Epidemiologic Reviews
Vol. 25, 2003

Printed in U.S.A.
DOI: 10.1093/epirev/mxg005

PREVENTION

Introduction: Back to the Future—Revisiting Haddon's Conceptualization of Injury Epidemiology and Prevention

Carol W. Runyan[1,2,3]

[1] The University of North Carolina Injury Prevention Research Center, Chapel Hill, NC.
[2] Department of Health Behavior and Health Education, School of Public Health, The University of North Carolina at Chapel Hill, Chapel Hill, NC.
[3] Department of Pediatrics, School of Medicine, The University of North Carolina at Chapel Hill, Chapel Hill, NC.

Received for publication September 17, 2002; accepted for publication February 3, 2003.

INTRODUCTION

Critiques of contemporary epidemiology have addressed the increasing gap between its scientific foundations and its contribution to the practice of public health (1–12). This debate has also addressed the value of using theory and conceptual models to guide both research and practice (1, 6–9, 11). Although seemingly unrecognized in this recent debate, Dr. William Haddon, Jr., widely considered the father of modern injury epidemiology, raised very similar issues some 35–40 years ago as he argued for both a more scientifically driven approach to injury control and also developed two complementary conceptual frameworks to guide epidemiologic research and prevention practice (13–18). This paper examines Haddon's advances from both a theoretical and a practical perspective and demonstrates the applicability of his approach not only to injury problems but also to other public health issues.

THE CONTRIBUTIONS OF WILLIAM HADDON, JR.

William Haddon, Jr., made numerous contributions to the field of injury control through his research on a variety of injury topics and his leadership of the National Highway Traffic Safety Administration and later the Insurance Institute for Highway Safety. However, he is most well known for his conceptual work through which he developed two complementary conceptual frameworks for understanding how injuries occur and developing strategies for intervention. One conceptual framework has become known as the Haddon Matrix, while the other is his articulation of 10 countermeasure strategies for reducing injuries.

The Haddon Matrix

Haddon's work clearly was informed by at least two predecessors, Drs. John E. Gordon and James J. Gibson. Gordon, in a 1949 paper in the *American Journal of Public Health* entitled "The Epidemiology of Accidents," firmly placed injury control within the public health framework in which health problems are conceptualized to result from interactions among the host, agent, and environment (19). Gibson, a psychologist, in 1961 elaborated on this notion by classifying agents of injury in terms of various forms of energy including thermal, radiant, chemical, electrical, and mechanical (20). In addition to drawing on the agent-host-environment concepts in defining the columns of his matrix, Haddon relied on examples from public health efforts to address polio as he conceptualized countermeasures within phases of influence (14). For example, he described the first phase in combating polio as one of "preventing the etiologic agent from reaching the susceptible host"; the second phase as the "interaction of the etiologic agents and the susceptible structures"; and the third phase as "maximizing salvage, once damage has been done to the susceptible structures" (14, page 233). He expanded upon this by depicting the phases in the crash and injury process as precrash, crash, and postcrash to define the rows of his matrix.

Initially, in creating the matrix, Haddon crossed these concepts (the rows) with columns depicting such factors as driver, passengers, pedestrians, bicyclists, motorcyclists, vehicles, highways, and police (14). Later, Haddon (15, 17) refined the model to its current form, listing the columns as follows: human (or host); vehicles and equipment (vehicles for transmitting the agent); physical environment; and socioeconomic environment. Still later, he revised the model to

Correspondence to Dr. Carol W. Runyan, The University of North Carolina Injury Prevention Research Center, Bank of America Building, Suite 500, CB 7505, 137 East Franklin Street, Chapel Hill, NC 27599-7505 (e-mail: carol_runyan@unc.edu).

TABLE 1. The Haddon Matrix applied to the problem of injuries to children falling on playgrounds

