INJURY CLASSIC

Theory and methods of epidemiologic study of home accidents

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This is the sixth paper in a series of Injury Classics. Our goal is to reprint one such paper in each issue to initiate newcomers to the field of these old, often quoted, and important contributions. As many are difficult to find, it should help all of us to have a copy at hand. Your suggestions about future articles are welcome. Write to the editor with details of your favourite, most quoted paper.

Methods

Problems in the design of epidemiologic studies may be categorized conveniently into those related to ascertainment and those concerned with sampling. Sampling problems confronted in home accident studies are not different, in any essential way, from those encountered in any other epidemiologic studies. With reference to sampling, the epidemiologic critics are far in advance of epidemiologic practitioners, so that the latter have yet to propose a study which the former cannot demolish by attacking the sampling procedures. The critics apparently have already discovered a whole host of biases which will only be demonstrated by studies yet to be devised. For these reasons, sampling problems will be treated only briefly in this report, where they are inextricably involved with the business of ascertainment.

Problems of ascertainment in home accident studies do present some special, though perhaps not unique, features. Ascertainment is the process of acquiring desired information. The term carries the connotation that this is an active quest, involving a search for the data. Each item of information sought must be specified, defined, the need for it justified, and the method by which it is to be collected established. Generally, more attention is paid to the disease diagnosis than to other characteristics of the host. On logical grounds, one may hold that a correlation of the occurrence of disease with some other factor, such as age, may be rendered invalid as certainly by errors in recording age as by errors in recording the disease, but this has little emotional appeal and in practice we continue to expend the most concern on those things that interest us most. Therefore, this paper will be devoted largely to problems of ascertainment of cases. Many of the ideas referable to this characteristic of the host can be generalized to the ascertainment of other host and environmental characteristics.

To study home accidents requires that home accidents be defined and immediately home accident studies are in trouble. To my knowledge there is no satisfactory definition of an accident, and no satisfactory means of separating completely home accidents from other forms of accidents.

While number of recent publications on home accidents have failed to present a definition, Suchman and Scherzer,¹ in an excellent review, discussed a variety of definitions which have received some acceptance. Most of

them incorporate a statement of recognizable injury or loss. Some refer to 'chance' events, which connotes that accidents are distributed randomly, and this is clearly not true. The United States Public Health Service publication *Uniform Definitions of Home Accidents*² refers to an accident as a sequence, chain of events, or series of interactions between the person and environment or agent, including the measurable or recognizable consequences. This definition is perfectly satisfactory if one already knows what an accident is; if not, it could just as well define typhoid fever or cancer of the lung. Most definitions share this lack of selectivity. Part of the difficulty comes from the great number of diverse events included as accidents and this is compounded by the inability to speak very confidently about causes, for specificity of definition often is attained by reference to cause.

Epidemiologic studies may reasonably have as an aim more precise definition of disease syndromes. Data from studies already done are adequate to propose that much of the needed clarification can be realized by characterizing each event independently along four axes, and subjecting each subset obtained in that way to more detailed analysis. Although this approach does not permit generalization to the whole class of events commonly called accidents, I deem this an advantage, since these generalizations lump such diverse events that more is lost than is gained. The four axes are:

- A. The nature of the event.
- B. The nature and severity of the injury
- C. The responsibility for the event.
- D. The place of occurrence.

A. THE NATURE OF THE EVENT

This classification is the most important step in sorting out from the general melange groups of accidents which can be handled, and this classification permits satisfactorily specific definition of the events to be studied. The subcategories used most often employ such terms as falls, struck by or against an object, burns, poisonings, etc. A more general classification is as follows:

1. Injury resulting from the absorption of kinetic energy. It may be important to specify whether the object or the injured person or both were in motion at the time of impact, but I know of no instance in which this has been tried.

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2. Injury resulting from the absorption of radiant energy.
3. Injury resulting from chemical toxins.
 - (a) Corrosive.
 - (b) Metabolic.
4. Other: suffocation, drowning, electrocution, animals and insect bites.

The heterogeneity of home accidents may be exemplified by some data from a study of childhood accidents in Alameda and Contra Costa Counties, California,³ although the classification scheme presented above was used only in part. In this instance, the cases were collected by a reporting system from the emergency services of all of the non-federal hospitals in the two counties, and the population base was estimated by the California State Department of Finance. In figure 1 the age distribution of all reported accidents is shown together with the age distribution of two categories of accidents classed by the nature of the accident. Classification by characteristics other than age shows similar variation in different categories of accidents and illustrates the necessity of sorting home accidents into more homogeneous subgroups.

