Ecological approaches to the prevention of unintentional injuries

John P. Allegrante[1], Dale W. Hanson[2], David A. Sleet[3], Ray Marks[4]

[1]Department of Health and Behavior Studies, Teachers College, and Department of Sociomedical Sciences, Mailman School of Public Health, Columbia University, New York, NY, USA; [2]School of Public Health Tropical Medicine and Rehabilitation Sciences, James Cook University, Queensland, Australia; [3]National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, Atlanta, GA, USA; [4]Department of Health and Physical Education, School of Health and Behavioral Sciences, York College, City University of New York, Jamaica, NY and Department of Health and Behavior Studies, Teachers College, Columbia University, New York, NY, USA

Correspondence to: John P. Allegrante, Box 114, 525 West 120th Street, New York, NY 10027. E-mail: jpa1@columbia.edu

Abstract

Background: Injury as a cause of significant morbidity and mortality has remained fairly stable in countries with developed economies. Although injury prevention often is conceptualised as a biomedical construct, such a reductionist perspective overlooks the importance of the psychological, environmental, and sociocultural conditions as contributing factors to injury and its consequences. This paper describes the potential of the ecological model for understanding the antecedent causes of unintentional injuries and guiding injury prevention approaches. We review the origins and conceptualise the elements of the ecological model and conclude with some examples of applications of ecological approaches to the prevention of unintentional injury and promotion of community safety.

Methods: A review of the English-language literature on the conceptualization of ecological models in public health and injury prevention, including the application of the ecological model in the prevention of falls and road traffic injuries and in the community safety promotion movement.

Results: Three dimensions are important in social-ecological systems that comprise key determinants of injuries: 1) the individual and his or her behaviour, 2) the physical environment, and 3) the social environment. Social and environmental determinants have profound impact on population health and in the causation of injuries.

Conclusions: Social and environmental determinants of injury should be studied with the same energy, urgency, and intellectual rigor as physical determinants. Application of the ecological model in injury prevention shows the most promise in falls injury prevention, road traffic injury prevention, and community safety promotion.

Key words: ecologic model, injury prevention, public health, safe communities, safety promotion

Introduction

Health is not merely a product of individual biological, psychological, and behavioural factors; it is the sum of collective social conditions created when people interact with the environment. Preventing unintentional injury, like preventing diseases, requires attention to the entire social system [1].

Much of our thinking about health and disease causation has been dominated, since almost the beginning of the 20th century, by the prevailing medical model [2]. By extension, injury prevention has been conceptualised as a biomedical construct in which preventing injury is conceived as preventing the sudden release of energy that produces tissue damage, or protecting the individual when energy is released (e.g., from seat belts). This reductionist perspective overlooks the importance of the psychological, environmental, and sociocultural conditions as contributing factors to an injury event and its consequences.

William Haddon, the father of modern injury prevention, prophetically introduced the concept of ecological injury prevention with publication of his seminal paper, "On the Escape of Tigers: An Ecological Note" [3]. In the context of the prevailing epidemiological model of causation in which the agent, host, and environment interact, he highlighted the opportunities for

harm reduction through redesign of the physical environment. Moreover, he argued that by preventing or dissipating the adverse release of energy, it was possible to minimise the chance of injury without necessarily preventing the "accident" [4]. By doing so, Haddon precipitated a major paradigm shift from accident prevention to injury prevention.

Now, three decades later, disease control has embraced an ecological perspective on the determinants of health that realises the importance of both the physical and social environments and the interaction of the individual with the environment [5]; however, injury prevention has lagged behind. While mounting evidence suggests that the social and economic environments exert profound and lasting effects on unintentional injury [6, 7], this knowledge has not yet been adopted in such a way to influence the prevention of unintentional injuries [8].

In this article, we describe the potential of the ecological model for understanding the antecedent causes of unintentional injuries and guiding injury interventions. We review the origins and conceptualise the elements of the ecological model, using the "injury iceberg" [8] as a useful metaphor, and conclude with some applications of the ecological model to the prevention of unintentional injury and community safety promotion.

The ecological model

Concepts underlying the ecological model date back to the early 20th century when Park, Burgess, and McKenzie [9] are believed to have coined the term *human ecology,* extrapolating the theoretical paradigm of plant and animal ecology to the study of human communities. More recently, Last [10] defined *ecology* as "the study of relationships among living organisms and their environment" (p. 52), while *human ecology* refers to the "study of human groups as influenced by environmental factors, including social and behavioral factors" (p. 52).

