ACCIDENT PREVENTION RESEARCH

What it takes *Who can do it*

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SUCCESSFUL research has two basic requirements: substantive knowledge of the subject under study and skill in the pertinent techniques of investigation. Both are necessary, and neither assures the presence of the other. For research in accident prevention, one must know the world of accidents and the appropriate world of research methodology.

What is the substantive knowledge in regard to accidents? What is the phenomenon to be studied? What is an accident? What is the nature of the phenomenon? What class of accidents are we talking about and how are such classifications made? Where do accidents happen? To whom do they happen and when? Under what conditions? What are the special circumstances within the human being or in the environment? What are the statistical characteristics of the events to be studied? What is the frequency? What is the unit of exposure? What are the forces at work making for higher or lower risk? What efforts are being made to control accidents now? What is already known or thought to be known about accidents? What is already known not to be true or believed not to be true? What blind alleys have already been explored?

In my view it is utterly impossible to evaluate the substantive knowledge of this or any other area unless one is prepared to examine with scientific criticalness the bases of the knowledge. One cannot do research in an area where one is not prepared to exercise scientific criticism; this is necessary, but not sufficient. What, then, does it take?

First and foremost is a thorough knowledge of the logic of scientific inference, especially from experimental data. This includes concepts of variables, measurement, controls, manipulation, and analysis. If we are talking about quantitative science (and what science is not quantitative), we are involved with measurement. As soon as we are involved with measurement, we are concerned with error of measurement. We must, then, understand sampling and probability and, hence, mathematical statistics, in order to make meaningful analyses.

From this it follows that one must have training and experience in at least one area of the basic sciences: biological, behavioral, physical, or mathematical. Accidental phenomena are so broad in scope that variables in all of these areas and many more are involved. In addition to training and experience in a basic science area, it is generally necessary to have formal instruction in at least one or more associated disciplines. Among the disciplines which have implications for the wide variety of aspects of accidents are: psychology, sociology, cultural anthropology, physiology (including pathology), clinical medicine, preventive medicine, pharmacology, toxicology, bacteriology, and biochemistry. Engineering disciplines are often very important in accident research—civil engineering, public health engineering, mechanical, electronic, electrical, and chemical engineering, and others, depending on the problem to which we are addressing ourselves. In addition to knowledge about the kinds of variables represented in the disciplines mentioned, it is often necessary to have knowledge of stochastic models, operations research, systems analysis, computer programing, and simulation techniques.

It is by no means necessary, or even possible, for anyone to be expert in all of the areas listed.

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But if he is expert in one basic area and is sufficiently acquainted with the variables, concepts, and techniques of others so that he can work with experts in them, this is about all that can be reasonably hoped for.

Apart from the content of the various disciplines, there are conceptual and methodological problems peculiar to accident research which one does not learn about as such in any of the respective disciplines.

First is the problem of the classification of accidental events, that is, how to put together those events which belong together in some functional, meaningful, or useful way. Ideally, of course, we should put together those accidents that have common causes, but if we really knew the causes there would be little need for research. So we make first approximations: we talk of traffic accidents, home accidents, childhood accidents, accidental poisonings, and so on. Within traffic accidents, we speak of intersection accidents; running-off-the-highway accidents; single-vehicle, multiple-vehicle, rural, urban, nighttime, and daytime accidents, plus many others. Very importantly, recent analyses strongly suggest that almost never does an accident happen for one reason only; it almost always involves a concomitance of several factors.

A second class of conceptual and methodological problems arises out of the fact that accidents are rare events, relative to exposure. This rarity creates special problems in mathematical statistics, in measurement of both human and environmental variables, and in the very logistics of research. Methods of investigation and analysis that are familiar in other areas are often inappropriate here. This is especially true if one is addressing himself to the role of human characteristics and human behavior in accident generation. He is confronted with the reality that accident involvement is not a highly stable characteristic of individual human beings. What variables, then, are relevant? How are they measured? And how is this relevance established?

It is at this point precisely that we face the question, must we know accident causation if we are interested in accident prevention? The answer is not certain. Presumably a knowledge of causes facilitates control, but it is not at all clear what it is we need to know in order to prevent accidents. For instance, intersection accidents can be prevented by building roads without intersections and we need not know what used to "cause" the old-type intersection accident. Is it feasible to thus eliminate all hazards or even all intersections? What do we, then, really mean by "cause of accident"? Does anyone know why aspirin relieves headaches? It is sufficient for purposes of control to know that relief follows ingestion of aspirin. Scientists, of course, will never rest until they know precisely how this happens.

The translation of accident prevention problems into researchable problems requires knowledge of accidents and of research methodology. Definition of the problem thus requires the highest research talent and the highest skill. Once the problem is defined, it is often possible for less skilled and less experienced persons to take on segments of the research.

The task does not end with research findings. Unless the findings are translated into operational countermeasures for prevention, they are of academic interest only. And here again the two areas of knowledge—the world of accidents and the world of research—must be brought together.