B. THE NATURE AND SEVERITY OF THE INJURY

A number of studies have used a scheme of classification based on the nature of the injury, using categories such as contusions, abrasions, lacerations, sprains, strains, fractures, head injuries, burns, ingestions, etc. This is justified on epidemiologic grounds by consideration of a further analysis of data from the Alameda-Contra Costa Counties study. In figure 2, the age distributions are given for three classes of accidents: falls, automobile accidents, and injuries resulting from being hit by or against

an object. In each of these kinds of events, a number of different kinds of injuries might result. Here, the head injuries have been selected and, despite the variation in the age distributions of the accident groups, show a remarkably similar age selection. That is, there appears to be an age selection factor affecting the occurrence of head injury which is partly independent of the age selection factors which affect the occurrence of the different kinds of accidents in which heads were injured. Thus the nature of the injury is a second characteristic which must be accounted for before homogeneous groups of cases can be obtained.

The severity of the injury, as well as the nature of the injury, also surely must have an independent effect, but even more importantly is intimately associated with the method of ascertainment of cases. Epidemiologists favor viewing problems in an holistic way, studying the whole spectrum of a phenomenon, and this has been a rewarding approach in a large number of diseases where the picture became clear only after the whole gamut of the disease process came under scrutiny. In accident studies this laudable aim leads only to chaos. The spectrum is there, right enough, and can be treated theoretically, but practically a large segment of the spectrum cannot be reduced to identifiable, measurable phenomena.

The spectrum starts at the far right (figure 3) with death resulting from an untoward, unexpected, non-infectious, traumatic event. Moving to the left on the spectrum, a series of points correlated with severity of injury can be selected, marking identifiable events which can be ascertained by one means or another. This holds true down to the far left of the spectrum but there things fall apart. Previous problems with definitions pale beside the difficulty of defining an accident which did not happen.

The requirement for an epidemiologist is to establish some criteria which will define a point along the spectrum and apply these criteria in a consistent and comprehensive fashion. The cutting point which is selected will restrict the selection of methods of ascertainment of cases, for some are obviously inappropriate. Some

Figure 1 Age distributions of all reported accidental injuries and of poisonings and injuries incurred in sports and games; Alameda and Contra Costa Counties, California, 1957.

Figure 2 Age distributions of three classes of accidents and of the head injuries associated with them; Alameda and Contra Costa Counties, California, 1957.

generalizations may be made concerning the more common methods of ascertainment.

1. Mortality analyses

Analyses of mortality data not only are relatively inexpensive and relatively easily accomplished, but also usually permit relating the cases to a definable population without too great difficulty. However, the information on the base population (usually from the national decennial census) is collected intermittently and in a different fashion. While the recording of deaths may be reasonably complete, the deaths do not provide a satisfactorily complete record of accidents. In many accident categories the proportion of events terminating in death is exceedingly small, and even when this is not true, the deaths cannot reasonably be treated as a representative sample of the accidents. The consequences of a fall down a flight of stairs vary greatly by age, for example. Where conditions occur in low frequency or where death is not often associated with a condition under study, the collection of cases may have to extend over a long time or cover a large population. The data available directly from death certificates are limited and augmentation of them may be difficult. Finally, the investigator has little or no control over the quality and variability of the information.

If mortality analyses are based on other sources of data, such as hospital records, the information may be more complete in some particulars, but the population of hospital deaths is very difficult to relate to a definable population base and comprises an indefinite sample of all accident deaths.

2. Morbidity analyses

(a) Hospital admissions — Admission to hospital constitutes an easily defined event which can serve to identify a study group. As with

deaths, the hospital admissions are a very biased sample of all accidents and the inference drawn from such studies must be interpreted in this light. Also, since the data were recorded for purposes other than epidemiologic study and usually by a number of different people, there are serious deficiencies of completeness and consistency. If a study is designed to collect cases over a period of time in the future, some of these difficulties may be reduced.

Comparability between hospitals is difficult to secure, since the selection biases operating on hospital populations are expected to differ from one hospital to another.

(b) Medical attendance — The collection of all accidents coming to medical attention is feasible under some circumstances. Ordinarily, this involves review of the records of practitioners, which is even less satisfactory than review of hospital records, or a survey of current experience of the practitioners. In the latter case, the problem of non-response becomes significant.

(c) Disability — Accidents causing disability may be determined by population surveys or through such means as school or work absenteeism records. Population surveys will be considered in the next section. School and work absence records serve as a valuable resource, but rarely are they useful other than as a starting point, for the information concerning the event to be studied is likely to be very sketchy. This may be supplemented by interview, however, and then this group has the major advantage of being related immediately to a base population, in which many individual characteristics are already known.

