Injury Surveillance

John M. Horan¹ and Sue Mallonee²

¹ Division of Applied Public Health Training, Epidemiology Program Office, Centers for Disease Control and Prevention, Atlanta, GA.
² Injury Prevention Service, Oklahoma State Department of Health, Oklahoma City, OK.

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Abbreviations: CDC, Centers for Disease Control and Prevention; EMS, emergency medical services; ICD, International Classification of Diseases; NEISS, National Electronic Injury Surveillance System; NHTSA, National Highway Traffic Safety Administration.

INTRODUCTION

Public health surveillance is the ongoing, systematic collection, analysis, interpretation, and dissemination of data on health-related events for use in public health action to reduce morbidity and mortality and to improve health (1). More simply put, surveillance is about translating information into action. In the United States, much of the focus of public health surveillance has traditionally been on prevention and control of infectious diseases, an area where surveillance has been used to identify outbreaks, monitor emerging problems, and assess the impact of prevention measures (2–5). Another essential role of public health surveillance is monitoring causes of death, including premature mortality. In that context, injuries clearly emerge as a major public health problem. In 1999, unintentional injuries were the fifth leading cause of death in the United States and were the leading cause for persons in the age group 1–34 years (6). Unintentional injury, together with homicide and suicide, accounted for nearly 60 percent of all deaths among persons aged 1–34 years (6).

Following Congressional authorization in 1983, the National Research Council and the Institute of Medicine (National Academy of Sciences) produced the 1985 report Injury in America (7), which documented the burden of injury and became a major impetus for developing support for research and programs to address this important problem. A 1988 review of public health surveillance in the United States (8) noted that recognition of intentional and unintentional injuries as major public health problems had led to the need for developing systems of public health surveillance for injuries. Additionally, as injury research and prevention programs have evolved, so has the need for surveillance data to identify populations at risk, determine programmatic priorities, support prevention activities, and evaluate prevention efforts. While there have been substantial advances in injury surveillance in recent years, there are still many challenges and needs. In this paper, focusing primarily on the United States, we provide an overview of current injury surveillance data sources and systems, and we review their use for surveillance of major categories of injury. We also present several new developments in injury surveillance and comment on some of the new challenges facing injury surveillance in an era of rapidly changing information technology and growing recognition of the need for effective integration of information systems.

DATA SOURCES AND SURVEILLANCE SYSTEMS

The book Principles and Practice of Public Health Surveillance identifies three sources of health-related information: individuals, health care providers, and other entities (9). All three make important contributions to injury surveillance. Through telephone surveys or other means, individuals are a source of data on injury incidence, risk-taking behaviors, and use of preventive measures. Health care providers at different levels of the medical care system are a source of data on outcomes of injury events, including the terminal event of injury-related mortality. Additionally, a variety of agencies and institutions that collect data for other purposes, such as police reports on traffic crashes and crimes, fire department records, insurance claims, and worker’s compensation files, are sources of important information on the circumstances and sequelae of injury events.

The primary responsibility for public health surveillance in the United States resides at the state level. Within state health departments, injury prevention has struggled for
recognition as a critical component of public health practice. Development of injury surveillance capacity has been variable across states. Even in states with relatively advanced capacity, surveillance priorities have not been consistently based on public health criteria such as premature mortality and preventable morbidity; they have also depended on the level of popular and political interest in bringing certain conditions under surveillance. The need for a coordinated approach to state-based injury surveillance served as the motivation to form an injury surveillance work group in 1998. This cooperative undertaking by state, federal, and academic injury prevention organizations produced the Consensus Recommendations for Injury Surveillance in State Health Departments (10). This document recommended putting 14 injuries and injury risk factors under surveillance by all states. Basic surveillance of most of the 14 recommended conditions is achievable through the use of data sets that are present in most states. To begin implementing the recommendations, 12 states contributed to the first State Injury Indicators Report, a summary report of 1997 and 1998 data for 12 of the recommended conditions (11). The second annual summary report, based on 1999 data, is expected to include more than 20 states, with eventual expansion to include all US states and territories within several years.

The capacity for national-level injury surveillance has grown in recent decades. For example, in a 1998 review of national data systems useful for firearm-related injury surveillance, Annest and Mercy (12) noted that seven of the 13 systems they reviewed either did not exist or did not have the capacity to capture information on firearm-related injuries 10 years previously. In 1996, the federal Centers for Disease Control and Prevention (CDC) published the Inventory of Federal Data Systems in the United States for Injury Surveillance, Research, and Prevention Activities (13). These systems cover a broad range, including mortality, morbidity, risk factors, and preventive factors.

Brief summaries of various data sources and systems for surveillance of injury mortality, morbidity, and risk factors are presented below. Sources and systems that are related to specific causes of injury (traffic injury, occupational injury, violence, etc.) are described in later sections of the paper.

Mortality data

Vital records. In the United States, state laws require completion of death certificates for all deaths. State offices of vital records maintain death certificate files and provide regular summary reports based on these data. Through cooperation between all 50 states, the territories, the District of Columbia, and the CDC, death certificate data are compiled into the National Vital Statistics System (http://www.cdc.gov/nchs/nvss.htm) (14), which produces public summaries of various data sources and systems for surveillance of injury mortality, morbidity, and risk factors are presented below. Sources and systems that are related to specific causes of injury (traffic injury, occupational injury, violence, etc.) are described in later sections of the paper.

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Medical examiner and coroner records. Medical examiner and coroner systems offer a rich source of data on injury deaths that are complementary to vital statistics data. For example, computerized systems or records may include data that are unavailable on death certificates, such as the decedent’s alcohol and drug use, the premise of injury, the type of firearm involved, a description of injuries incurred, and a narrative on the circumstances resulting in death (15). Physician-oriented medical examiner systems began replacing the older, more political lay coroner systems around 1950, but this trend stalled; currently, only 18 states have a centralized, statewide medical examiner’s office (16), and not all of these states have computerized data systems. In addition, comparability among states or even among counties within states is problematic because there is no standardized, national coding system for medical examiner or coroner data.

Morbidity data

Hospital inpatient records. Hospital discharge records are important sources for injury morbidity data because they include injuries severe enough to warrant hospitalization, and when linked to vital statistics data or medical examiner data, they provide a more complete picture of serious trauma. Forty-four states collect hospital inpatient data for various purposes through voluntary or mandatory health reporting requirements (17). These data are usually collected from hospital records that are intended primarily to serve administrative and management purposes (such as billing files). Moreover, collection of hospital discharge data varies across states and within states over time, and most state systems exclude federal (military and Indian Health Service) facilities. A 1997 survey showed that 36 states and the District of Columbia were routinely collecting data on external causes of injury in their statewide hospital discharge data systems (18), yet the completeness of external-cause coding in hospital discharge data has been shown to vary substantially among states (11). To use these data for injury incidence surveillance, it is necessary to avoid double-counting patients transferred from one facility to another and patients readmitted for the same injury. Adding an additional field in hospital discharge systems that reflects readmission for a previous injury, a transfer from another hospital, and the date of injury has been recommended to improve this data source (19). Thus, while these systems can be very useful for injury surveillance, they have limitations, and their data elements may have limited relevant information. To promote and improve the use of hospital discharge data, the State Injury Prevention Directors’ Association, in collaboration with partner organizations, published recommendations for using hospital discharge data for injury surveillance (20).

