesses to the incident. Injuries that were not brought to medical attention will not be included, but as noted in the next chapter, the more severe injuries that are the primary targets for injury control are unlikely to be excluded.

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