Interventions that simultaneously influence multiple levels and multiple settings of an ecological system may be expected to lead to greater and longer-lasting changes in health outcomes [11]. McGinnis, Williams-Russo, and Knickman [12] have attempted to quantify how multiple determinants account for premature deaths. They estimated that genetic predisposition accounts for 30% of early deaths; social circumstances, 15%; environmental factors, 5%; behaviours, 40%; and shortfalls in medical care for 10% of all premature deaths. It follows, then, that the most effective interventions to address multiple influences will occur at multiple levels [13].

According to Stokols [14, 15], health promotion programmes, and by extension injury prevention programmes, often take into account the individual's interactions with the physical and social environments. Edward Rogers [16] was perhaps the first to advance the conceptual and potentially pragmatic value of ecological models in organised public health. This ecological perspective—especially as applied to changing health behaviour—was furthered by Moos [17], Green and McAlister [18], and McLeroy and colleagues [19].

Green and Kreuter [20] proposed a socioecological model of health promotion, compatible with injury prevention, in which health and safety can be interpreted in the context of the whole (ecological) system. The three dimensions to this system are: 1) the individual and his or her behaviour, 2) the physical environment, and 3) the social environment. Each dimension can be analysed at five levels:

1. *The intrapersonal level:* Characteristics of the individual, that is, his or her knowledge, skills, life experience, attitudes, and behaviours as they interface with the environment and society.
2. *The interpersonal level:* The immediate physical environment and social networks in which an individual lives, including family, friends, peers, and colleagues and coworkers.
3. *The organisational level:* Commercial organisations, social institutions, associations, clubs, and other structures that have rules and regulations enabling them to have direct influence over the physical and social environments maintained within their organisation.
4. *The community level:* The community can be defined within geographical or political boundaries and may share demographic, cultural, ethnic, religious, or social characteristics, with its members having a sense of identity and belonging, shared values, norms, communication and helping patterns.
5. *Societies:* These are larger systems, often defined along political boundaries, possessing the means to distribute resources and control the lives and development of their constituent communities.

To better understand the multiple levels of intervention required in an ecological approach to injury prevention, Hanson and colleagues [8] have proposed a visual metaphor, the *injury iceberg*, showing the relationship of the individual

to the physical and social environment, together with various levels of interaction (Figure 1).

The individual is, metaphorically speaking, the tip of the iceberg—just one part of a complex ecological system with many levels. While the individual may be the most visible component of this system, important determinants of their behaviour and environmental risk are "hidden below the waterline." Attempts to modify the risk of injury at one level in isolation (for example, individual behaviour) will be resisted by the rest of the system, which will attempt to maintain its own internal stability (homeostasis). Syme and Balfour [21] have observed that "it is difficult to expect that people will change their behavior easily when many forces in the social, cultural, and physical environment conspire against such change . . . more attention will need to be given not only to the behavior and risk profiles of individuals, but also to the environmental context in which people live" (p. 796)—a strong argument for ecological approaches to change.

The socioecological paradigm emphasises the dynamic interplay among the three dimensions—the individual, the physical environment, and the social environment—which act at five levels: intrapersonal, interpersonal, organisational, community, and societal. These provide the ecological context in which the individual behaves within the environment [22]. Each level is built on the foundation of a "deeper" level. As these deeper levels become larger and exercise more inertia, it becomes more difficult to change them. But once changed, these levels are more likely to sustain the desired outcome [23]. This ecological model provides a complex web of causation and creates a rich context for multiple avenues of intervention. It can be used to map the key links to an injury, identifying upstream latent failures, along with the more obvious downstream active failures. Identifying the most strategic links thus ensures effective action.

