14) I may be run over going to the hospital.
15) The hospital may burn down.

I understand: the anatomy of the body, the pathology of the development of hernia, the surgical technique that will be used to repair the hernia, the physiology of wound healing, the dietetic chemistry of the foods that I must eat to cause healing, the chemistry of body repair, and the course which my physician will take in treating any of the complications that can occur as a sequela of repairing an otherwise simple hernia.

Patient

Lawyer for Patient

Lawyer for Doctor

Lawyer for Hospital

Lawyer for Anesthesiologist

Mother-in-Law

Notary Public

Date

Place

Data Collection and Systems Analysis

W. C. H. Prentice writes (Letters, 4 March) about the problems raised by the increasing tendency to collect data for their own sake, particularly by means of questionnaire surveys. The remedies he proposes deserve close attention, for they can be generalized to apply beyond the limited domain of such surveys. The problem that Prentice addresses is far more pervasive and serious than may be realized. Because of the ease with which data may now be collected and processed, in some technical, economic, political, and social fields we are almost being studied to death. Many of the studies serve to obscure rather than to illuminate the central issues to be examined for effective decision-making. In addition—and this is potentially more serious—many such data collection studies are being represented as valid systems analyses of complex engineering, economic, political, and social problems.

In recent years some notable successes have been achieved through the application of the "systems approach" to a range of national security problems. The points of view and the techniques developed in such predominantly military systems have just begun to be extended wholesale to nonmilitary government, commercial, and industrial sectors. Examples include the fields of communication, transportation, urban development, education, health, and water-resources development. In the next 5 to 10 years this trend will increase sharply.

Systems analysis can be a powerful tool for decision-making in which are involved major allocations of resources in complex situations characterized by considerable uncertainty. Its essential components include goal setting (objectives, requirements, constraints), postulation and evaluation of alternatives (modeling, simulation, cost-effectiveness), and data collection (historical surveys, description of environment, structuring of relationships). These components are circularly related in the sense that the process of decision-making involves *sequential* and *iterative* application of goal-setting, alternative generation and evaluation, and data collection at successively deeper levels of analysis. The interactions among these phases—together with considerable human judgment—yield adjustments that ultimately converge to a "best" decision. Representing as it does the application of the scientific method to practical problem-solving, systems analysis is as applicable to problems involving personal choices as to problems involving the selection of an anti-missile missile system.

The basic point is that, in any of these applications, any data collection must be considered an integral part of the systems-analysis process. When this precept is ignored, considerable misplaced effort will result. These difficulties will increase as the complexity of the systems increase, for few limits can then be placed on the quantity of data that might be pertinent.

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Statistical Method

In reading the Reports in *Science* during the last quarter of 1965, I noted 16 in which statistical procedures were employed to the extent of making statements about "significance" or citing *P* values. (This count did not include reports giving means, standard deviations, or standard errors merely as summary values.) In eight of these reports I found errors in statistical method resulting from failure to understand the following:

1) The analysis of variance must be compatible with the experimental design described.

2) With regard to regression: (i) The correlation coefficient cannot "validate" a regression. (ii) The square of the correlation coefficient does not "demon-

strate that x determines y." (iii) When the observations are not occurring randomly about the regression line, then the usual probability statements are not valid.

3) When several values are constrained—for example, total 100 percent—then probability statements about the last value are dependent on those made about the earlier values.

4) Subdivision of an "observation" into several "readings" does not increase the number of "observations."

5) Experimental groups composed of members each treated somewhat differently from the others provide a dubious basis for probability statements.

One report cited *P* values although there was no clue to how they could have been obtained. In none of the 16 reports was there any discussion of whether results that were nonsignificant were based on sufficient observations so that an effect of interest or concern could reasonably have been expected to be demonstrated. I refrain from commenting on more "subtle" problems, such as the validity of probability statements based on planned vs. unplanned comparisons, on multiple comparisons, or multiple analyses of the same observations.

There seem to be too many weekend statisticians, who don't know much about the art but know what they like.

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Car Safety: Another View of Science

In the picture it presents of the relations between science and society, *Unsafe at Any Speed*, Ralph Nader's book about lagging automobile safety, runs directly counter to other views of science-and-society of recent years. The trend has been to view science and technology as plowing ahead, guided only by their own internal value systems, applying new knowledge hastily without regard to human and esthetic consequences. In the force of this advance, according to the usual indictment, not only the individual but even organized institutions are almost helpless.

Nader finds almost the exact opposite. Application of scientific knowledge to automobiles is slow and limited . . . the tastes of the common man win out, in least-common-denominator design that is technologically stagnant. Despite the acres of buildings symbolizing devotion to science, despite the giant proving grounds, the one revolutionary car in 25 years is treacherous on the road and remains uncorrected 5 years later. The institutions of traffic safety . . . are busily directing attention away from science; they have even captured the imprimatur of the President of the United States with which to oppose the spread of knowledge. A group of physicians desperately erects a picket line before the showplace of industry, demanding not freedom from dehumanization by overweening science but some small use of scentific design principles that have been known for over a decade. The picture is of a world-turned-upside-down, and suddenly reverted to the 19th century. Yet the facts are there. . . .

The book constantly reminds one of the struggles of science and technology to aid human welfare 50 to 100 years ago. Those efforts also met powerful adversaries. . . . The time between the first invention of the railroad air brake and its full adoption exceeded 25 years. Long delay in the use of the automatic railroad-car coupler exacted tens of thousands of workers' lives before the Railway Safety Appliance Act of 1893. . . . Even the promulgation by an uncritical automotive technical society of comfortable recommendations for the industry which funds its work has a historical ring; the same sort of "professional" engineering phenomenon was attacked in even greater detail by the English sociologists Sidney and Beatrice Webb more than 50 years ago. . . .

Nader's implied solution is federal control, but he also notes the lack of an organized constituency of informed scientists and engineers. There are two such organizations in the medical profession, neither beholden to the automobile manufacturers. In effect, they are carrying the entire burden of representing the consumer's interest wherever there is a need to speak out about automobile safety. Similar organizations among engineers and scientists would provide a fitting opportunity for public service. In a world which misunderstands the role of the scientist in shaping society, an organized voice demanding scientific reform for human benefit would fill a great need.

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