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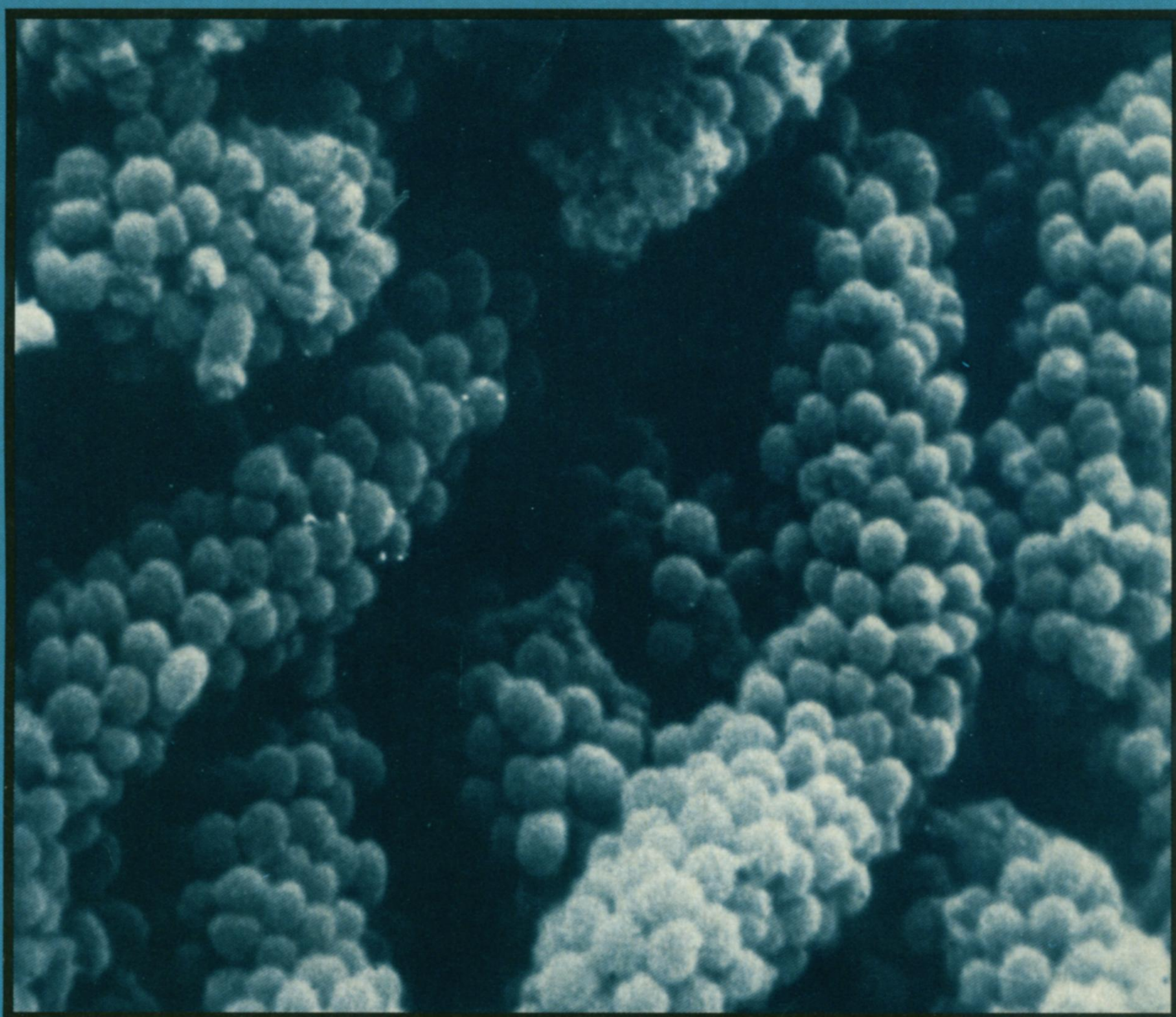


Complexities of Plaque

The Normalization Pairing

A scientist at the General Motors Research Laboratories has developed a new method for accurately determining the effectiveness of safety belts in preventing traffic fatalities. The approach may be used to answer a wide variety of questions using data bases that lack conventional measures of exposure.

