METHODOLOGIC ISSUES

# Using the Haddon matrix: introducing the third dimension

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William Haddon Jr developed his conceptual model, the Haddon matrix, more than two decades ago applying basic principles of public health to the problem of traffic safety.[1 2] Since that time, the matrix has been used as a tool to assist in developing ideas for preventing injuries of many types. As such, it provides a compelling framework for understanding the origins of injury problems and for identifying multiple countermeasures to address those problems. However, users then must decide for themselves among the alternatives. This paper adds a third dimension to the matrix to facilitate its use for making decisions about which countermeasures to apply.

## Haddon's matrix

The matrix of four columns and three rows combines public health concepts of host-agent-environment as targets of change with the concepts of primary, secondary, and tertiary prevention.[3 4] More specifically, the *factors* defined by the columns in the matrix refer to the interacting factors that contribute to the injury process (see tables 1 and 2). The host column refers to the person at risk of injury. The agent of injury is energy (for example mechanical, thermal, electrical) that is transmitted to the host through a vehicle (inanimate object) or vector (person or other animal). Physical environments include all the characteristics of the setting in which the injury event takes place (for example a roadway, building, playground, or sports arena). Social and legal norms and practices in the culture are referred to as the social environment. Examples include norms about child discipline or alcohol consumption or policies about licensing drivers or sales of firearms.

The *phases* in Haddon's initial configuration referred to rows in the matrix. These are the phases at which change would have its effect—pre-crash, crash, or post-crash. These have been broadened beyond the motor vehicle arena to encompass other injury problems by using the terms "pre-event," "event" and "post-event". Thus, by identifying interventions that fit within each cell of the matrix one can generate a list of strategies for addressing a variety of injury or other public health problems.

## How to use the Haddon matrix

As indicated in table 3, the first step in planning, whether using the matrix or any other technique, is to identify clearly the problem to be addressed using appropriate data from the community to assess need. Before using the matrix to derive potential interventions, it is necessary to identify the injury issue to be addressed; for example, falls from playground equipment, bicycle crashes, bathtub drownings, child physical abuse, or residential fires. Second, one needs to define each

*Table 1 Haddon matrix applied to the problem of residential fires caused by cigarettes igniting upholstered furniture*

| | *Host (children in home)* | *Agent/vehicle (cigarette, matches, and upholstered furniture)* | *Physical environment (home)* | *Social environment (community norms, policies, rules)* |
|---|---|---|---|---|
| Pre-event (before fire starts) | Teach children not to play with matches | Redesign cigarettes so they self extinguish before ignition of upholstery | Lower flammability of structures | Improve efforts to curb smoking initiation<br>Improve smoking cessation efforts |
| Event (during fire) | Teach children to stop, drop, and roll<br>Plan and practice a fire escape route with children<br>Teach children not to hide during a fire | Design furniture with materials that are less toxic when burned<br>Design upholstery that is flame resistant | Install smoke detectors<br>Install sprinklers<br>Increase number of usable exits | Pass ordinances requiring smoke detectors and/or sprinkler systems<br>Fund the fire department adequately to provide enough personnel and equipment for rapid response |
| Post-event (after child in injured by fire) | Provide first aid and CPR to all family members | Design heaters with quick and easy shutoff device | Build homes with less toxic building materials | Increase availability of burn treatment facilities |

CPR = cardiopulmonary resuscitation.

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*Table 2 Haddon matrix applied to the problem of school violence by firearms*

| | *Host (students at school)* | *Agent/vehicle (firearm and bullets)* | *Physical environment (school)* | *Social environment (school and community norms, policies, rules)* |
|---|---|---|---|---|
| Pre-event (before teen uses weapon) | Educate teens about the dangers of carrying guns to school<br>Educate parents about dangers of allowing teens access to guns<br>Teach students to recognize and report student behaviors indicative of possible violent behavior | Modify guns so they are only operable by the owner | Install metal detectors at entrances to schools<br>Eliminate storage places in schools (for example lockers) where guns might be kept | Adopt school procedures/policies to notify authorities if a student is suspected of having a gun at school<br>Prohibit gun carrying on school grounds<br>Enforce restrictions on the sale or transfer of handguns to teenagers |
| Event (when gun is taken out to be fired) | Teach students to take cover when they see guns or hear gunfire | Reduce capacity of weapons to fire multiple rounds quickly<br>Modify bullets to be less lethal | Install alarm systems to call law enforcement as soon as weapons are visible | Have law enforcement officers on duty at school to intervene during fights<br>Develop safety plans to help students move to safety in event of violent episode |
| Post-event (after students are shot) | Teach students first aid skill | Reduce the capacity of the gun to continue firing | Make school grounds readily accessible to ambulances | Ensure well trained emergency medical personnel and access to trauma facilities<br>Provide post-event counseling to students, staff, and families |

