causal links, most notably the family environment. It is not sensible for children to be exposed to separate curricula or social service intervention programs to prevent each of these bad outcomes. Efforts should be integrated into a more potent delivery system, and evaluated prospectively.

Though hopelessness is a cardinal feature of suicide, we should not be affected in our efforts to seek the prevention of youth suicide. We need to push the rate of progress, broaden our alliances, and demand further opportunities to design and evaluate interventions, directly and indirectly. The alternative will be to watch the canary become an endangered species.

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Epidemiology and injury prevention

It is widely recognized that epidemiology is the basic science in public health.1 Since injuries represent a major public health problem throughout the world, it is only natural to turn to epidemiology as a resource for identifying the underlying causes of injury and, eventually, for controlling them. Indeed, the editor of this journal, and a large portion of the contributing authors are card-carrying epidemiologists. A more careful examination, however, of the contribution of epidemiology to the prevention of injuries poses some questions.

A comparison of past accomplishments of epidemiology in various fields of public health illustrates this point. Epidemiology was the battleground in which the war against most infectious diseases was fought and won.2 Even with respect to AIDS, for which molecular research has reached unprecedented depths, successful control of disease spread has been accomplished by implementing lessons learned from epidemiologic studies.3 Moreover, epidemiology has been instrumental in the identification of much of what is currently known about the etiology of cardiovascular diseases, including the role of hypertension, hyperlipidemia, tobacco smoking, diet, and physical activity.4,5 Lastly, epidemiology has contributed to the documentation of all but a few of the established human carcinogens, including tobacco smoking, virtually all occupational carcinogens, hepatitis viruses B and C, strains of human papilloma virus, and ionizing and ultraviolet radiation.6,7

Set against this impressive background, the contribution and the potential of injury epidemiology appears more limited. Is this because epidemiologic instruments are not appropriate for the investigation of the occurrence of injuries? Or does it reflect the fact that injuries have not been recognized as a major public health problem until recently?

The first explanation cannot be easily dismissed. There are important differences between the pathobiology that underlies most human diseases and the constellation of external factors that trigger most ‘accidents’. Many of the component causes of cardiovascular, neoplastic, or infectious diseases are distinct and identifiable physical, chemical or biologic entities, whereas the factors contributing to injuries are frequently behavioral, poorly defined, and inadequately operationalized. In addition, most chronic, and several acute, diseases have natural histories with identifiable stages that allow a consideration of time sequence in the establishment of causation. Such timing is frequently impossible in the study of injuries.

These differences create genuine problems in the application of traditional epidemiologic methods8 to the investigation of the causes of injuries. Thus, a cohort study that is frequently thought of as the method of choice in observational research is compromised by our inability to specify in advance the relevant proximal exposures, be these behavioral or environmental—for instance, how a driver reacted to unpleasant or exciting news on the radio. Case-control studies, on the other hand, face not only the problem of selection bias generated by instantaneous death (a problem shared by cardiovascular epidemiology) but also the fact that proximal to the accident, events and conditions are difficult to ascertain because of post-traumatic shock or denial of responsibility on the part of the victim. Moreover, manifestational homogeneity, created by the inclusion of injuries of similar nature and severity does not necessarily imply etiologic homogeneity, and heterogeneity hinders statistical substantiation of causality. Last, but by no means least, control selection—challenging in any epidemiologic study—confronts an additional major difficulty: should controls have had no history of accident, and, if not, how far back should the time horizon be extended?

The argument that epidemiologic studies of diseases different in nature require different paradigms is not new.9 It has been invoked in relation to infectious diseases, in the context of deductive investigation of outbreaks due to known causes, for example salmonella outbreak, as well as in inductive investigations of diseases of unknown etiology, for example breast cancer. These arguments, however, do not challenge the applicability of the discipline of epidemiology, but call for its enrichment with methods customized to address the specific problems characterizing different disease entities. This is particularly true with respect to injuries, for which neither animal studies nor randomized experiments can be contemplated.