At the national level, data are available through the National Hospital Discharge Survey, which is conducted by the CDC (http://www.cdc.gov/nchs/about/major/hdasp/nhds.htm). Begun in 1965, the survey collects information from a probability sample of discharges from nonfederal short-stay hospitals with six or more beds in the United States. While these data specify types of injuries, external-cause coding for injuries in the National Hospital Discharge Survey is limited but improving; in 2000, 70 percent of discharges with a principal injury diagnosis had at least one external-cause-of-injury code.
Trauma registries. Forty-four US states collect either statewide or regional trauma registry data (21). The American College of Surgeons established the National Trauma Data Bank as a national repository of trauma data in 1994; over 430,000 records from 130 trauma centers in 28 states and US territories were voluntarily submitted between 1994 and 2001 (22). Trauma registry data provide detailed information on the nature and severity of the injury, the treatment, and the outcome upon discharge from the hospital. While trauma registries are a potential part of the data needed for comprehensive injury surveillance, the data are collected primarily to monitor and evaluate trauma care, and they have limitations (23, 24). Most state or regional trauma registries are limited to trauma center hospitals and are not population-based (25); few are statewide, and few include all hospitals (26). In addition, the case criteria of most trauma registries exclude some causes of injury (i.e., same-level falls, poisonings, drownings, etc.), include only severely injured persons (persons with “major trauma” or persons hospitalized for more than 24 or 48 hours, etc.), and exclude prehospital deaths (25). Thus, trauma registries may be incomplete and nonrepresentative sources of injury surveillance data (27).

Outpatient care records and reports. Surveillance based on outpatient records can address the substantial proportion of injuries severe enough to require medical care but not resulting in hospitalization. Seventeen states currently collect emergency department data, and an additional seven states are actively planning to collect emergency department encounter data within the next 2 years (17). In addition, several states are collecting ambulatory surgical data from hospitals and free-standing clinics. These data have limitations for injury surveillance similar to those of inpatient records.

The National Electronic Injury Surveillance System (NEISS) obtains data on all consumer product-related injury cases from a nationally representative sample of approximately 100 hospital emergency departments (http://www.cpsc.gov/CPSCPPUB/PUBS/3002.html). The NEISS was started in the early 1970s by the Consumer Product Safety Commission. In 1999, the Institute of Medicine recommended expanding the system to include all nonfatal injuries (19), and in July 2000 the NEISS All Injury Program was initiated to collect data on all types and causes of treated injuries in a nationally representative subset of 65 of the NEISS hospital emergency departments (28). These data may be accessed through the World Wide Web-based Injury Statistics Query and Reporting System (29).

Several national surveys conducted by the CDC collect data on outpatient care that are useful for injury surveillance. The National Ambulatory Medical Care Survey began in 1992. The survey comprises a national probability sample of visits to emergency and outpatient departments of general, nonfederal hospitals (http://www.cdc.gov/nchs/about/major/ahcd/ahcd1.htm). Data included in the survey include alcohol- and drug-relatedness and, for injury-related visits, codes for reason for the visit, up to three diagnoses and external causes, and place and intent of injury. The National Health Interview Survey has collected self-reported information from approximately 38,000–40,000 US household interviews annually since 1957 (http://www.cdc.gov/nchs/nhis.htm). The survey provides estimates of injuries and poisonings for which medical attention was obtained within 3 months of the interview date. The National Health Interview Survey was redesigned in 1997; it now includes detailed injury-specific questions for all members of the family as part of the core survey.

Emergency medical services records. Most states collect emergency medical services (EMS) data for persons who are transported to a hospital by an ambulance. These data have been utilized for injury surveillance (30) or integrated into existing categorical injury surveillance systems (31, 32). While the National Highway Traffic Safety Administration (NHTSA) has developed a set of 81 uniform prehospital data elements (33), EMS systems vary in their ability to collect and use injury-related data. In over 90 percent of states, complete EMS data are missing at the regional or state level (34). EMS systems within cities, regions, and states should continue to refine and systematize data collection (35). The National Association of State EMS Directors is working with the NHTSA and the Trauma/EMS Systems program of the Health Resources and Services Administration to develop a national EMS database (36).

Post-acute-care data. Data systems describing the duration of rehabilitative care and outcomes beyond hospital mortality and morbidity are rare (37). It has been recommended that more efforts be made to extend trauma registries to determine long-term outcomes and to develop norms for these outcomes (19). The Uniform Data System for Medical Rehabilitation was developed with support from the National Institute of Disability and Rehabilitation to capture the severity of patient disability and the outcomes of rehabilitation (19). Registries such as Model Systems of Care, established for the treatment of traumatic brain injury (38) and spinal cord injuries (39), have collected data on patients through rehabilitation, community reintegration, and long-term follow-up. However, these registries are costly, are labor-intensive, and only follow select patient groups after specialized care; thus, findings cannot be interpreted widely. The CDC has funded population-based surveillance of traumatic brain injury outcomes in two states and the National Study on Costs and Outcomes of Trauma Care. The latter will examine the relation between treatment and outcome for up to 12 months postinjury (40). There is a need for further development of outcome registries, including practical tools that can be applied routinely at low cost, effective and efficient patient tracking systems, and standardized guidelines for developing and maintaining such registries (19).
Risk factor data

Surveillance of preinjury risk or protective factors (e.g., bicycle helmet or seat-belt use, prevalence of smoke detectors, etc.) can be a timely, efficient approach to providing data for injury prevention. Two systems that provide state-level data on risk factors are the Behavioral Risk Factor Surveillance System and the Youth Risk Behavior Surveillance System. The Behavioral Risk Factor Surveillance System, established by the CDC in 1984, is a random-sample household telephone survey that monitors self-reported health behaviors in all 50 states, the District of Columbia, and three territories (http://www.cdc.gov/bfrfss/). The number of injury-specific risk and protective behaviors about which all adult respondents are asked is limited, but states can add injury-specific modules. Data from the survey have proven useful for identifying and highlighting a broad range of national and state-level injury prevention issues (41–45). The Youth Risk Behavior Surveillance System, developed by the CDC in 1989, includes national, state, territorial, and local school-based surveys of US students in grades 9–12 regarding risk behaviors associated with leading causes of morbidity and mortality (http://www.cdc.gov/nccdphp/dash/yrbs). Survey topics include behaviors related to injury risk, such as lack of seat-belt use, drinking and driving, weapon-carrying, and suicide attempts (46). Youth Risk Behavior Surveillance System data are a source both for summary national-level reports (46) and for targeted investigations on state issues (47, 48).