(d) Population surveys — The most comprehensive way in which to collect cases is by population survey. This may be done once, repeated at intervals, or, by a diary system, maintained over a period of time. However done, the survey is at the mercy of respondents, who, through lack of interest, memory lapse, or inborn contrariness, make life precarious for investigators. Population surveys are generally expensive, for sampling procedures and interviewing cause costs to mount rapidly. In this form of study, adherence to a predetermined definition of accidents is very difficult, for each event sought must be evaluated by each respondent, communicated to the interviewer, and interpreted by him. Persons knowledgeable in survey methods have provided us with means for reducing and handling interviewer variation with some success, but there is no way to assure that the respondents will adopt that commonality of viewpoint which we desire.

We may conclude that not one of the usual methods of collecting a series of cases is entirely satisfactory. The investigator must weigh the relative values of the methods available to him, and having made his choice, proceed with the study with full awareness of its shortcomings.

Figure 3 Relation of severity of injury incurred in home accidents to the portion of cases ascertained by different methods.

C. THE RESPONSIBILITY FOR THE EVENT

Two kinds of assessment of responsibility may be considered. One calls for a differentiation between acts of God and acts of man, and the other attempts to separate injuries incurred as a result of the action of another person or persons from those resulting directly from the activities of the injured person. In either case, the differentiation is often difficult and sometimes impossible. A golfer struck by lightning during a thunder shower may be thought of as a victim of celestial caprice, but he may have considered the risk and accepted it in the hope that an unfavorable weather report would clear the fairways of many of his less dedicated competitors. There must be some accidents that are truly unaffected by human design, but the utility of characterizing these seems to me not to have been demonstrated. However, there is utility in determining whether the injured person played an active or a passive role in the accident leading to his injury. If a mother drops her baby and the baby is injured, the accident may be considered to have occurred to the mother, although the injured infant is likely to be the index person in a study. This distinction is hopelessly blurred in many instances, but some attempt to account for responsibility is needed since certain control procedures must be directed toward the responsible persons.

D. THE PLACE OF OCCURRENCE

The classification of accidents by place of occurrence poses many problems for the investigator. The common categories of home, farm, occupational, transportation, and recreational accidents are not mutually exclusive. Our golfing injury may be classed as a recreational accident but if the golfer were an insurance salesman he might consider it as an occupational hazard. If a pedestrian is struck down by a motorcar while crossing a public thoroughfare, this is clearly a motor vehicle accident; however, if the car invades a front yard and assaults a pedestrian peacefully watering his lawn, it may be classed as a home accident. Perhaps in the great bulk of events, these aberrant occurrences are of a frequency low enough that they may be ignored, or at least handled by a series of arbitrary decisions. This does offer an easy way out, and considering the variety of problems confronted in these studies,

the easy solution to one like this may well be the best solution.

Thus, a multiple classification by type of event, by type of injury, by person responsible, and by place of occurrence appears to be a necessary step in the analysis of accidents. The classification option which is adopted will serve to define the events to be studied in a manner more precise than has been forthcoming from any general definition of accidents. The specification of events to be studied also may dictate, or at least restrict, the method of ascertainment of cases and thus profoundly affect the study design. The difficulty which this poses for epidemiologic study is formidable, for the frequency of occurrence of many accidents classified in this way is so low that very large populations are required to generate sufficient cases to permit meaningful interpretations. This is illustrated in the table. In this study, previously described, although the number of events recorded was large, as the classification became more complex the numbers in the cells were too small to permit detailed analysis, especially for some of the more interesting categories.

Theory

Some general consideration of the theory of accidental injuries and accident prevention may help to guide this discussion.

There are two absolute requirements for an accidental injury to occur. (1) There must be present in the environment a situation which threatens injury to a person exposed to it in a specified way. (2) There must be a person susceptible to the injury and exposed to the hazard. Accident prevention may be viewed as a task for environmental engineers, and this is a useful approach. Many of the rough edges have been knocked off of our environment with undoubted salutary results. However, the myriad aspects of the environment which are potentially harmful overwhelm the student of these problems and it is neither feasible nor desirable to send a human being through life in a sterile, stimulus-free, shock-resistant package. An existence free of danger and without stress is devoid of interest or purpose. Thus, the control of accidental injury in the home by environmental manipulation is limited to attacking a small fraction of the

All childhood accidents reported by hospitals, by type of accident, and by type of injury; Alameda and Contra Counties, California, 1957³