row and column of the matrix. For example, as in table 1, the host is the child in the home experiencing the fire. The vehicles in this example are the cigarettes, matches, or flammable upholstery fabrics. The home and its immediate environs, including adjoining structures (for example a garage) represents the physical environment. The social environment refers to the social norms, policies, and procedures that govern such practices as how buildings are constructed, installation of smoke detectors, the use of space heaters, and the use of alcohol by residents.

Most injuries are the result of a sequence of events representing a continuum of activity, rather than a discrete moment in time defined as the event. Consequently, it is critical that the rows of the matrix also be defined carefully. In most situations, the event could be defined in a variety of ways depending on one's perspective. In the residential fire and school violence examples provided in tables 1 and 2, the event might be defined as the moment the cigarette is dropped in a wastebasket, or the point at which the sofa ignites or when the room is engulfed in flames, or when the whole house is on fire, or when the child is overcome by carbon monoxide. Likewise, in the case of school violence, the event might be the time the teenager takes out the firearm from his or her backpack, the moment he or she points it at a crowd on the playground or the point in time when it is fired, or when it strikes another individual.[5] The choice is arbitrary, but is important so as to anchor one's thinking about what comes before and after the event.

Once both dimensions of the matrix have been carefully defined, individual or group brainstorming is useful to generate ideas about interventions in each of the cells. If participants are from different disciplines, they will bring different perspectives to the problem and to solutions, enriching the overall pool of ideas. By applying the principles of brainstorming in which all ideas are recorded without critical comment before discussion, the process can yield a wide variety of options.

In this process it is frequently tempting, but incorrect, to identify the phase of the strategy in terms of when the strategy was put into place. For example, the smoke detector or sprinkler system was installed as the house was being constructed. However, it has its effect at the time of the event (that is when the smoke filled the room and the detector sounded). Consequently, the smoke detector is properly classified as an event phase strategy. A pre-event strategy would be redesigning cigarettes so they self extinguish before having a chance to ignite upholstery. When filling in the cells of the matrix, a sentence completion exercise can be helpful. That is, one might state: "..... (idea) is an intervention to affect a change in ..... (factor), having its effect at the time of ..... (phase)."

Examples of completed matrices for residential fires and school violence appear in tables 1 and 2 respectively. For many injury problems,

*Table 3 Steps in using the three dimensional Haddon matrix*

| *Step* | *Activity* |
|---|---|
| 1 | Use community needs assessment data to determine the problem in need of intervention |
| 2 | Define dimension #1 (columns) of matrix as the targets of change (host, agent/vehicle or vector, physical environment, social environment) |
| 3 | Define dimension #2 (rows) of matrix by delineating the precise event and phases of change (pre-event, event, post-event) |
| 4 | Define dimension #3 (depth) of matrix by delineating value criteria, defining each in clear terms |
| 5 | Determine weights to be applied to each value listed in dimension #3 |
| 6 | Brainstorm potential interventions and fill in cells formed by columns and rows |
| 7 | Organize and/or collect data to permit assessment of each criterion for each intervention under consideration |
| 8 | Assess each intervention according to its attributes relative to each value criterion |
| 9 | Conduct overall assessment using weights for each value criterion across the set of interventions and criteria |
| 10 | Make decisions about best options |
| 11 | Explain decisions based on criteria applied and assessment of each intervention option according to the criteria |
| 12 | Document the assessment process to assist in future reanalyses |