Several systems are currently being used in the United States for national surveillance of injury risk factors. The Motor Vehicle Occupant Safety Survey and the National Survey of Drinking and Driving Attitudes and Behavior are nationally representative telephone surveys (49, 50). The National Occupant Protection Use Survey is a nationally representative observational survey that provides estimates of shoulder belt and motorcycle helmet use and data on the characteristics of belt users (51). The Injury Control and Risk Survey was a random digit dialing telephone survey sponsored by the CDC in 1994 for collection of injury risk factor and demographic data from a nationally representative sample of adult respondents (52–54). The Injury Control and Risk Survey was a single survey, not an ongoing system of surveillance. A subsequent similar survey, Injury Control and Risk Survey 2, is currently under way. These and other surveys are valuable sources of national-level estimates, but they cannot provide state- or local-level data.

The widespread use of data from these various systems and surveys is an indication of the importance and value of surveillance that focuses on preinjury factors. However, the diversity of these systems also reflects the absence of a systematic, coordinated approach to addressing this issue.

CODES AND STANDARDS FOR INJURY SURVEILLANCE

In order for information about injury mortality, morbidity, and risk factors to be efficiently accessed and used for surveillance, it needs to be categorized under standard codes and definitions. For injury prevention, the usefulness of information being collected and coded is greatly enhanced if the data include not only the nature or type of injury (e.g., fracture, poisoning) but also the external cause or mechanism of injury (e.g., motor vehicle crash, unintentional ingestion). Standard codes and definitions are required for accurate comparison of state, local, or international data regarding the magnitude and distribution of injuries as a public health problem.

Mortality data on death certificates are coded using the International Classification of Diseases (ICD). The Ninth Revision of the ICD (ICD-9), the common standard since 1979, was replaced in the United States by the Tenth Revision (ICD-10) in 1999. In the ICD-9, coding of external causes of death was done with a supplementary set of codes commonly known as E-codes, and all deaths resulting from an external cause of injury were assigned an E-code. The external cause is the mechanism causing death (e.g., a motor vehicle traffic crash), and the injuries resulting from the external cause (e.g., fractures, open wounds, etc.) are listed as contributing causes on the death certificate. In the ICD-10, external causes are classified under a series of alphanumeric codes, V01–Y98 (55).

Morbidity data, for example, data in hospital discharge and emergency department medical records, are currently coded in the United States using the clinical modification of the ICD-9 (ICD-9-CM). Coding of external causes has been considerably less complete for morbidity data, and this has limited the usefulness of sources such as hospital discharge records for injury surveillance. A 1997 survey showed that, on average, states with laws requiring E-coding had a higher percentage of E-coded hospital discharges; however, it was possible to achieve a high level without such a law (18). LeMier et al. (56) have recently shown a high level of accuracy of computerized E-code data in Washington State for reporting of injury mechanism and intent. The ICD-9-CM system is expected to be replaced by the clinical modification of the ICD-10 (ICD-10-CM) in the next few years.

Although major revisions such as the change from the ICD-9 to the ICD-10 pose challenges for temporal comparability of data, in general the ICD coding systems enhance comparability and consistency in mortality and morbidity statistics, helping decrease the costs of collecting, linking, and using data. Similar benefits are potentially available from standards for recording other essential health-related information. In recent years, standards development work has been under way in several areas of injury surveillance. The Data Elements for Emergency Department Systems (57), designed to conform to established formats for patient data, is a recommended set of specifications for information entered in emergency department records. Data Elements for Emergency Department Systems is not intended as a mandated essential or minimum data set; rather, it is intended to foster uniformity among individual data elements that are chosen for use. Similarly, recommended uniform data elements have been developed for firearm-related injury surveillance (58, 59) and central nervous system injuries (60); definitions and recommended data elements for surveillance of intimate partner violence (61) have been developed and are being pilot-tested.

Just as standards for recording data can facilitate collection and analysis, standards for presentation can better
enable data dissemination and display. Development and publication of the Recommended Framework for Presenting Injury Mortality Data (62) has provided a widely accepted systematic approach for the display of standard ICD-9 E-code groupings in a matrix of mechanism/cause by manner/intent; a similar framework has been developed for morbidity data (63). In addition, the International Collaborative Effort on Injury Statistics has recently developed and published an injury diagnosis matrix, known as the Barell Matrix, as a recommended approach for displaying data on the nature of the injury (fracture, amputation, burn, etc.) by body region (head and neck, torso, etc.) (64).

SURVEILLANCE OF MAJOR CATEGORIES OF INJURIES

Transportation injuries

According to the National Vital Statistics System, transportation-related injuries are the leading cause of injury-related death in the United States, accounting for over 46,000 deaths in 1999 (14). Transportation injuries were the leading cause of all deaths for persons of every age from age 4 years to age 33 years (65). The NHTSA provides the most comprehensive surveillance system for transportation-related injuries in the United States. Detailed data regarding the circumstances of transportation fatalities are collected in the Fatality Analysis Reporting System in all 50 states and the District of Columbia (66). The Fatality Analysis Reporting System is a powerful tool for uncovering new epidemiologic information on crashes and injury risks (67).

Since 1988, crash and injury statistics have been based on data from the General Estimates System. The General Estimates System is a probability-based sample of police-reported crashes from 60 locations across the country, generating national estimates of crashes and injuries (68). In 2000, there were an estimated 6,394,000 police-reported traffic crashes resulting in 41,821 deaths and over three million related injuries in the United States (69). Vehicle occupants accounted for nearly 90 percent (over 36,000) of these deaths, followed by 4,739 pedestrians and nearly 700 pedal cyclists (69).

Until late 1991, the NHTSA’s 19-city survey was used to track national use of seat belts. In 1991, the 19-city survey was replaced with an aggregate of individual statewide observational surveys weighted by each state’s population (70). In addition to the state belt-use surveys, the National Occupant Protection Use Survey has conducted observation surveys since 1994, using a multistage probability sample to estimate occupant protection in the United States (70); the prevalence of seat-belt use in 1998 was found to be 68.9 percent (71).

The Crash Outcome Data and Evaluation System is a state-based surveillance system initially funded by the NHTSA in seven states to determine the benefits of use of seat belts and motorcycle helmets in motor vehicle crashes (72). The system utilizes a probabilistic computer algorithm (73) to link crash data from police reports, medical data from EMS, hospital emergency department, and discharge files, and claims data from third-party payors to evaluate injuries and their associated costs from motor vehicle crashes. A strength of the linked system is that person-level data are available for uninjured, injured, and killed persons, and these data provide a more comprehensive assessment of the consequences of safety behaviors (e.g., use of belts and helmets) and countermeasures (e.g., air bags) (70). At least 26 states have received funding from the Crash Outcome Data and Evaluation System for numerous applications through 1999 (32).

In addition to measuring the magnitude of the problem, injury surveillance systems have been instrumental in documenting the effects of state legislation in reducing the burden of transportation-related injuries and in measuring adverse consequences of safety measures. Some types of legislation that have been evaluated include: establishing 21 years as the minimum age for the purchase of alcoholic beverages (74, 75); safety-belt primary enforcement laws (76, 77); child safety seat laws (78); sobriety checkpoints (79); graduated licensing of teenage drivers (80, 81); and administrative license revocation and lower blood alcohol concentration laws (75, 82, 83). Analysis of a combination of data from risk factor surveillance systems and survey data has also been used to show relations that have policy implications (84).