	Host (children on the playground)	Agent/vehicle (specific playground equipment and devices)	Physical environment (overall playground design)	Social environment (community norms, policies, rules)
Pre-event (before the fall)	Teach children to follow safety rules on the playground (e.g., no crowding on the climbing equipment)	Construct equipment with tacky grips, sized to children's hands, to reduce the risk of hands slipping	Build sliding boards into hillsides so children do not have to climb to heights	Foster social norms that encourage adults to help maintain orderly play on the playground
Event (during the fall and time of impact)	Teach children to fall in ways that reduce injury	Reduce the number of protrusions on equipment so falling children do not hit sharp components	Ensure the presence of resilient surfacing	Organize community-watch systems to monitor playground safety (e.g., maintaining surfacing)
Post-event (after the child is injured by the fall)	Teach children how to summon help when injuries occur (e.g., using emergency call boxes)	Avoid equipment in which children can fall into areas not easily reached by rescue personnel	Provide benches for supervisors that afford good visibility of all playground areas to facilitate noticing when children are injured	Ensure funding for adequate emergency personnel appropriately equipped to deal with pediatric emergencies

consider topics other than traffic crashes, changing the labeling of the rows to "pre-event," "event," and "post-event" (17). In the columns, Haddon identified the host (or person affected by the injury); the agent, which he defined in terms of energy transferred to the host by either an inanimate vehicle (e.g., a firearm or automobile) or an animate vector (e.g., an assailant); and the environment consisting of those elements of the physical surroundings that contribute to the occurrence of potentially injury-producing events or to injury (e.g., the physical characteristics of the roadway, building, playground, athletic field, or factory). In contrast, the social environment refers to the sociopolitical milieu affecting the process, which could include cultural norms or mores (e.g., tolerance of corporal punishment or alcohol consumption), political environments (e.g., willingness to adopt regulatory interventions that restrict the freedom of motorcyclists or gun owners), and the legal environment (e.g., the presence or absence of seat belt usage laws; practices regarding enforcing drunk driving laws or prosecuting perpetrators of domestic violence or child abuse).

This model has been used both to conceptualize etiologic factors for injury and to identify potential preventive strategies, making it a useful tool not only for guiding epidemiologic research but also for developing interventions. Table 1 provides an example of how to apply the matrix to the problem of injuries to children falling on playgrounds.

By filling in the cells of the matrix, one can identify a range of potential risk and protective factors and/or strategies for prevention that are directed at each of the factors (the columns) and have an influence during the different phases (the rows). For a further explanation of how to apply the matrix, refer to Runyan (21). Part of the model's utility lies in its facilitation of brainstorming in an interdisciplinary group that encourages development of innovative ideas that often stretch beyond anyone's singular perspective.

Once potential interventions are identified, the task becomes one of choosing among them. A third dimension was articulated by Runyan (21) to facilitate a systematic decision-making process among interventions developed in the two-dimensional model. It extends the Haddon Matrix to a third dimension, borrowing concepts from the policy analysis field. These concepts represent key values that might be considered when choosing intervention strategies (e.g., effectiveness, equity, freedom, cost, stigmatization). This third dimension is proposed as a way to help decision makers judge the relative merits of alternative intervention options. The examples supplied by Vernick et al. (22) in their paper in this volume of *Epidemiologic Reviews* provide a further reason to understand some of the factors driving judicial, jury, or business decisions.

Countermeasures

Another contribution of Haddon was that he organized 10 countermeasure strategies to address injury control. In his 1973 paper, he stated that one landmark in the advancement of scientific thinking was the development of classification schemes for understanding relations among phenomena (16). Table 2 lists the Haddon countermeasures as they apply to injuries from handguns and to cancer associated with smoking, demonstrating the utility of the model to both injury and noninjury problems. As with the matrix, this is an excellent brainstorming tool for developing ideas about a range of strategies for intervention.

The Haddon models, although developed to help understand the processes by which injuries occur and can be prevented, are extremely useful tools in public health and can help build the bridge between behavioral scientists and epidemiologists, as urged by Gielen and Sleet (23) in this volume. The models can be used either to understand any public health issue from the perspective of risk factor identification or to devise a diverse array of preventive strategies. In so doing, they provide both epidemiologists and interventionists a framework within which to examine problems systematically and to take action. Gielen and Sleet elaborate on this point, urging that interventions be based on both sound theory and systematic principles of practice, including efforts such as individual behavior, corporate decisions, and policy making aimed at influencing decisions in multiple sectors, and through other actions at the community level.