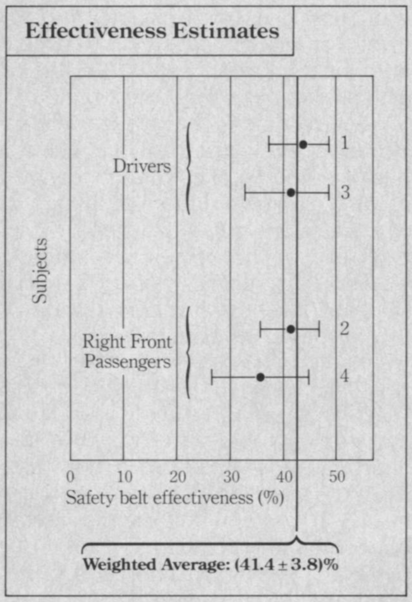
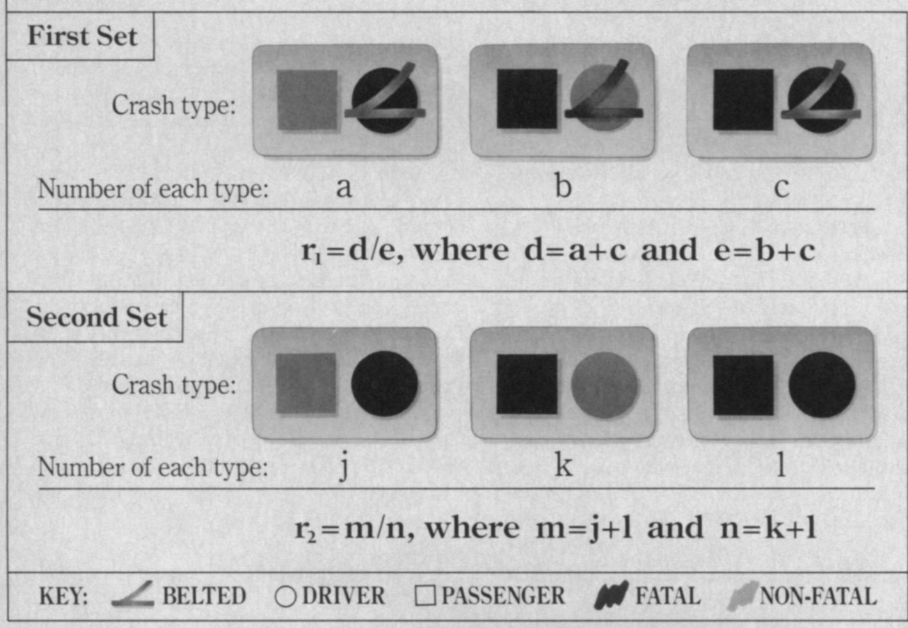


Figure 1: Weighted estimates of safety-belt effectiveness by subject, with standard error. Estimate 1 pairs subjects with right-front passengers; 2 pairs subjects with drivers; 3 and 4 pair subjects with occupants of all other seating positions.

Figure 2: Schematic representation of a sample double-pair comparison.



THERE IS A serious problem that researchers often encounter when trying to analyze large collections of information. It is the problem of measuring exposure. Though a collection of data may contain a large number of cases, and though the facts in each case may be highly detailed, there may be no way of comparing events selected for inclusion in the collection against the normal occurrence of similar events in the world at large.

One such data base is the Fatal Accident Reporting System (FARS) maintained by the U.S. Department of Transportation's National Highway Traffic Safety Administration. FARS details all fatal accidents in the U.S. since January 1, 1975—more than 300,000 crashes. However, it lacks an explicit measure of exposure.

FARS contains, for example, the number of fatalities classified by safety belt use. But fatalities among users depend on two considerations: first, the effectiveness of safety belts; and second, the crash involvement differences between users and non-users—that is, the exposure of belt users to crash involvement. If crash involvement were independent of belt use, it would be a simple matter to calculate the effectiveness of safety belts in preventing fatalities. However, belted drivers have fewer crashes, and the crashes they do have tend to be of lower average severity than those of unbelted drivers.

Now a scientist at the General Motors Research Laboratories has developed an approach to drawing inferences from FARS using only the information contained in the file. Dr. Leonard Evans has designed a method for comparing the effects of isolated characteristics by using two sets of crashes. In each set, a *subject* occupant is paired with an *other* occupant. In the first set, the subject exhibits the characteristic to be studied; in the second, the subject does not. The *other* occupant is chosen to have similar characteristics in both sets of crashes (e.g. always unbelted), and thereby acts as a measure of exposure.