Determining unanticipated adverse outcomes of prevention strategies is an important use of surveillance. Motor vehicle injury surveillance documented the adverse consequences (including death from air bags) that have occurred among unrestrained children under age 13 years, small-statured adults, and infants in rear-facing car seats in the vehicle front seat (85, 86). In addition, an insurance-based crash and injury database demonstrated significant injury risks associated with restraining young children (age 2–5 years) in regular seat belts as compared with child restraint systems (87); these data have led to educational efforts and policy changes throughout the country. Efforts in utilizing surveillance systems to support and evaluate motor-vehicle-related safety legislation and policies should serve as a model for supporting and evaluating policy for other causes of injury.

Residential injuries

Burn and fire-related injuries. Per capita, the fire problem in the United States, including fatal injuries due to fire, is one of the worst in the industrialized world. Injuries from fire and burns are the seventh leading cause of injury death in the United States, accounting for 3,910 deaths in 1999 (14). According to the National Health Interview Survey, over one million burn injuries are reported annually in the United States (88); this number of injuries has declined significantly from the two million annual injuries estimated in the first report of the National Health Interview Survey, drawn from 1957–1961 data.

In 2000, public fire departments responded to nearly two million fires in the United States, according to estimates based on data received by the National Fire Protection Association from fire departments responding to the 2000 annual National Fire Experience Survey; these fires resulted in over 4,000 and 22,000 civilian deaths and injuries, respectively, and over $11 billion in property loss (89). In 2000, residential fires accounted for approximately 80 percent of the fire injury problem, including nearly 400,000 residential fires, 3,445 civilian deaths, 17,400 injuries, and almost $6 billion
in direct property damage (89). The National Fire Incident Reporting System is a voluntary reporting system that has been overseen by the US Fire Administration (Federal Emergency Management Agency) since 1976. This database collects information on one million fires (approximately one half of all reported fires) from 14,000 fire departments in 42 states and the District of Columbia (90), including data on causes, locations, and temporal and geographic trends in fires and injuries.

An important risk factor for death or serious injury during a residential fire is the lack of a functioning smoke alarm (31, 91). According to surveillance for smoke-alarm ownership in US households conducted by the Behavioral Risk Factor Surveillance System, the prevalence of smoke alarms in the United States is nearly 94 percent (42); however, in-home surveys by the Consumer Product Safety Commission and others have shown that 25–30 percent of household smoke alarms are not functional (92–94).

The utility of linking (manually or electronically) population-based morbidity data (fire/burn injury surveillance systems, emergency department or hospital discharge data, ambulance run reports), mortality data (medical examiner, vital statistics, and coroner data), and fire department data in determining risk factors and high-risk populations and in evaluating targeted interventions has been demonstrated (31, 95, 96). However, published reports to date have only linked these data on a community, city, or county basis rather than on a statewide basis. The Federal Fire Partnership—the US Fire Administration, the Consumer Product Safety Commission, and the CDC—has set a goal of eliminating residential fire-related deaths by 2020 (Christine Branche, CDC, personal communication, 2002). State efforts to achieve this goal could benefit from systematic data linkage to enhance surveillance capacity.

**Fall injuries.*** Falls were the fourth leading cause of injury death in the United States in 1999 (14) and the leading cause of medically attended injuries, accounting for 11.3 million fall episodes (97), including eight million emergency department visits (98). Age-specific rates of hospital-treated falls are highest in the youngest and oldest populations, but the proportions of these falls that require hospitalization are very different (3 percent in persons aged less than 25 years vs. 33 percent for person aged 75 years or older) (98). Elderly persons have the highest fall mortality rates (99).

State or local surveillance for falls is typically based on existing E-coded systems such as emergency department or hospital discharge data systems. While data on patient descriptive factors (age, sex, race/ethnicity, etc.) are available in these systems, external-cause coding only offers a description that the person slipped or tripped or fell on the same level or at a distance. The data often do not provide specific details about how the fall occurred (98), and E-codes do not provide sufficient detail regarding risk factors (environmental hazards, medication use, etc.) (100). With an aging US population, fall rates appear to be increasing, and prevention efforts could benefit substantially from expanded surveillance systems that collect more detailed information on the causes and outcomes of fall injuries.

**Occupational injuries***

The International Labor Organization has estimated that work-related injuries kill approximately 335,000 persons annually, resulting in a worldwide rate of 14.0 deaths per 100,000 workers, with developing nations having the highest injury fatality rates (101, 102). In the United States, occupational injury deaths are routinely reported by three sources. The National Safety Council has estimated work-related deaths and injuries for the US population since 1933 (103). The CDC’s National Institute for Occupational Safety and Health, utilizing death certificates from all 50 states and the District of Columbia (104), has collected data in the National Traumatic Occupational Fatalities Surveillance System since 1980. In 1992, the Bureau of Labor Statistics developed a federal-state partnership, the national Census of Fatal Occupational Injuries, in all 50 states and the District of Columbia that cross-references multiple sources of data (i.e., death certificates, medical examiner certificates, worker’s compensation records, and federal and state agency reports) (105). Fatality counts from the Census of Fatal Occupational Injuries have exceeded those of the National Traumatic Occupational Fatalities Surveillance System annually by approximately 20 percent (104, 106).

Discrepancies between the different reporting sources occur because of differences in methods of case identification and case definition (107, 108). Although existing systems are discrepant and may undercount the number of deaths (108–110), these surveillance systems have documented a large public health problem, high-risk occupations, and temporal trends (102) and have greatly improved the availability of data in the United States. This has led to expanded research on and policy changes regarding newly recognized issues such as prevention of workplace violence (111, 112). Other surveillance systems around the world have noted similar surveillance problems (113) and improvements in surveillance data (114).

There is no single surveillance system capable of capturing the majority of nonfatal occupational injuries in the United States (115). The Survey of Occupational Injuries and Illnesses is a federal/state program in which private-sector employer reports are collected and processed by state agencies in collaboration with the Bureau of Labor Statistics (116). This system underestimates nonfatal injuries nationally, since it excludes the self-employed, farms with fewer than 11 employees, private households, and federal, state, and local agencies (109, 116). Surveillance of nonfatal occupational injuries by the Bureau of Labor Statistics’ annual survey and state-based worker’s compensation systems provides general estimates of the burden of nonfatal injuries in states but lacks detail for characterizing injuries beyond broad diagnostic classifications and the number of workdays lost. Additionally, national data are collected for injuries serious enough to be treated at a hospital emergency department in the NEISS and the National Hospital Ambulatory Medical Care Survey (115, 117, 118); however, self-reporting from the National Health Interview Survey has suggested that only 34 percent of persons with occupational injuries are treated in an emergency department (119).
State-based occupational surveillance systems are important for determining state and local patterns and priorities for prevention. Many state surveillance systems have reported state-specific mortality data and trends (120–122). State population-based surveillance systems for nonfatal occupational injuries are incomplete and fragmented. There are several factors that restrict data collection. First, there are no multiple case-level data systems that can be linked at the state level (i.e., labor, worker’s compensation, hospital emergency department or discharge data). Second, external-cause coding of hospital data does not separately identify “injury at work” (123). Third, using worker’s compensation coding as the source of payment on hospital data undercounts work-related injuries (124). The Alaska Trauma Registry is a rare example of a system capable of assessing all occupational injuries involving admission to an acute-care hospital (125).