TABLE 2. Application of the Haddon countermeasures to reducing risks of injury by handguns and of cancer associated with smoking

Preventing injury by handguns	Preventing cancer associated with smoking
Countermeasure 1: Prevent the creation of the hazard	
Eliminate handguns	Eliminate cigarettes
Countermeasure 2: Reduce the amount of hazard brought into being	
Limit the number of handguns allowed to be sold or purchased	Reduce the volume of tobacco production by changing agricultural policy
Countermeasure 3: Prevent the release of the hazard	
Install locks on handguns	Limit sales of tobacco to certain age groups
Countermeasure 4: Modify the rate of release of the hazard from its source	
Eliminate automatic handguns	Develop cigarettes that burn more slowly
Countermeasure 5: Separate the hazard from that which is to be protected by time and space	
Store handguns only at gun clubs rather than at home	Establish shutoff times for vending machines and earlier closings of convenience stores and groceries
Countermeasure 6: Separate the hazard from that which is to be protected by a physical barrier	
Keep guns in locked containers	Install filters on cigarettes
Countermeasure 7: Modify relevant basic qualities of the hazard	
Personalize guns so they can be fired only by the owner	Reduce the nicotine content of cigarettes
Countermeasure 8: Make what is to be protected more resistant to damage from the hazard	
Create and market bullet-proof garments	Limit exposure to other potential synergistic causes of cancer (e.g., environmental carcinogens) among smokers
Countermeasure 9: Begin to counter damage done by the hazard	
Provide good access to emergency care in the prehospital period	Set up screening to detect cancer in the early stages
Countermeasure 10: Stabilize, repair, and rehabilitate the object of damage	
Provide high-quality trauma care in hospitals	Provide good-quality health care for cancer patients

However, in another paper in this volume, Peek-Asa and Zwerling (24) caution that injury problems and their solutions are complex, requiring funding and methodologies adequate to enable satisfactory understanding and development of effective solutions.

HADDON'S MODELS IN A THEORETICAL CONTEXT

The social-ecologic framework created by Urie Bronfenbrenner (25) in the context of understanding human development is very compatible with a broader view of public health as adopted by Gordon (19), Gibson (20), and Haddon (13–18) in the context of injury and as articulated later by others, namely Susser (1), Susser and Susser (8, 9), and Kreiger (6, 7). Social-ecologic theory, as proposed by Bronfenbrenner, defines various levels of the social environment, depicting the nested roles of intrapersonal factors, interpersonal factors, institutional elements, and cultural elements. As previously argued by Runyan (26) and Margolis et al. (27), this social-ecologic framework enhances the standard public health model of agent-host-environment and is similar to what Susser and Susser (9) propose in describing the interactions among contributory factors to health as nested Chinese boxes.

With respect to understanding injury prevention, intrapersonal factors include both developmental and sociobehavioral features of individuals (i.e., the host), for example, a young child's curiosity and exploratory behaviors through touching, tasting, and crawling; an adolescent's propensity to take risks and the varied responses to parent and peer influences; or the elderly person's suicide risk due to a sense of hopelessness in the face of an incurable chronic disease or avoidance of walking in certain locations because of a fear of falling or assault. Likewise, biologic features of the host, such as the young child's lack of balance and strength, high center of gravity, and small size, relate to some of the hazards encountered. For an elderly person, biologic characteristics such as bone brittleness; reduced visual acuity, reaction time, and balance; and thinner skin increase susceptibility to injury events such as traffic crashes, pedestrian injuries, falls, and burns.

Interpersonal factors are those that result from the interactions between two persons, for example, intimate partners, parent and child, employer and employee, or adolescents. In the injury sphere, this clearly relates to intentional injury as a result of behaviors associated with disciplinary practices or conflict resolution as well as, in the unintentional realm, certain kinds of activities such as contact sports or other recreational exposures more commonly engaged in by dyads.

Institutional elements are those that reflect the multiple organizations in which individuals function, for example,

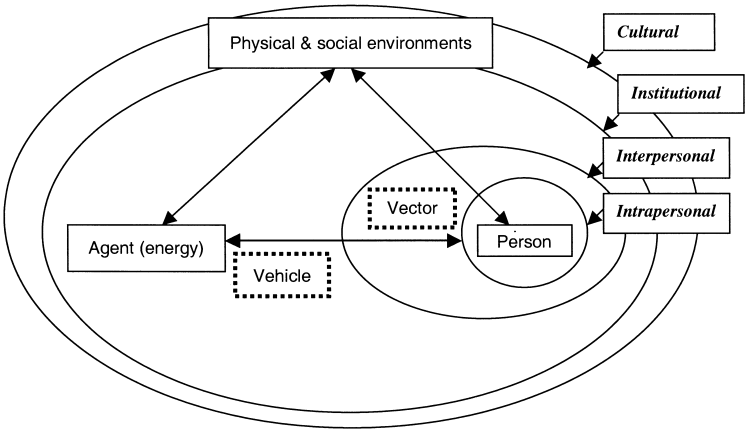

FIGURE 1. Integration of the public health model (28) with Bronfenbrenner's social-ecologic model (25).

schools, places of worship, and workplaces. How these organizations promote or control activities and environments—for example, the types of interscholastic sports at a school and the presence or required use of protective gear—can affect injury risks. Likewise, work sites contain many hazards and adopt many types of safety practices, whereas places of worship may either encourage or discourage certain safe or unsafe practices. In addition, prehospital trauma care and inpatient health care systems are institutions that affect injury outcomes. Several examples are included in the article by Peek-Asa and Zwerling (24) in this volume.