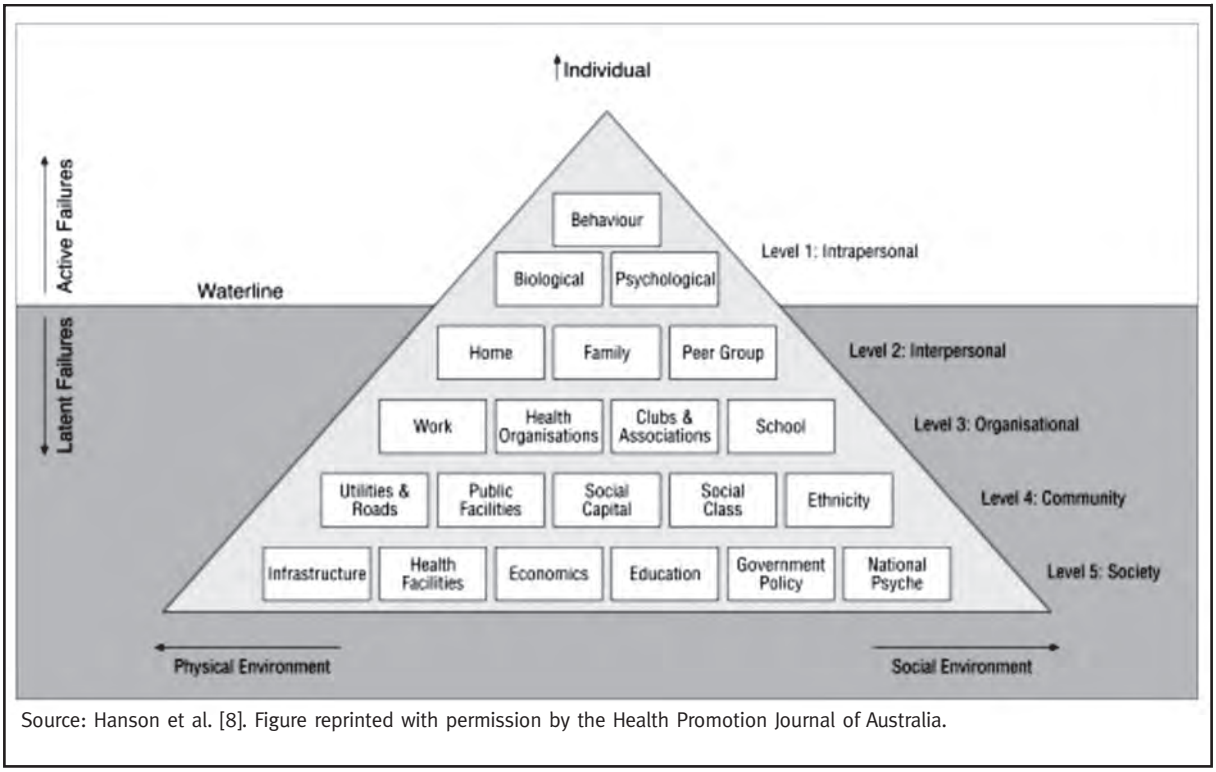
Applications of the ecological model in injury prevention

While the use of behavioural and social science theories in the context of injury prevention has been limited to a selected few [24], there are numerous examples of using behavioural, social and ecological approaches designed to promote safety in physical activity [25], prevent obesity [26], and improve nutrition and food choice [27]. In injury prevention, the application of the ecological model in injury prevention has shown the most promise in falls injury prevention, road traffic injury prevention, and community safety promotion.

Falls injury prevention

There is increasing support for the application of multi-faceted interventions to reduce falls among older adults [28]. Clemson et al. describe

Figure 1. The injury iceberg.



Source: Hanson et al. [8]. Figure reprinted with permission by the Health Promotion Journal of Australia.

a multi-faceted community-based programme to reduce the incidence of falls in an elderly population [29]. Applying the ecological framework, Clemson and colleagues studied the impact of improving individual falls self-efficacy and lower-limb balance and strength, while improving home and communal environmental and behavioural safety. In addition, attention to regular vision screening and medication reviews was encouraged. Compared to a control group, the intervention group experienced a 31% reduction in falls. A similar home-based intervention to prevent falls among community-dwelling frail older people, which included a home environmental assessment, facilitating any recommended changes, and training in the use of adaptive equipment, especially among previously frequent fallers, was effective in reducing falls rates among those with a history of recurrent falling [30].

A number of studies have demonstrated that multifaceted community-based approaches that utilise an ecological model of intervention are more effective than single-strategy intervention approaches [31,32]. Moreover, an ecological approach that focuses on the multiple causative factors for falls, and policies that foster screening and referral programmes are most likely to succeed. The ecological model also takes into consideration the need to train personnel to conduct risk assessments, and preventive interventions. Moreover, legislation to optimise safety in the home and its environment and adequate medical coverage and funding for counseling are all important elements in the ecological approach [28, 33].