Trade-specific analyses of surveillance systems have been found to be useful in determining potential areas for further work-based prevention programs (126–128). Other population-based systems have utilized worker’s compensation claims (129), telephone surveys (130), trauma registry data (131), and police and employers’ reports (132). Finally, comprehensive company-wide injury surveillance systems, such as those implemented by the Ford Motor Company (Dearborn, Michigan), have proven useful for occupational injury prevention activities (133).

Surveillance for occupational injury in the United States has improved substantially in the past two decades, but it could be improved further (107). The use of free text analysis as a source of case-finding and improving surveillance data has been demonstrated to be promising by the National Traumatic Occupational Fatalities Surveillance System and other surveillance systems (133–136). Surveillance at the state level needs considerable attention and improvement. State-level hospital data collection systems could enhance the utility of such data for injury surveillance for the more severe injuries by mandating a field denoting injury at work (123). States could also add collection of work-related injuries to the statewide Behavioral Risk Factor Surveillance System. The collection of case-level data from multiple sources (including labor, worker’s compensation, hospital, and vital statistics data) that could be linked, in a manner similar to data on transportation-related injuries in some states (32), should be explored.

Injuries related to violence and firearms

In 1999, violent deaths from suicide and homicide combined accounted for approximately 29,000 deaths among persons aged 1–44 years in the United States, ranking as the second leading cause of death in this age group behind unintentional injuries (29). For the age groups 15–24 years and 25–34 years, suicide and homicide ranked as the second or third leading causes of death after unintentional injury (29).

Suicide and suicidal behavior. The National Vital Statistics System is the major source for national surveillance data on suicide (137), documenting more than 29,000 suicide deaths in 1999 (99). The overall age-adjusted rate of suicide reported in the United States has been fairly stable for decades, but there are important differences by age, sex, race/ethnicity, and region (138–141). In 1999, The Surgeon General’s Call to Action to Prevent Suicide (142) proposed a national suicide prevention strategy, with a series of recommendations for a nationwide collaborative effort to reduce suicidal behaviors and premature deaths due to suicide.

One of the strongest predictors for suicide is a previous attempt (143). Thus, local or state surveillance of nonfatal suicidal behavior can play a key role in prevention. The recent expansion of the NEISS offers the potential to generate national estimates of suicide attempts requiring emergency medical treatment (144). The Youth Risk Behavior Surveillance System has also been used to provide national and state-level estimates of suicidal thoughts and behavior among youth in schools (145, 146). Together with vital statistics, data from these systems can provide information on a range of suicidal behaviors, from thoughts to completion. Continued and improved suicide surveillance using these data will be important in measuring the impact of the National Strategy for Suicide Prevention.

Homicide. In 1999, there were nearly 17,000 reported homicides in the United States (99). For surveillance of homicides, death certificate information from the National Vital Statistics System provides basic information on the underlying cause of death, the injuries sustained, and the date and place of occurrence (147). However, death certificate data generally do not report important details, such as the decedent’s relationship to the perpetrator or other key information—for example, for firearm-related deaths, the type of firearm involved. That information is included in the supplemental homicide reports that are part of the Federal Bureau of Investigation’s Uniform Crime Reporting Program. These reports include information on the relationship between the victim and the offender, the circumstances surrounding the incident, the type of weapon used, and the demographics of victim and offender. The supplemental homicide report data are used in the Bureau of Justice Statistics’ publication Homicide Trends in the United States (148). A recent summary report on surveillance of intimate partner homicides (149) used supplemental homicide report data to document a steady decrease in rates of intimate partner homicide during 1981–1998; these decreases were noted to be temporally associated with social programs and legal measures implemented to curb intimate partner violence. To provide more comprehensive and detailed crime statistics, the Bureau of Justice Statistics and the Federal Bureau of Investigation have designed the National Incident Based Reporting System to supplant the Uniform Crime Reporting Program (150).

Child Fatality Review teams, first formed in Los Angeles County, California, in 1978 (151), are an important source of data on child homicides. An estimated 2,000 child deaths due to abuse and neglect occur in the United States annually; the majority of victims are younger than age 5 years (152). Local Child Fatality Review teams generally include members from coroners’ offices and from law enforcement, child protective services, and public health agencies. Variation in definitions and data elements used by different teams...
limits the current potential for national surveillance, but state and local teams can provide information to promote effective child health and safety policies (155).

**National Violent Death Reporting System.** The 1999 Institute of Medicine report, *Reducing the Burden of Injury*, noted that “an ongoing federally sponsored system of surveillance for all intentional injuries (homicides and suicides) is conspicuously absent from the array of data systems available on a national level” (19, p. 73). The report recommended development of a fatal intentional injury surveillance system for collection of data on all homicides and suicides. In 2001, Congress appropriated $1.5 million to the CDC to begin implementing the National Violent Death Reporting System. In collaboration with federal and state partners, the CDC has produced an outline for the National Violent Death Reporting System that proposes the development of state-based systems to routinely link data already being collected by four sources: death certificates, medical examiner or coroner reports, police reports, and crime laboratory reports. Death certificates indicate the cause of death and whether the death was work-related. The medical examiner/coroner data include information on the perpetrator relationship and other circumstances of the event; and crime laboratory reports provide detailed information on the type of firearm used in firearm-related deaths (e.g., caliber, barrel length, type). In the proposed system, each state health department would collect and link data from these sources in a state-level system, and together the states’ data would form the basis for national surveillance (154).

**Surveillance of nonfatal violence.** For every death due to homicide, it has been estimated that there are over 100 nonfatal injuries due to violence (155). National data on nonfatal violence are collected in two systems administered by the US Department of Justice. The Uniform Crime Reporting Program, operated by the Federal Bureau of Investigation, collects law enforcement reports on violent crimes, including rape and aggravated assault. Reporting by local enforcement agencies is voluntary, but participation is widespread, and the program has been estimated to represent over 95 percent of the US population (156). The Bureau of Justice Statistics’ National Crime Victimization Survey is an ongoing nationally representative sample survey of households that collects data on rape, assault, and other crimes. The Uniform Crime Reporting Program and the National Crime Victimization Survey are complementary systems with different strengths and limitations. Uniform Crime Reporting Program reports can provide national, regional, state, and local data based on incidents reported to law enforcement authorities. The National Crime Victimization Survey includes incidents that may have gone unreported to authorities; however, the data are self-reported and the system is designed to provide only national estimates. Recent expansion of the NEISS to include surveillance of all injuries may provide an opportunity to improve national-level surveillance for these conditions (157). Other survey-based surveillance systems, such as the Youth Risk Behavior Surveillance System, are additional potential sources of important data on nonfatal violence (158).