Progress in the prevention of injuries has relied until now either on theoretical arguments based on laws of physics or on observational research that has essentially been based on case studies, case series, or critical incident analyses. The observational approaches are essentially epidemiological, except that statistical uncertainty and confounding are evaluated informally on the basis of common sense and background knowledge. They are more useful for hazard identification than risk estimation. These processes are not

inappropriate, and they are similar to the 'case reports' that have in the past led to more formal epidemiological investigations of other disease entities. What is now needed is to develop epidemiologic methods that can effectively address the problems generated by the peculiar circumstances that increase the long term likelihood of an accident or, just as important, trigger it. An important development in this direction was the introduction of the case-crossover design that has been effectively used in cardiovascular epidemiology to identify and quantify the importance of triggering factors for acute events. The potential of this method in injury epidemiology is being increasingly recognized, and several injury investigators have already used it. Other promising developments are those that focus on more reliable exposure ascertainment and the creation of large databases that can highlight the problems and set the stage for their solutions.

Injury epidemiology is a young discipline that must borrow from its core methodologies while exploring alternatives and refinements. As the discipline matures, so will its methodology. The basic concepts and principles of epidemiology, however, are already established, as is its potential to document causality in health and disease. Injuries are no exception.

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Injury and entropy

As one jumble of molecules to another, I would quite like the answers to some questions. Why do unintentional injuries occur? Are they intrinsically probable in some biological or chemical sense? I can partly understand infectious disease, intentional injury, and even genetic variations, as the results of biological competition. But why did I slice the end of my finger off when opening the oil can? I know it was hilarious fun ferreting around in the grass to find it, wash the oil off, and conduct a full thickness skin graft without anaesthetic—but all the same, nothing and nobody gained from it. If it has no obvious biological purpose, perhaps unintentional injury has a more fundamental aspect—a common property we share with the wider jumble of molecules we call our environment.

The physical and chemical fabric in which we live suffers from an overriding probability of increased molecular disorder over time and a related tendency towards the dispersal of concentrations of energy (entropy). I would like to extend this concept of entropy to serve as a simile for a process that appears to occur throughout the physical and social environment.

The construction and maintenance of these environments requires investment of resources for which there is competition—that is, there is a trade off between the repair of cracked paving, the provision of child care, and the procurement of cycle helmets, as well as other potentially foregone benefits. Furthermore, this investment of resources is unequally distributed, such that those in socially deprived communities are a priori likely to be living in situations of high entropy. A litmus test for this dissociation and decay of the fabric might be the frequency of injury (that is entropy of the people as a result of entropy of the fabric).

Learners, explorers, and survivors

New personal situations may be imposed by developing (or deteriorating) faculties, may be sought for pleasure, or may be suffered during unwanted changes in circumstances. Injuries are particularly common in immature children (including adolescents), among those who climb mountains, and among the socially marginalised. In the past, there has been a view that children and adolescents are the only 'learners' in our society. When the environment was relatively fixed for human lifespan, this may have been appropriate. Now, in many cases, adults are also forced to adapt to new environments, both social and physical, throughout their lives. This process of spontaneous disorder and the rebuilding of the social and physical fabric, therefore, has a dimension of speed relative to biological time.

Injury might be partly a product of the novelty of such encounters with entropy and of the stresses that accompany human adaptation. The particular individuals likely to be injured may be difficult to identify in advance as this adaptability and skill in learning is not necessarily on the same dimension as risk aversion. For instance, people in risky circumstances may have little insight into their capacities and especially into the capacities of others who are in their care or upon whom they may have an impact.

Testing the model

INJURY AS A RESULT OF SOCIAL ENTROPY

The processes by which social disintegration might be manifest as individual injury could be because the physical environment is not maintained in a safe state through lack of corporate investment, because individuals in the com-

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Updated information and services can be found at:
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