Motor vehicle injury prevention

Like falls, motor vehicle crashes and their associated injuries have multiple determinants; however, because of the weak behavioural technologies of the past, efforts to prevent injuries have largely focused on passive approaches. Nonetheless, with the decline in the potential for further engineering improvements, it has become clear that in addition to other considerations, behavioural and social change is essential to effective improvements in road safety [34].

The consensus among experts is that behaviour change is most likely to occur in the context of comprehensive, multisectoral, participative, and socially supportive interventions [35, 36]. Even the simplest behaviour is determined by a complex mix of biological, psychological, and sociocultural factors [37]. Road safety interventions can benefit from the incorporation of an ecological approach that addresses these factors in intervention planning and implementation.

There is general agreement that single interventions do not have the same impact as multiple interventions in efforts to reduce or prevent injury [38]. Health promotion approaches to road traffic injury prevention have been advocated as one approach to ensure an ecological context is included [39, 40]. Indeed, a U.S. Centers for Disease Control and Prevention (CDC) report describing motor vehicle safety as one of the 20th century's 10 important public health achievements strongly suggests that success was achieved because of multiple interventions applied within an ecological context [41]. The changes held responsible for the improvements in motor safety included legislative policies, educational programmes, and changes in the physical and social environment [42, 43].

In the late 1980s, Sleet [44] and Simons-Morton et al. [45] proposed taking an ecological perspective and diagnostic framework to identify factors associated with drinking and driving, and applying a conceptual intervention model with multiple components. This has been subsequently supported by Sleet and colleagues [46] in describing effective interventions to prevent drinking and driving. These authors have suggested that while health education interventions may contribute to reducing alcohol-related traffic injury, ecological approaches are preferred and have been shown effective [35].

In ecological approaches, each intervention builds synergistically on the strengths of every other one. More specifically, given the complexity of factors that influence driving under the influence of alcohol, ecological approaches to reducing alcohol-impaired driving that use four components of the health promotion model, as proposed by Howat et al. [47], are likely to be especially effective. These include the use of: 1) economic interventions, 2) organisational interventions, 3) policy interventions, and 4) health education, including media, school and community education, and public awareness campaigns.

Similarly, Lonero and Clinton [36] identified four broad classes of tools with which to influence driver behaviour: legislation, enforcement, education, and reinforcement. In its report on preventing road traffic injuries [48], the World Health Organisation (WHO) focused attention on a systems approach to prevention, including the interaction among its elements—vehicles, roads, and road users and their physical, social, and economic environments.

Community safety promotion

To focus solely on the biomedical concept of injury prevention is to misunderstand the fundamental nature of the human experience, and hence how the positive state of "safety" is achieved. Maurice et al. [49] define *safety* as "a state in which hazards and conditions leading to physical, psychological, or material harm are controlled in order to preserve the health and well-being of individuals and the community" (p. 237). The United Nations, in its 1994 report on human development, has asserted that safety and security is a fundamental human right and an essential condition for the sustainable development of societies [50]. Safety is as much concerned with the subjective dimension—the perception of safety—as it is with the objective dimension—the absence of injury. It is as much concerned with the community in which individuals reside as it is with the behaviour of the individuals who comprise the community. Thus, it is evident that safety is a psychological, sociological, and environmental phenomenon, as much as it is physiological. As such, safety is inherently an ecological concept [51].

Moller [52] states, that the community-based model for injury prevention includes the application of multiple countermeasures and multiple strategies in the context of community defined problems and community owned solutions. Effectively managing context by implementing the most appropriate mix of strategies to address the specific injury problems faced by the community is a critical factor determining the success. Most important, the community must be involved in the process of defining the problem, locating data, identifying practical solutions, and mobilising the resources necessary to implement and sustain the solution [8, 53, 54].