In 1995, the National Institute of Justice and the CDC sponsored the National Violence Against Women Survey (159). The survey estimated annual intimate partner victimization rates higher than those reported in the National Crime Victimization Survey; however, there were important methodological differences between these surveys (160). Subsequently, in 1998, the Department of Health and Human Services and the Department of Justice sponsored a workshop, “Building Data Systems for Monitoring and Responding to Violence Against Women” (161). The summary report recommended using uniform definitions to define and measure violence against women, and it identified the need for guidelines for intimate partner violence surveillance on local levels. In recent years, the CDC has supported several states in developing pilot projects on surveillance of intimate partner violence (162), and it is currently developing a pilot project for possible ongoing periodic national surveys.

**Surveillance of firearm-related injury.** From the late 1960s through the early 1990s, the number of firearm-related deaths in the United States increased by more than 50 percent, and in 1991, firearms equaled or surpassed motor vehicle crashes as the leading cause of injury death in seven states and the District of Columbia (163). With growing awareness of this public health issue, the capacity for surveillance of firearm-related injuries and risk factors has improved. In the early 1990s, Massachusetts implemented the first statewide reporting system for gunshot wounds resulting in death, hospitalization, or emergency department treatment (164). National surveillance for nonfatal injuries was enhanced in 1992 by the addition of firearm-related injuries to the data collected in the NEISS (165). To further advance development of state-level firearm-related injury surveillance, in 1994 the CDC provided funding for seven states to develop, implement, and evaluate systems (166). These projects demonstrated both the feasibility and the value of state-level surveillance for firearm-related injuries. They also illustrated several important challenges, including the resource-intensive nature of the endeavor (167). The experience gained and lessons learned from these projects have provided important context for the development of the National Violent Death Reporting System (see above), which is envisioned as the future basis of state- and national-level surveillance of firearm-related mortality.

**Other major categories**

**Poisoning.** In 1995, poisoning ranked as the third leading cause of injury mortality in the United States, following deaths from motor vehicle traffic injuries and firearm injuries (168). The number of poisoning deaths increased 24 percent from 1995 ($n = 16,307$) to 2000 ($n = 20,230$) (29). Several surveillance systems address different aspects of poisoning morbidity and mortality. Virtually all poison control centers in the United States participate voluntarily in the Toxic Exposure Surveillance System maintained by the American Association of Poison Control Centers (169). The annual reports of the Toxic Exposure Surveillance System.
are published each year in the American Journal of Emergency Medicine; the report for 2000 includes over 2.1 million poison exposure cases (170). In addition, data from individual poison control centers can help in identifying and characterizing problems at a state or local level (171).

The Drug Abuse Warning Network, sponsored by the Substance Abuse and Mental Health Services Administration, is an ongoing drug abuse data collection system that provides data on morbidity and mortality from abuse of illegal drugs or use of legal drugs for nonmedical purposes. Recent evaluation and redesign of the Drug Abuse Warning Network system has produced several reporting changes, including semiannual reports of morbidity data, annual reports of mortality data, and periodic short publications (The DAWN Report) on selected topics (172). The Hazardous Substances Emergency Events Surveillance system is maintained by the Agency for Toxic Substances and Disease Registry to provide information for participating states with which to reduce morbidity and mortality from releases of hazardous substances. Sixteen state health departments participate in the Hazardous Substances Emergency Events Surveillance system; annual summary reports are available on the World Wide Web (173).

Disaster events. During the last quarter of the 20th century, natural disasters such as floods, earthquakes, hurricanes, tornadoes, fires, and volcanic eruptions claimed approximately three million lives worldwide and adversely affected the lives of another 800 million persons (174). In addition, disasters may be caused by deliberate or unintentional human actions (175). Terrorism throughout the world is widely reported in the media, and events in the United States (176–179) and abroad (180–182) have suggested that mass casualties associated with domestic and international terrorism among US citizens and military personnel are increasing. In fact, in the United States alone, from 1988 to 1997, the number of actual and attempted bombings increased by 127 percent (183).

Disaster surveillance can help determine the magnitude and nature of health/injury problems, identify groups at high risk for adverse health effects, optimize relief responses, evaluate the effectiveness of relief efforts, and recommend ways of decreasing the consequences of future disasters (184). Public health surveillance for disasters presents many challenges: 1) data must be collected under highly adverse conditions; 2) multiple sources of information must be integrated in a cohesive fashion; 3) circumstances and forces may exist that impede surveillance (incomplete documentation of adverse effects, restricted or prohibited access to records); and 4) data collection and postdisaster action must be completed rapidly, accurately, and repeatedly in order to rescue persons at risk or prevent further adverse consequences (185).

Standardized reporting methods, including case definitions, reporting procedures, and standardized data collection tools that could be easily modified to determine disaster-related injuries and deaths, do not exist and should be developed (185–187). After the World Trade Center attack of September 11, 2001, the National Center for Health Statistics convened an ad hoc working group and developed a set of new codes within the framework of the ICD-10 and ICD-9-CM that will allow the identification of deaths from terrorism reported on death certificates through the National Vital Statistics System, as well as the identification of injuries and illnesses from terrorism reported in medical records (http://www.cdc.gov/nchs/about/otheract/icd9/terrorism_code.htm; also see reference 250). In addition, a recent (April 2003) ad hoc working group was convened by the National Center for Injury Prevention and Control to develop standardized data collection tools and methods for bombings or explosions. Finally, it has been recommended that experienced public health disaster surveillance teams, similar to National Transportation Safety Board investigators in the United States, be established and rapidly deployed to assist communities experiencing disasters (187).

Patient safety. Although injuries related to medical care have not traditionally been included in public health surveillance of injuries, some investigators have commented thatiatrogenic injuries may account for more deaths than all other accidents combined (188). The Institute of Medicine addressed the issue of injuries related to medical care and medications in its report To Err Is Human: Building a Safer Health System (189), which called for a comprehensive approach to improving patient safety. In response to the recommendations of the Institute of Medicine, the federal government’s Quality Interagency Coordination Task Force issued a report in February 2000 (190) that proposed the establishment of error reporting systems in all states. The report proposed to foster an environment of support for these systems by implementing mandatory reporting in Department of Defense medical facilities. It also proposed to implement a voluntary reporting system nationwide in Veterans Administration hospitals and to integrate federal voluntary systems with data collection activities by states and private organizations. Concurrently, the CDC is developing the National Healthcare Safety Network for reporting of information on patient and health care worker safety. The patient safety component focuses on infectious and noninfectious adverse events associated with health care delivery, and the health care worker component focuses on adverse events associated with vaccines, vaccine-preventable diseases, and exposure to bloodborne pathogens (e.g., from needlestick injuries).