Type of accident	Type of injury							Total	Per cent of total
	Contusion or abrasion	Laceration	Sprain or strain	Fracture	Head injury	Burn	Poisoning		
Automobile accident	657	222	35	122	114	0	0	390	5.6
Fall	1291	4096	832	1385	529	50	0	939	33.0
Caught in device or object	736	466	26	83	1	3	0	145	5.3
Hit by object	753	2818	181	216	181	404	4	582	18.6
Stepped on object	69	425	4	0	0	30	0	912	5.2
Fire or explosion	2	4	1	1	1	56	0	7	0.3
Firearms	2	1	0	1	1	3	0	20	0.1
Ingestion	0	8	0	0	0	0	2109	509	9.5
Strangling or suffocation	0	1	0	1	0	0	1	18	0.1
Other and not stated	792	2031	272	241	53	235	22	2529	22.4
Total	4302	10 072	1351	2050	880	781	2136	6051	27 623
Per cent of total	15.6	36.5	4.9	7.4	3.2	2.8	7.7	21.9	100.0

outstanding hazards, redesigning appliances and machinery, and altering the structure and configuration of objects which seem most likely to cause injury. Epidemiologic studies have a definite, but limited, place in this area of endeavour, in the recognition and designation of the nature of the environmental hazards. Much information of this kind has been derived from contemplation of case series — only casual perusal of mortality data or the records of poison control centers is required to show that something needs to be done to limit the accessibility of kerosene or aspirin to small children.

The second popular approach to accident prevention is that of education. This is predicated on the notion that a large proportion of accidents are the result of failure of the accidentee to appreciate the nature of a hazardous material or dangerous situation. One of the more serious problems here is to distinguish between conscious awareness and intuitive perception of danger. Many of our avoidance reactions operate below the level of conscious thought and are presumably accumulated through experiencing repeated painful stimuli. Whether instruction at a conscious level can ever satisfactorily substitute for the conditioning process remains to be demonstrated, but seems to me to be an uncertain presumption. Much more work is needed to assist us to understand the mechanisms whereby we develop the capacity to recognize and avoid danger and the relation of these to conscious thought and overt behavior. One may conjecture whether the conditioning process must result from the uncertain aggregation of natural events, occasionally marked by a tragic result, or whether some artificial procedure could be developed to produce the same result more predictably and more safely.

Epidemiologic study has a considerable contribution to make in the field of education. It permits the identification of specific events in the accident complex which require attention. It identifies the subgroups of a population in which the specific event is of greatest consequence and toward which the prevention program should be directed. It provides a means for assessing the effectiveness of the prevention program. The design of studies for this past purpose is perhaps the most seriously underdeveloped aspect of home accident epidemiology. I think it has never been done at all satisfactorily, although it is evident that no reasonable statement of the value of any preventive activities can be made until the programs can be assessed with some rigor.

The application of epidemiologic methods to home accidents presents the promise not only of furthering preventive activities of the kind just discussed, but also of development of means of prevention not presently apparent to us.

Epidemiologic studies of home accidents would be furthered by the development of some general theoretic concept of the occurrence of accidental injury in human populations. I do not believe that any satisfactory formulation of this kind has been presented. The simple host:agent:environment model developed

from epidemiologic studies of infectious disease has some value, but calls for a series of arbitrary distinctions between host, agent, and environment which have little basis in reality and little utility as abstractions. Perhaps the chief use of this model is contained in the implication that an holistic approach is desired, but this view is hardly unique to this conceptualization.

The 'web of causation' concept propounded by MacMahon and coauthors⁴ also seems to me to be of little assistance in developing a rationale for studying accidents. With little effort we can weave a very tangled web. The idea of a 'web' of causation, while implying that the interaction of a large number of factors may be involved in the causation of an accident, leaves their identification and the assessment of their interactions to be discovered empirically, merely providing a scheme into which they may be fitted after the fact.

Suchman and Scherzer¹ have proposed that accidents be studied as phenomena reflecting a balance between subjective assessment of the probability of injury and risk-taking behavior. These factors are to be considered against an environmental background which contains situations representing varying degrees of risk of accident. In these terms, prevention might be achieved by reducing the accident potential of the environment, by increasing the accuracy of judgment of the probability of an accident, or by decreasing the willingness to take chances. This concept certainly has the advantage of indicating a number of specific approaches to accident research, using the methods of behavioral science. It also emphasizes that some accidental injuries are properly studied not by treating the person injured as the study subject, but rather the person who was capable of exercising some control over the situation, the person whose judgment was involved.