One approach is to maximise the capacity of a community to institutionalise and maintain change within its own "ecosystem" [8, 54]. Hanson [55] has identified four types of community resources that enable such capacity:

1. *Financial capital:* The economic resources available to a community. While clearly important, it is frequently overemphasised at the expense of other forms of capital.
2. *Physical capital:* The natural environment and man-made resources (for example, buildings and equipment) available to a community.
3. *Human capital:* The skill and knowledge of the individuals contained within a community.
4. *Social capital:* The features of social organisation such as networks, norms, and trust that facilitate coordination and cooperation for mutual benefit [56].

WHO Safe Communities

Safe Communities is an approach to injury prevention and safety promotion that is supported by the WHO [57]. The safe community model seeks to understand injury and intervene at a community level. By involving people in finding their own solutions to community problems, the community aims to be a catalyst for environmental, structural, sociological, and political change. This empowers the community, and ultimately individuals within a community, to change their environment and their behaviours to reduce the risk of injury and increase the perception of safety. It uses an ecological paradigm to promote community safety promotion [8]. There are currently 177 WHO-designated Safe Communities [58]. Communities are assessed for WHO designation based on six indicators, designed to encourage best practice in safety promotion [53]:

1. An infrastructure based on partnerships and collaborations, governed by a cross-sectoral group that is responsible for safety promotion in their community;
2. Long-term, sustainable programmes covering both genders and all ages, environments, and situations;
3. Programmes that target high-risk groups and environments and programmes that promote safety for vulnerable groups;
4. Programmes that document the frequency and causes of injury;
5. Evaluation measures to assess their programmes, processes, and the effects of change; and
6. Ongoing participation in national and international Safe Communities Networks.

Spinks and colleagues [59] conducted a systematic review of the WHO Safe Communities approach on behalf of the Cochrane Collaboration. They identified 21 community-controlled evaluations using population-based injury morbidity and mortality data. These studies were conducted in two geographical regions: Europe (Austria, Sweden and Norway) and Australasia (Australia and New Zealand). Although the authors concluded that some communities were able to achieve a reduction in injury using the WHO model, important methodological limitations were present in all studies, illustrating the challenges of conducting ecological research on safety.

Programmes conducted in Scandinavia demonstrated stronger population outcomes than those conducted in Australasia. Falkoping, a

city in Sweden demonstrated a 23% decrease in all injury morbidity rates at the time the community coalition was active [60]. Motala, also a city in Sweden, demonstrated a 13% reduction in injury rates [61]. Harstad (a city in Norway) produced significant reductions in child burns and scalds, and traffic injury rates [62, 63]. In New Zealand, the Waitakere Safe Communities Project documented a significant reduction in child injury admission rates, but was unable to demonstrate a significant reduction in hospitalisation rates for all ages and all injuries [64]. In Australia, the Shire of Bulla (later to become the Hume Safe Communities) was unable to demonstrate a significant reduction in injury rates [65]. The Child Injury Prevention Project conducted in Mackay and Mt. Isa (Queensland) was able to demonstrate a decrease in Emergency Department (ED) presentations and hospital admissions in children aged four years and under while ED presentation and injury hospitalisations increased in control communities [66].

No studies were identified by WHO Safe Communities in low and middle income countries, so any generalisation of these results to the international community must be undertaken with caution. However, Spinks et al. [59] conclude it is time to conduct an appropriately funded and rigorously conducted global multi-community trial of the Safe Communities approach. These studies can provide further evidence of the value of taking an ecological approach within a community setting.

Conclusions

This article has sought to highlight the limitations of approaching injury causation simply as a biomedical construct related to a sudden release of energy resulting in tissue damage to an individual. Such an approach underestimates both the influence and effects of environmental and social contextual factors and narrows the prospects for developing effective prevention programs. Injury prevention and safety promotion should consider physical, psychological, and sociological dimensions and thus should be considered an ecological concept.

Hanson's [8] injury iceberg is a useful metaphor for understanding the concept of injury causation as an ecological system. In this system, the individual is just the tip of the iceberg, the most visible and identifiable component of a complex system in which the individual interacts with the physical and social environments. The most enduring means to reduce an individual's risk of injury in such a system is to systematically address the physical and social environmental factors hidden beneath the waterline, which ultimately shape individual and social behaviours that can give rise to injury.

While much has been achieved in the past 50 years, we face a new frontier of challenges in the prevention and control of injury in the 21st century. Social influences have a profound impact on population health and injury outcomes. Social and environmental determinants of injury should be studied with the same energy, urgency, and intellectual rigor as physical determinants.

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