To illustrate the workings of the method of double-pair comparison, Dr. Evans first applied it to a study of the effects of safety belt use on fatality risk. He could define the effectiveness of safety belts in terms of the ratio:

$$R_{true} = \frac{N_b}{N_u} = \frac{N' \int q_{D,b}(s) f_u(s) ds}{N' \int q_{D,u}(s) f_u(s) ds}$$

where N′ is the number of crashes per year by unbelted drivers, s is crash severity, $f_u(s)$ is the probability that a crash involving an unbelted driver has a severity s, $q_{D,u}(s)$ is the probability that an unbelted driver will become a fatality in a crash of severity s, and $q_{D,b}(s)$ is the probability that a belted driver will become a fatality in a crash of severity s. R_{true} is a ratio of new to old fatalities—assuming a formerly unbelted population became a belted population, with nothing else changing. But while N_u, the number of unbelted driver fatalities, can be determined from the FARS data, N_b, the number of these who would still have been fatalities had they been wearing safety belts, clearly is not coded in the data base.

Dr. Evans applied the double-pair comparison method to determine a quantity, R, that would, under plausible assumptions, accurately estimate R_{true}. Figure 2 shows the pattern of the first application. In it, one set of crashes paired belted drivers and accompanying unbelted front-seat passengers, generating a ratio, r_1, of belted driver fatalities per unbelted passenger fatality. The second set paired unbelted drivers with unbelted front-seat passengers, leading to a ratio, r_2, of unbelted driver fatalities per unbelted passenger fatality. This yields a value of $R = r_1/r_2$ as a measure of safety-belt effectiveness.

IN ADDITION to calculating R for driver *subjects* using front-seat passenger *others*, effectiveness was also calculated for right-front passenger *subjects* using driver *others*. Additional calculations were made pairing driver or right-front passenger *subjects* with passengers in any other seating position. Figure 1 reflects the synthesis of these estimates. Estimates 1 and 2 represent *subject* and *other* occupants disaggregated into three age categories and averaged. Estimates 3 and 4 represent pairings of *subjects* with occupants in other seating positions and averaged.

In all, Dr. Evans calculated 46 estimates of R. The weighted average of these gives a safety-belt effectiveness of (41.4 ± 3.8)%. This should be an accurate estimate whenever the distribution of severities is the same for both sets of crashes in each double-pair comparison.

Moreover, a formal analysis showed r_1/r_2 to be an accurate estimate of R_{true} under much less stringent restrictions. Even when the distributions of crash severity differ for belted and unbelted drivers, Dr. Evans concluded that the simple ratio $R = r_1/r_2 = nd/me$ is indeed an accurate estimate of safety-belt effectiveness.

Dr. Evans' confidence in the method rests on some key assumptions. But, as he points out: "One of the beauties of the method is its ability to remove the biasing effects of confounding interactions that may undermine those assumptions. It is necessary only to disaggregate occupants into different categories of the suspect variable.

"Because of bias elimination, and the ability to create a measure of exposure, the method of double-pair comparison lends itself to a broad range of investigations. We can estimate, for example, fatality risk as a function of helmet use by motorcyclists, or safety-belt effectiveness in different accident types. More broadly, we can estimate fatality risk as a function of age, sex, or alcohol use. We may even have revealed a trend in trauma response, in general, as a function of sex and age."

General Motors

GM
MARK OF EXCELLENCE

THE MAN BEHIND THE WORK

Dr. Leonard Evans is a Senior Staff Research Scientist in the Operating Systems Research Department at the General Motors Research Laboratories.

He received his undergraduate degree in physics from The Queen's University of Belfast, and holds a D. Phil. in the same discipline from Oxford University. He was a Post-Doctorate Fellow at the National Research Council of Canada in Ottawa.

Since joining GM in 1967, Dr. Evans has published research on such diverse topics as atomic physics and trauma analyses. His current area of concentration is traffic safety research.

He is a member of the Human Factors Society and is a Past President of the Society's Southeastern Michigan Chapter. In 1985, Dr. Evans received the Society's A. R. Lauer Award "for outstanding contributions to the human factors aspects of highway safety."