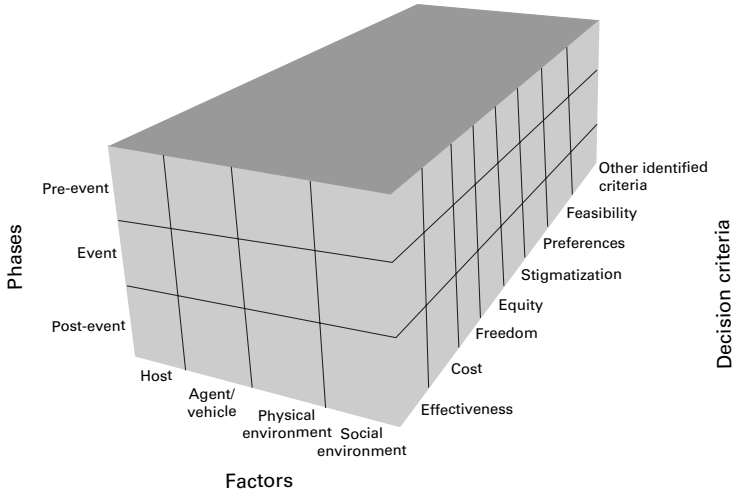


*Figure 1 Proposed three dimensional Haddon matrix.*

particularly those involving repeat occurrences, strategies identified in the post-event phase may actually be effective as pre-event strategies for a subsequent event. For example, efforts to deal with a violent offender are often directed at avoiding a future violent offense. Consequently, the strategy is both post-event in the context of one event and may be pre-event in the context of preventing the occurrence of future events. Similarly, efforts to punish and rehabilitate a drunk driver who has had a crash (a post-event strategy) serves as a pre-event strategy for future potential incidents.

## Expanding the matrix for decision making

Once alternative intervention strategies are identified, program planners and decision makers need to choose among the strategies. By applying principles of policy analysis,[6–8] this process can become systematized, permitting concrete articulation of those values that guide the decision process.

Policy analysis typically involves a series of steps including: problem identification, identification of alternative policy options, and identification of values to be assessed relative to each option. Then the analyst uses a process by which each option is assessed according to the extent to which it adheres to the values identified as important. Following this, the analyst chooses among the options. Once they are implemented, others can evaluate their success and the information can be incorporated into future analyses of alternatives. The policies or other interventions considered can be new or may reflect policies or programs already in place.

The third dimension of the matrix proposed here incorporates the use of value criteria in the decision making process (fig 1). Each needs to be carefully thought through in the context of the injury countermeasure being considered, whether a policy (for example drinking age laws), a program (for example training of bartenders not to serve underage or inebriated customers), or a technological intervention (for example ignition interlock device).

The assessment process can be done either quantitatively or qualitatively. To accomplish the task, the decision maker must determine the relative weights to be placed on each value—for example, how much is the cost of conducting the intervention to be valued compared with the potential effectiveness of the intervention when applied. Though this process is not easy, it has the potential to be extremely helpful in encouraging a community group or agency board to consider and articulate what factors are important determinants of their decisions.

### SELECTING VALUE CRITERIA

Social policy analysts suggest some standard criteria for evaluating all policies, with additional ones often added for specific problem areas.[6–9] For example, a list of values pertinent to motor vehicle safety at railroad crossings were suggested by Wakeland, as referenced in Waller's book, *Injury Control*.[10]

A set of value criteria are listed here only as suggestions to provide a starting point for injury intervention planners. Such criteria will vary according to the injury problem and the setting. Likewise, the types of information available for assessing each also will differ. Suggested criteria include: effectiveness, cost, freedom, equity, stigmatization, preferences of the affected community or individuals, and feasibility. As described below, each has several dimensions. For each, there are various ways one might determine how well a given countermeasure embodies a particular value criterion.

#### *Effectiveness*

Central to any discussion of public health interventions is the criterion of effectiveness; in other words, "How well does the intervention work when applied?" To assess effectiveness of a particular intervention, one might use information available from the literature describing the efficacy of the intervention under controlled conditions or effectiveness of applications of the intervention in other locales. Assessment may require estimation based on information about similar types of interventions associated with other problems or related dimensions of the intervention. For example, the planner might estimate the effectiveness of a media campaign about smoke detectors based on what is known about the effectiveness of media campaigns to encourage use of some other device such as cabinet safety latches or bicycle helmets.