Traumatic central nervous system injuries. Traumatic brain injury has been estimated to cause 50,000 deaths, over 200,000 hospitalizations, and one million emergency department visits annually in the United States (191–193). Among survivors of traumatic brain injury, over 80,000 people per year are left with subsequent disabilities (194). The age-specific incidence of traumatic spinal cord injury is highest among adolescents and young adults, and some of the most common causes are potentially preventable (195, 196). To support state-based surveillance of traumatic brain injury and traumatic spinal cord injury, the CDC has developed the Guidelines for Surveillance of Central Nervous System Injury (60) and has provided financial support to some states to conduct surveillance of the incidence, risk factors, and causes of these injuries. States have used this surveillance for highlighting urban-rural differences in rates of traumatic brain injury (197) and risk factors or risk groups specific to a state (198). However, evaluation of traumatic spinal cord
INTEGRATION, EVALUATION

IMPROVING INJURY SURVEILLANCE—LINKAGE, INTEGRATION, EVALUATION

Data linkage

Linking data elements from more than one data set has many advantages over the use of a single data set. Many types of databases have been linked for public health surveillance and found to be useful in understanding injury risk factors and outcomes. The Crash Outcome Data and Evaluation System funded by the NHTSA is an example of the utility and application of linking multiple data sets (traffic collision, EMS, hospital discharge, and vital statistics data) at the state and national levels (32). The Crash Outcome Data and Evaluation System has allowed states to more accurately assess the occurrence, costs, and outcomes of transportation-related injuries and to evaluate the efficacy and cost savings associated with highway safety initiatives. By aggregating these data from multiple states, policymakers can be provided with extensive scientific information for their consideration regarding public safety and health care cost containment (72).

Police and traffic collision reports have also been linked to trauma registries or death certificates to demonstrate the association of type, severity, and outcome of injury with crash type, to advance the understanding of crash biomechanics and the design of vehicle occupant protection systems (200), and to evaluate current recommendations on the use of seat belts during pregnancy (201). Other examples include linking driver’s license data with trauma registry data to compare police assessment of alcohol use with blood alcohol measurements (202) or with hospital discharge data to examine the possibly decreased ability to drive following traumatic brain injury (203). Linkage of hospital discharge data with death certificate data has shown that discharge status has limitations as an outcome measure among injured persons (204) and that death certificate cause-of-death coding is sometimes incompatible with the main conditions of decedents while hospitalized (205). Thus, linking data sets used for surveillance can facilitate prevention research and permit evaluation of existing data sources.

Integration of surveillance systems

Surveillance of injuries should be viewed as one component of the larger system of public health surveillance. A 1994 report by Thacker and Stroup (206) commented on the fragmented approach to surveillance and the development over time of a collection of poorly coordinated systems that evolved in response to various needs. They proposed that a comprehensive public health surveillance system be structured as a network of compatible health information systems linked electronically and readily accessible to public health practitioners. Major efforts have begun to reorganize public health surveillance along such lines. In 1994, the Council of State and Territorial Epidemiologists called for the creation of a national public health surveillance system to expand, coordinate, prioritize, and standardize approaches to public health surveillance (207). Subsequently, the CDC, in collaboration with the Council of State and Territorial Epidemiologists and other key partners, began the development and implementation of the National Electronic Disease Surveillance System to promote the use of information system and data standards for integrated surveillance at the local, state, and national levels (208). Thus far, progress is real but slow. Although the concept of integration is compelling, functional implementation is proving to be an expensive and difficult task that may take many additional years to complete.

Evaluation

In 1963, Alexander Langmuir observed that “good surveillance does not necessarily ensure the making of the right decisions, but it reduces the chances of wrong ones” (209, p. 191). Thus, surveillance has limitations, even when done well. Assessing surveillance systems’ performance can be accomplished through periodic evaluations. In 1988, the CDC published a set of guidelines for evaluating surveillance systems (210). The guidelines focused on basic, practical issues such as the public health importance of the condition(s) under surveillance and the usefulness and costs of a surveillance system. These guidelines have been widely accepted and used in public health practice. An updated version published in 2001 (1) reiterates the original approach and principles and also addresses several issues of growing importance, including integration of information systems, establishment and use of data standards, and protection of confidentiality in the electronic exchange of health data.

Evaluations of injury surveillance systems have proven useful in identifying important strengths and shortcomings. Results from evaluation of a pediatric injury surveillance system in Canada indicated that data from the system might be representative of “general youth injury patterns” in the country, even though the system was not originally designed to include a nationally representative sample (211). Evaluations of newspapers as a potential source for injury surveillance have found that a substantial proportion of fatal cases and cases requiring hospitalization are not identified by newspaper reports (110, 212). In 1994, the CDC sponsored the development and evaluation of several state-based firearm injury surveillance systems. Summary reports included both surveillance data and system evaluations, thus providing a fuller picture of the strengths, limitations, benefits, and costs of these systems (166). Evaluation of the quality of injury surveillance data is necessary if prevention activities based on the data are to be appropriate and effec-
tive (213). Assessing the usefulness of surveillance systems is a key element in evaluation; reports demonstrating the practical use of data (26, 95, 214) provide examples that the systems are serving their intended purposes. In general, the time and effort spent in evaluation can provide information assuring that the resources being put into surveillance are well invested.

INTERNATIONAL INJURY SURVEILLANCE

Injuries are a major cause of mortality worldwide, causing more than five million deaths each year (215). As in many other areas of public health, major differences exist in countries’ capacities for injury surveillance, generally corresponding to their overall economic development. A comprehensive review of injury surveillance in countries other than the United States is beyond the scope of this report. We present instead several examples to illustrate the spectrum of injury surveillance activities internationally. In addition, the World Wide Web page of the CDC-sponsored International Collaborative Effort on Injury Statistics provides access to information on many countries’ injury prevention programs and injury surveillance activities (http://www.cdc.gov/nchs/about/otheract/ice/links.htm).

Injury surveillance in some developed countries

The European Union’s Home and Leisure Accident Surveillance System was designed for use in emergency departments for collection of data on the causes of home and leisure injuries, including consumer products involved in those injuries. Approximately 85 hospital emergency departments in all but three European Union countries participate in the Home and Leisure Accident Surveillance System. Germany, Luxembourg, and Spain participate through household surveys that use the same key variables as the emergency department recording system. The data are used for generating national summary statistics (216) as well as for highlighting specific injury issues (217, 218). In the Netherlands, a key participant in the Home and Leisure Accident Surveillance System, the Dutch Consumer Safety Institute has conducted emergency department-based surveillance for home and leisure injuries since 1984. In 1997, the Dutch Injury Surveillance System was initiated in a sample of hospital emergency departments for ongoing surveillance of injuries from all causes (219). The Dutch Injury Surveillance System provides a basis for priority-setting in injury control in the Netherlands (220), for obtaining information on the direct medical costs of injury (221), and for identifying research priorities.