Cultural elements include broad social values and norms as well as the governmental policies that guide or mandate behaviors of individuals or organizations. Examples are values placed on individual freedom; social norms about drinking or corporal punishment; or laws, policies, and regulations about producing, selling, and storing firearms or providing alternate forms of transportation for the elderly who can no longer drive.

Any health problem can be viewed as resulting from and being alleviated by the interactions among these multiple factors that are constantly changing together. For example, the intrapersonal biologic characteristics of both elderly persons and toddlers increase the risk of falls. In each, balance may be unstable although the desire to walk is great. Developmentally, the toddler is also curious and may be eager to see inside an interesting-looking bucket, resulting in him tipping into the bucket and risking drowning. The features of the bucket and its contents that make it interesting and attractive to the child interact with his sense of curiosity.

By being developmentally oriented, Bronfenbrenner's social ecology theory (25) naturally includes a historical dimension that considers the constantly changing relations among the variables over time. This notion of changing interactions in historical perspective is consistent with Susser's eco-epidemiology approach (1, 28) as well as the concepts of interbehavioral psychology (29, 30).

Figure 1 depicts this new integration of Bronfenbrenner's social-ecologic model with that of the classic public health model, depicted by Susser (28). This depiction is presented to demonstrate that Haddon's concepts fit within a much broader social theoretical context.

CONCLUSION AND SYNTHESIS

Haddon (14) urged that injury research advance from what he termed "pre-scientific" thinking focused on accidents as random events or acts of God to applying scientific principles to understanding injury. A related argument in the contemporary debate about epidemiology posits that as epidemiology has evolved, it has adopted various conceptual models consistent with the scientific wisdom of the era, for example, the miasma theory, the germ theory, and what Susser (1) and Susser and Susser (9) describe as the "black box" theory of chronic illness. Susser suggests that the trend in epidemiology has been to develop research guided less by theory and more by the methodologies derived from varied scientific advances (e.g., molecular biology), implying that even the most novel and sophisticated methods in the presence of unclear thinking can impede scientific progress (1, 8, 9). Haddon et al. also warned of this possibility in their 1964 book, *Accident Research: Methods and Approaches*, pointing out that "the quality of research cannot be superior to that of its weakest element" (13, page 85). Although Savitz (12) argues for pragmatism over theory, Haddon's contributions demonstrate the practical value of using theory and conceptual models to guide epidemiologic inquiry and prevention planning.

Although developed in the context of injury control, Haddon's models are applicable to any health problem and nicely demonstrate the value of using a conceptual approach to address practical problems through research and intervention. As such, his contributions to injury epidemiology were ahead of their time, because contemporary epidemiologists continue to debate the relative merits of using theory to inform research and practice as well as attempt to adopt a cogent theoretical approach to epidemiology. Even though Haddon does not appear to have explicitly developed his

models with a specific theory in mind, they are consistent with the established social-ecologic theory of Bronfenbrenner (25), as described above. This theory is very similar to the eco-epidemiology theory proposed by Susser (1) and the eco-social theory put forth by Kreiger (6, 7), as well as aspects of interbehavioral psychology developed in the 1920s by Kantor (29, 30).

Furthermore, Haddon most likely would have agreed with Kreiger's assertion 30 years later that "theory, absent action, is an empty promise" (7, page 674), contending that theories should not only inspire the questions asked in research but also provide insight into how to translate research findings into practical strategies to improve health. However, he probably would also have agreed with Kurt Lewin's assertion that "there is nothing so practical as a good theory" (31, page 169), arguing for the utility of theory to help guide thinking and practice. Haddon's work is exemplary of this principle, providing injury epidemiologists and interventionists a compass to guide both their research and their practice. Perhaps reflecting on Haddon's work will help epidemiologists find utility in a more theoretical approach.

ACKNOWLEDGMENTS

This work was supported by funding from the National Center for Injury Prevention and Control (R49/CCR402444) to The University of North Carolina Injury Prevention Research Center.