#### *Cost*

Cost of an intervention activity can be considered in several ways. One way is to consider the costs of implementing and enforcing the program or policy—for example including expenses associated with such elements as advocacy efforts, promotional activities, implementation of the program, or enforcement of a law. In addition, the planner might separately assess who bears the costs of a particular program and value the criterion differently according to how the costs are borne by different parties affected—for example, by poten-

tially injured persons or their families, the taxpayers, or the manufacturer of a product. It is also appropriate to balance these costs with those associated with choosing not to implement the intervention.

*Freedom*

With most public health interventions, the freedom of some group may have to be compromised to achieve the intended goal.[9] For example, motorcyclists sacrifice freedom to ride unrestricted when a helmet law is passed. Manufacturers required to make children's sleepwear from flame resistant fabrics have their freedom restricted. In some cases, the freedoms of one group are in conflict with those of another. For example, when a government decides to permit the carrying of concealed guns, those members of the community who wish to carry guns experience an increase in one type of freedom while those wanting to be free from encountering a gun carrying citizen lose freedom. Though freedom is often a critical issue in debates about public health interventions, metrics for assessing this value generally are inadequate. Rather, consideration of the freedom dimension usually is based on personal judgments that may be informed by opinion surveys.

*Equity*

Both horizontal and vertical equity are important concepts in the policy debate and equally apply to other types of program deliberations. *Horizontal equity* involves treating people equally or in a universal fashion.[6] Federally applied policies typically are horizontally equitable. For example, US requirements that poisonous substances be packaged in childproof containers protects all children equally. In contrast, *vertical equity* refers to the unequal treatment of unequally situated individuals so as to make them more equal with respect to a particular attribute, such as injury risk. For example, a community smoke detector giveaway program might target low income persons or residences in high fire neighborhoods to help them have the opportunities to protect their homes equal to those of more affluent families.

*Stigmatization*

The criterion of stigmatization, or avoidance of stigmatization, typically refers to the concept that a program or policy should not stigmatize a person or group in the process of serving other purposes. For example, many would consider it undesirably stigmatizing for schoolchildren to have to identify themselves as low income in order to be eligible to receive a free bicycle helmet. In some situations, however, stigmatization may be considered desirable. For example, some argue that public identification of prior sex offenders is an appropriate strategy for reducing future crimes.

*Preferences of the affected community or individuals*

If a population exposed to an intervention is opposed to the strategy, compliance is likely to be limited. In addition, the perceptions of the community about the suitability of a particular intervention may reflect whether the intervention has appropriately taken into account the sociocultural context in which the injury problem exists and in which the intervention is to be implemented. Not only is this important for the success of a particular intervention, but also for the credibility, over the long term, of the public health or injury control organization or decision making body responsible for the intervention.

*Feasibility*

Intervention feasibility is important to consider in several ways but not until all other elements are considered. By considering feasibility too early, creativity may be stifled and options excluded that may, in fact, be judged highly desirable by other criteria. Sometimes what might be judged unfeasible at the outset can be made feasible if sufficient other values support efforts to attempt innovations so as to implement the strategy. For example, until sufficient public demand is present, efforts to require safer playgrounds in child care facilities may meet with too much resistance from providers for a feasible solution to emerge. However, with public awareness and demand increased, facility directors may be willing to accept such a policy.

Feasibility has several dimensions, beginning with technological feasibility. That is, can the intervention actually be produced? For example, does the technology exist to produce fire safe cigarettes or airbags suitable for young children? If the answer is "yes" then it is useful to consider political feasibility. This frequently relates to the issue of preferences discussed above. One might consider if the intervention raises significant political issues such that implementation is unlikely or compromised in some way. For example, a proposed ban on the sale of handguns in the US, while potentially effective in reducing certain types of homicide and suicide, would be met with intense political opposition that would limit the feasibility of the intervention being implemented in the near future, but perhaps not in other countries. Another element of feasibility is the extent to which the organization or group responsible for implementing the countermeasure has the technical or financial resources required to carry it out. For example, providing crossing guards at all crosswalks before and after school won't work in a community that has too few volunteers to perform the task or too little money to hire them.