Even when research findings are translated into operational measures, we still are not finished. The effectiveness of the countermeasures must be evaluated. This in itself is no mean research task, for it requires the conduct of research in the real, live world, where it is most difficult to control and to manipulate and to measure. But without such scientific evaluation, we never know what works, what does not work, what is worth doing, what is worth the expenditure of resources, and what is useless.

How, then, does one prepare himself for accident prevention research? There is no discipline that bears this name. There is no place where one studies for such a profession. The prospective researcher must become expert in a basic scientific area. He must be acquainted and conversant with one or more associated disciplines. He must then undergo a practicum in association with and under the supervision of senior personnel who are engaged in accident prevention research.

There are currently developing two or three sizable research programs in this country which can begin to take on such persons for training after they have finished their academic work. The next 5 or 10 years, hopefully, will see the establishment of several more full-blown centers for accident prevention research. Conversely, such centers await the development of personnel who are competent to lead them and to conduct research. Both must develop simultaneously.

It follows that career opportunities in accident prevention research will become available for those people who are capable and willing to accept the challenge.

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Link Viral Genes to Cancer

Recent studies have opened new avenues for experiments on genetic factors in viral cancers. At a symposium chaired by Wendell Stanley, University of California, at the 100th annual meeting of the National Academy of Sciences, April 22, 1963, panel members agreed it has become possible to design studies of viral factors in human cancer which a year ago would not have been conceivable. Speakers included Renato Dulbecco, California Institute of Technology; Robert J. Huebner, Public Health Service; Harry Rubin, University of California; and Albert Sabin, University of Cincinnati.

Findings reported for the first time by Huebner at this meeting suggest the possibility of testing the hypothesis that specific antigens in human tumors may be linked to viral agents of cancer. Since mammalian cells experimentally made cancerous by viruses do not necessarily contain infectious virus, attention has shifted to cells that are "virus-free." It has long been hypothesized that such cancer cells contain viral genetic material. Huebner found direct evidence of such genetic material by demonstrating complement-fixing specific antigen associated with adenoviruses 12 and 18 in cancers provoked in hamsters and rats by these viruses. At the same time, there was no evidence of the viruses in infectious form; the infectivity disappeared shortly after entering the tissue and before tumors formed. Further studies of these antigens, it is assumed, may help to identify some of the mechanisms by which viral information becomes part of the genetic material in cancerous cells.

The persistence of some carcinogenic virus in some tumor cells and the absence of carcinogenic virus from similar cells have been observed in many experiments. On the theory that the cancerous cells had merely hidden the virus, without changing its structure, one line of attack has been to devise methods of bringing the virus out of hiding.

Sabin reported finding simian virus 40 in minute amounts in serially transplanted tumors provoked by the virus in hamsters. This virus is detectable by its lethal effect on very sensitive cells originally cultured from cercopithecus monkeys and adapted for continuous growth on glass by Hope E. Hopps, Public Health Service. Using these cells as indicators for the virus, Sabin and Koch were able to demonstrate that all or almost all simian virus 40 tumor cells carried the virus in noninfectious form, and that only occasionally were minute amounts of infectious virus formed.

These investigators found three procedures effective in inducing a higher frequency of development of infectious virus in the tumor cells: (*a*) prolonged cultivation of the tumor cells on glass, (*b*) intimate association of the hamster tumor cells with the sensitive cercopithecus monkey indicator cells even under conditions which were not suitable for the growth of the tumor cells, and (*c*) exposure of the tumor cells in a suitable medium to X-rays. Cells transformed by the simian virus 40, like cells transformed by the Rous sarcoma virus and adenoviruses, appear capable of transmitting the genetic material of the virus from one generation of tumor cells to another without producing the virus in infectious form, except under the special conditions mentioned above.

In pursuit of the distinctive character of an avian carcinogenic virus, Rubin found that the carcinogenic Rous sarcoma virus, RSV, is unable to reproduce itself in infectious form in the absence of another virus called RAV, Rous associated virus. This defect in its reproductive capacity, Rubin observes, is the only discernible difference between RSV and its noncarcinogenic counterpart, RAV. Nevertheless, although RSV cannot alone give rise to infectious virus particles, it is able to effect the malignant transformation by itself. The genetic material of the virus multiplies in the transformed cells and can be evoked to produce infectious virus by the addition of RAV. Rubin postulates that the reproductive defect of RSV offers a clue to its uniquely direct and exclusively carcinogenic activity.

As noted by Stanley and Shope, broad acceptance of the viral role in cancer has been reluctant. Few credited the possibility as recently as 1937, when the National Cancer Institute was established. But today, as Shimkin has observed, "Many viruses under certain conditions can be involved in the neoplastic process. The small group of viruses previously considered unusual in their carcinogenic potential fit nicely into larger groups of such entities."

The biochemistry of cancerous growths today embraces the provocative role of environmental chemicals and such physical forces as heat, mechanical irritation, and radiation, and the biological activities of malignant cells, viruses, and genetic materials.