The author thanks Dr. Desmond K. Runyan, who provided comments on an earlier draft of this manuscript, and Dr. Irvin S. Wolf for help in interpreting Kantor's theory of interbehavioral psychology.

REFERENCES

1. Susser M. Does risk factor epidemiology put epidemiology at risk? Peering into the future. J Epidemiol Community Health 1998;52:608–11.
2. McPherson K. Wider "causal thinking in the health sciences." J Epidemiol Community Health 1998;52:612–13.
3. Poole C, Rothman K. Our conscientious objection to the epidemiology wars. J Epidemiol Community Health 1998;52:613–14.
4. Mackenbach JP. Multilevel ecoepidemiology and parsimony. J Epidemiol Community Health 1998;52:614–15.
5. Kogevinas M. The loss of the population approach puts epidemiology at risk. J Epidemiol Community Health 1998;52:615–16.
6. Kreiger N. Epidemiology and the web of causation: has anyone seen the spider? Soc Sci Med 1994;39:887–903.
7. Kreiger N. Theories for social epidemiology in the 21st century: an ecosocial perspective. Int J Epidemiol 2001;30:668–77.
8. Susser M, Susser E. Choosing a future for epidemiology: I. Eras and paradigms. Am J Public Health 1996;86:668–73.
9. Susser M, Susser E. Choosing a future for epidemiology: II From black box to Chinese boxes and eco-epidemiology. Am J Public Health 1996;86:674–7.
10. Pearce J. Traditional epidemiology, modern epidemiology, and public health. Am J Public Health 1996;86:678–83.
11. Kreiger N. Historical roots of social epidemiology: socioeconomic gradients in health and contextual analysis. Int J Epidemiol 2001;30:899–900.
12. Savitz DA. The alternative to epidemiologic theory: whatever works. Epidemiology 1997;8:210–12.
13. Haddon W, Suchman EA, Klein D. Accident research: methods and approaches. New York, NY: Harper & Row, 1964.
14. Haddon W. The changing approach to the epidemiology, prevention, and amelioration of trauma: the transition to approaches etiologically rather than descriptively based. Inj Prev 1999;5:231–5.
15. Haddon W. A logical framework for categorizing highway safety phenomena and activity. J Trauma 1972;12:193–207.
16. Haddon W. Energy damage and the ten countermeasure strategies. J Trauma 1973;13:321–31.
17. Haddon W. Advances in the epidemiology of injuries as a basis for public policy. Public Health Rep 1980;95:411–21.
18. Haddon W. Options for the prevention of motor vehicle crash injury. Isr J Med Sci 1980;16:45–68.
19. Gordon JE. The epidemiology of accidents. Am J Public Health 1949;39:504–15.
20. Gibson JJ. The contribution of experimental psychology to the formulation of the problem of safety—a brief for basic research. In: Haddon W, Suchman EA, Klein D, eds. Accident research: methods and approaches. New York, NY: Harper & Row, 1964
21. Runyan CW. Using the Haddon Matrix: introducing the third dimension. Inj Prev 1998;4:302–7.
22. Vernick JS, Mair JS, Teret SP, et al. Role of litigation in preventing product-related injuries. Epidemiol Rev 2003;25:90–8.
23. Gielen AC, Sleet D. Application of behavior-change theories and methods to injury prevention. Epidemiol Rev 2003;25:65–76.
24. Peek-Asa C, Zwerling C. Role of environmental interventions in injury control and prevention. Epidemiol Rev 2003;25:77–89.
25. Bronfenbrenner U. The ecology of human development. Cambridge, MA: Harvard University Press, 1979.
26. Runyan CW. Health assessment and public policy within a public health framework. In: Karoly P, ed. Measurement strategies in health psychology. New York: John Wiley & Sons, 1985: 601–27.
27. Margolis L, McLeroy K, Runyan CW, et al. Type A behavior: an ecological approach. J Behav Med 1983;6:245–58.
28. Susser M. Causal thinking in the health sciences: concepts and strategies in epidemiology. New York, NY: Oxford University Press, 1973.
29. Kantor JR. Principles of psychology. Vol. 1. New York, NY: Alfred A. Knopf, 1924.
30. Pronko NH. Psychology from the standpoint of an interbehaviorist. Monterey, CA: Brooks/Cole Publishing Company, 1980.
31. Lewin K. Field theory in social science. New York, NY: Harper and Brothers, 1951.