Epidemiologic study is based upon one central axiom, that disease is not randomly distributed in human populations. If it were, then a group of persons with the disease would constitute a random sample of the general population from which they came and study of their characteristics would be unrewarding. Instead of this, disease shows aggregation in time, in space, and according to measurable human traits. It is this aggregation observed as variations in the risk of occurrence of disease, which is properly the substance of epidemiologic study. Variations in the risk of disease are manifestations of variations in individual exposure or in individual susceptibility to the causative factors.

Thus, once a properly defined condition has been selected, an epidemiologic study proceeds according to the following steps.

1. Measurement of variations in the risk of a disease in human populations. These variations may be temporal, spatial, or according to any measurable attributes of the study subjects; usually a combination of all of these.
2. Development of inferences relating to the significance of these observations in terms of exposure and susceptibility.

3. Development of inferences explaining the variations in exposure and susceptibility in terms of other environmental or host factors, which may then be considered to play a part in the causation of the disease.

At any step, the substitution of direct observation for inference or the confirmation of inference by direct measurement greatly enhances the strength of the chain. It was this process which Frost described so well in the introduction to the Delta Omega publication of John Snow's work on cholera:⁵

Epidemiology at any given time is something more than the total of its established facts. It includes their orderly arrangements into chains of inference which extend more or less beyond the bounds of direct observation. Such of these chains as are well and truly laid guide investigation to the facts of the future; those that are ill made fetter progress.

This concept, that disease is not randomly distributed, that the aggregations of disease are attributable to variations in exposure and susceptibility, and these, in turn, are related to measurable differences in the characteristics of people and in the human environment, provides a theoretic framework of quite general applicability to epidemiology. It serves as a guide to the design and conduct of

epidemiologic investigations, stimulates the presentation of epidemiologic findings in precise, quantitative terms, and encourages study of the relation between findings and their arrangement in ordered arrays.

From such general theoretic considerations should come imaginatively designed and carefully conducted studies, and from these we may expect useful specific formulations of the causes of home accidents to emerge, together with new insights into the nature and interrelations of those personal and environmental factors which modify an individual's risk of exposure to those causes and his degree of susceptibility to injury following exposure. This, we may hope, will permit the development of programs for prevention that are scientifically sound, administratively feasible, and capable of evaluation.

- 1 Suchman EA, Scherzer AL. *Current research in childhood accidents*. New York: Association for the Aid of Crippled Children, 1960.
- 2 Suchman EA, Scherzer AL. *Uniform definitions of home accidents*. Washington, DC: US Department of Health, Education, and Welfare, Public Health Service, 1958.
- 3 Stallones RA, Corsa L Jr. Epidemiology of childhood accidents in two California counties. *Public Health Rep* 1961; 76: 25-36.
- 4 MacMahon B, Pugh TF, Ipsen J. *Epidemiologic methods*. Boston: Little, Brown and Co, 1960.
- 5 Snow J. *Snow on cholera*. New York: The Commonwealth Fund, 1936: ix.

You be the judge — preventable or 'freak accidents'?

'Freak accidents' can happen at a time or place when you least expect them. Here are some examples to educate parents of hidden dangers.

- A 2-5 year old boy was drinking from a straw when he tripped over a cat. The straw sliced open the back of his throat, requiring surgery.
- A 1 year old girl sitting in a high chair with the seatbelt secured slid down in the chair, strangling her to death on the seatbelt. The chair was not equipped with a T-strap (the strap which goes between the child's legs and secures to the seatbelt).
- A 2 year old girl was trying to step over a velvet rope divider at a bank. She stepped on it instead, causing the metal supporting pole to tip over and strike the child on the forehead. The child required several stitches.
- A teenager was pushing shut a door by the glass. When the door shut, her hand went through the glass. The glass just missed slitting her artery, and required 30 stitches.
- A 3 year old boy was shutting a corral gate and caught his thumb in it. The thumb was severed; however, it was able to be surgically reattached.
- A teenager was sitting on her bike, waiting to cross the street. A tractor trailer attempted a narrow right hand turn, causing the trailer to jump the curb. The trailer pinned the girl against a telephone pole, killing her instantly.
- A toddler was brushing his teeth, and somehow managed to swallow his toothbrush. A long procedure was required to extract the toothbrush.
- A 6 year old boy playing on the beach was digging a pit in the sand. When the pit reached approximately 5 feet deep, he jumped in it. The pit collapsed, suffocating the child before rescuers could reach him (from CCSN BBS).

(Editor's note: it seems to me all of these are preventable in one way or another. But others may disagree. If you do, do write and say why.)