## USING THE THIRD DIMENSION

Using the third dimension involves several steps, as listed in table 3. After steps 1–3 have been completed in forming the outline for the original Haddon matrix (but before completing it) one must determine what values are important to the decision process. As with the other dimensions of the matrix, each element needs to be carefully defined. At step 4, the planning group determines which values to consider in the analysis. For example, they may decide that taxpayer cost, intervention effectiveness, home-

owner freedom and non-stigmatization of poor people are the values they want to address in their decision making. Step 5 refers to the process of determining the relative importance of each value so that values can be weighted relative to each other. Step 6 involves completing the matrix by brainstorming or otherwise generating a list of potential intervention options. In completing step 7, the planners would collect and examine data about each value relative to each of the interventions under consideration.

In this example, assume they are considering two intervention options to reduce the high incidence of fatal fires ignited by cigarettes in their locale: (a) using paid fire fighters to install smoke detectors, purchased using public monies, in households where residents verified their low income with tax records or (b) requiring that cigarette manufacturers produce self extinguishing cigarettes. As part of step 8, information from fire safety research would help determine the relative effectiveness of smoke detectors, if installed properly, and efforts to mandate cigarette redesign and/or changes in upholstery flammability standards. If appropriate epidemiologic evidence were available, planners would examine the incidence of fires associated with cigarettes and also the evidence about the relative benefits of having a properly functioning smoke detector when a fire occurs. In addition, planners would examine program evaluation research to gauge the effectiveness of smoke detector installation programs in other locales in increasing the prevalence of properly functioning detectors in homes. They would also examine evidence that changes in cigarettes would reduce fire incidence. Likewise, they would want to estimate the costs associated with purchasing detectors and the personnel time required to install them, as well as the costs of developing and enforcing the cigarette safety standards. These costs would be balanced against costs associated with *not* doing each intervention. Similarly, each intervention would be examined with respect to stigmatization and freedom.

The extent to which the options considered span different jurisdictions (for example local *v* federal policy) makes comparisons more complex, but not impossible. This process requires that the planners assemble relevant evidence from varied sources: for example, epidemiologic studies, intervention studies, information from cigarettes or upholstery manufacturing companies, assessment of program costs, and opinions expressed in interviews with residents about issues of stigmatization and freedom. In many cases, there will not be published data available. In those situations, the planners will need either to extrapolate from other information or to make an educated guess. It should be remembered that the point of the process is to guide decision making and that it isn't always possible to conduct a rigorous scientific analysis in the timeframe required for program development. Often, however, sufficient information will be available from prior scientific studies so that decisions can be based on sound evidence. The more rigorous the sources of data used, the more detailed the analyses can be, and the more confident planners can be that their decisions will result in the desired outcome.

Both new and existing intervention strategies can be compared using the same method. However, the more the analysis involves previously untried strategies, the more difficult it will be to incorporate certain types of evidence in the deliberation. Although it is important to recognize this factor, it should not be allowed to limit creativity.

Once all the information has been gathered to assess each criterion for each of the interventions under consideration, the comparative analysis begins (step 9). Policy analysts or planners employ numerous ways, with varying degrees of complexity, to accomplish this task.[8] They may use a quantitative process involving summing scores for the relative importance of each criterion multiplied by a score representing the extent to which each option possesses the attributes of the criterion. For new interventions this will require some forecasting of the potential attributes of the intervention, once implemented. For interventions that have been tried already, various types of information may be available to quantify the effects, costs, and other attributes.

Qualitative information also can be examined. This might include reviewing testimony about preferences expressed in reference to prior efforts to enact a policy, news clippings giving indications of public sentiment about a proposed program, or reviews of process evaluations of programs or policies implemented in the past to assess potential barriers that could influence effectiveness.

Whether using quantitative or qualitative information, the process needs to be systematic, allowing planners to carefully assess the options. Decision making (step 10) can then be justified and explained in the context of pre-established criteria applied in a rational manner.

It is wise to document the process and record how assessments were made not only so that decisions can be more easily explained to others (step 11) but also so that interventions can be re-evaluated after some period of time using new data that may reflect changes in technology, epidemiology, or the political environment (step 12).

## Conclusion

Haddon's matrix has been an extremely valuable tool over nearly two decades. As a conceptual model, it has helped guide research and the development of interventions. The addition of the third dimension (fig 1) should facilitate its application in decision making. As the three dimensional formulation is applied, users should document successes and problems in using the revised model. Over time, the application of the model in different settings should be shared in the professional literature so that the model can be made even more useful and user friendly.

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