In Canada, the Canadian Hospitals Injury Reporting and Prevention Program (222) collects and analyzes data on injuries and poisonings from the emergency departments of 10 children’s hospitals and five general hospitals across Canada. The primary focus is on children and adolescents. Data collection is accomplished using standard forms that are forwarded to the Injury Section at Health Canada for computer entry into the database of the Canadian Hospitals Injury Reporting and Prevention Program. The program serves as a valuable source of summary statistics and a resource for surveillance information on specific injury conditions (223). In Australia, the National Injury Surveillance Unit of the Australian Institute of Health and Welfare uses mortality statistics and hospital discharge data to produce reports on major causes of injury morbidity and mortality (224, 225), and the National Injury Surveillance Unit has worked in conjunction with injury surveillance and prevention practitioners in Australia to develop a set of national data standards for injury surveillance. In addition, Australia recently developed the National Coroners Information System, an Internet-based data storage and retrieval system for coroner cases (226). A state-based system, the Victorian Injury Surveillance and Applied Research System, accesses data from death certificates, coroner records, hospital admissions, and emergency department visits to conduct statewide surveillance of injury mortality and morbidity (227, 228). In New Zealand, the Injury Prevention Research Unit was established in 1990 (229). The Injury Prevention Research Unit uses data files on deaths and public hospital discharges from the National Minimum Data Set compiled by the New Zealand Health Information Service to publish fact sheets and results of descriptive and evaluative studies on priority injury prevention issues (230–234). The Injury Prevention Research Unit also maintains the National Injury Query System, an Internet-accessible, menu-driven source of information on injury mortality and morbidity statistics (235).

Comparability across national borders is important for effective international surveillance. The International Collaborative Effort on Injury Statistics is a multinational effort, sponsored by the CDC, to improve the quality and comparability of international injury data. Participants include representatives from the World Health Organization, from countries in Western Europe and North America, and from Australia, New Zealand, and Israel. The International Collaborative Effort on Injury Statistics has investigated international differences in injury mortality rates (236) and has held symposia to identify problems and propose solutions for international injury statistics (237). A major current project in which members of the International Collaborative Effort on Injury Statistics are participating is the International Classification of External Causes of Injury, a multiaxial classification system for coding data on external causes, developed in response to a perceived need for more detailed information about injury circumstances than is available through the ICD classification system. The first version of the International Classification of External Causes of Injury was released in 2001 and is currently undergoing the requisite procedures for acceptance in the World Health Organization family of international classifications. A short version intended for use in emergency department-based surveillance has been pilot-tested in the United States (238).

Injury surveillance in developing and underdeveloped countries

In The Global Burden of Disease, Murray and Lopez noted that “still very little is reliably known about causes of death in much of the developing world” (239, p. 191). Although injury mortality and morbidity have been identified as major...
problems in some underdeveloped countries (240), injury surveillance is problematic because of the dearth of resources for public health activities in general. The World Health Organization and the CDC have recently developed a manual to help design, establish, and maintain injury surveillance systems, aimed in particular at persons working in settings with severe constraints on the capacity to keep records or assemble data into statistics (215).

In Asia, some countries have begun or are beginning to establish national systems for injury surveillance. In other countries without such systems, surveys and studies have used existing data sets to describe and quantify data on important injury issues. The People’s Republic of China has developed a sentinel system of disease surveillance points in lieu of a nationwide system of vital records and public health surveillance. The disease surveillance points system covers approximately 10 percent of the population (241). Disease surveillance points data have been used to estimate the overall injury mortality rate in China and to identify leading causes and high-risk groups (241, 242). Thailand initiated a provincial injury surveillance system in 1993, with reporting from five large hospitals located in Bangkok and four regions of the country. The data have been useful in documenting the large proportion of injuries from transport accidents and the large proportion of deaths occurring prior to hospitalization. The latter may indicate a need for improved prehospital transport and care. Hospital-based sentinel surveillance is being considered for a larger national injury surveillance system for the country (243). In Vietnam, which does not have a formal national system of injury surveillance, the Vietnam Multi-center Injury Survey was conducted in 2001. This nationally representative survey of over 127,000 respondents demonstrated that injuries are the leading cause of years of potential life lost. Drowning was the leading cause of years of potential life lost nationally, and road traffic injury was second. The high prevalence of personal transportation via motorcycle rather than via automobile or bicycle has important implications for the incidence and prevention of transport-related injuries (244).

In some underdeveloped countries in Africa and other areas, monitoring causes of death has been done by “verbal autopsy” interviews of the deceased person’s relatives or associates. Trained field-workers can perform these interviews, with subsequent review by clinicians to assign a cause of death (245). The latter step can be costly, and a study in Ghana and Tanzania using computer algorithms in lieu of physician review to assign cause-of-death diagnoses demonstrated that this might be an effective and less expensive alternative (246). Hospital-based surveillance can provide data on injury morbidity, although it does not identify the many patients who do not seek formal medical care (247). While acknowledging this important limitation, a study in Uganda demonstrated the feasibility of a hospital-based system using a minimum data set and a simple standard index of injury severity (248). The Caribbean Epidemiology Center of the World Health Organization is working with several member countries to develop emergency department-based injury surveillance. Recognizing the limited resources (money, personnel, etc.) available, the designers have emphasized simplicity, but they acknowledge that “even if the system is simple and flexible, sustainability will be difficult to achieve” (249, p. 246).

CONCLUSIONS

In recent decades, great strides have been made in injury surveillance. The systematic collection and use of data on risk factors, incidence, severity, outcomes, and costs has assisted practitioners and researchers in identifying populations at risk, implementing and evaluating prevention programs, and formulating and evaluating policy. These efforts have already improved the health of the population, and they will continue to do so.

In the United States, surveillance for the leading cause of injury fatality, motor vehicle-related injuries, has included linking multiple data sets in which data were collected for disparate purposes. This has supported innovative public health applications, such as evaluation of the effectiveness of state and national legislation or regulations. In some respects, motor vehicle-related injury surveillance has been further advanced than surveillance for other classes of injury, but important developments are under way in other areas. Surveillance systems are being designed for major issues in injury such as violent death and patient safety. Standards are being developed and used to facilitate consistency and comparability in data collection and dissemination. Federal, state, and academic partners are collaborating to promote and improve state-level injury surveillance capacity. Progress in injury surveillance can be fostered by developing systematic approaches to the access and use of existing data sources, as has recently been done in the Consensus Recommendations for Using Hospital Discharge Data for Injury Surveillance (20).

The growth and development of injury surveillance also presents important challenges. With more systems that can provide more data, there is a greater need for integration. Integration of information systems is a multidimensional issue encompassing data on risk factors, morbidity, and mortality for both intentional and unintentional injuries, involving local, state, national, and international levels, and including systems that are intended to serve not only public health but also clinical, administrative, and other functions. In addition, injury surveillance and public health surveillance in general face the challenge of integration during a time of increasing capacity for electronic access to and transmission of health-related information. The tools and systems at our disposal provide tremendous opportunity, but they also require responsible use, including the provision of data security and the protection of confidentiality.

Finally, a continuing challenge for injury surveillance is making effective use of the data. No matter how important the condition under surveillance, data collection is not an end in itself, as reflected in the observation by former CDC Director William H. Foege: “The reason for collecting, analyzing, and disseminating information on a disease is to control that disease. Collection and analysis should not be allowed to consume resources if action does not follow.” This is true for injury surveillance as well as disease surveillance. In that context, the public health investment in surveillance—whether it be in continuing or enhancing existing...
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