12. Exposure, safety and the use of rates

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The aim of the presentation is to convey a methodological problem which is fairly well-known in the field of safety research, but which still lacks a proper solution. Accidents can be defined as the product of risk and exposure. Risk is generally expressed as a rate and a number of community used rates are given in Figure 1. What do we need and use rates for? (Figure 2). We require rates when making comparisons, because the absolute numbers of fatalities or casualties are meaningless, or for monitoring trends over time. Some examples appear in Figures 3, 4. The use of rates, especially the travel-risk rate -- defined as casualties or fatalities per unit distance travelled, is very widespread. The problems associated with the use of this rate are described in Figures 5 and 6.

12.1 WHAT IS THE SOLUTION TO THE PROBLEM DESCRIBED?

We need good models, relating accidents to flow (Figure 7). Preferably models should be disaggregated by conditions and accident types.

Three levels of aggregation can be defined:

Level I - relating accidents, or fatalities, to the total national amount of distance travelled (see work by Smeed, 1974, Figure 8);

Level II - relating accidents, or fatalities, to traffic volumes per road, or road category (i.e., AADT) - (see work by Hakkert et al., 1995, Figure 9);

Level III - relating accidents to hourly traffic volumes (see work by Persaud and Dzibik, 1993 or Maycock and Hall, 1984 (Figure 10).

It is hoped that additional research on the above-described problem can be initiated. This will shed further light on the issue, and may lead to results that will eventually enable the use of non-linear rates, thus enabling comparisons of travel-based rates in a meaningful context.

EXPOSURE, SAFETY AND THE USE OF RATES

ACCIDENTS = RISK x EXPOSURE

↓

RATE

COMMONLY USED RATES

ACCIDENTS PER UNIT POPULATION

ACCIDENTS PER UNIT VEHICLE-POPULATION
(i.e., NO. OF VEHICLES)

ACCIDENTS PER UNIT DISTANCE TRAVELLED
(i.e., VEHICLE-KILOMETRES)

ACCIDENTS, OR CASUALTIES, OR FATALITIES

Figure 1

WHAT DO WE NEED RATES FOR?

FOR COMPARISONS

FOR TREND MONITORING

GENERALLY:

1. **WHEN COMPARISONS OF ACCIDENT NUMBERS ARE NOT MEANINGFUL**

2. **WHEN WE LACK KNOWLEDGE OF DETAILED RELATIONSHIPS BETWEEN ACCIDENTS AND INDEPENDENT VARIABLES, i.e., THERE IS NO MODEL**

Figure 2

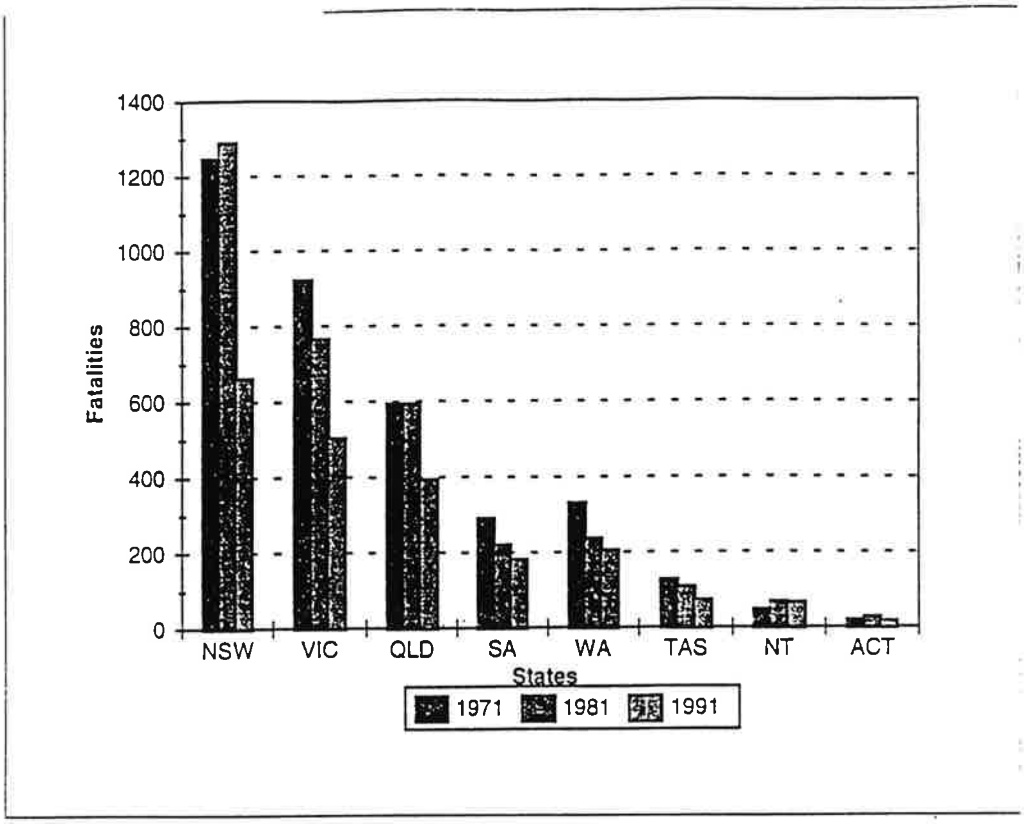

Figure3.1:
Fatalities in Australian States,1971-1991

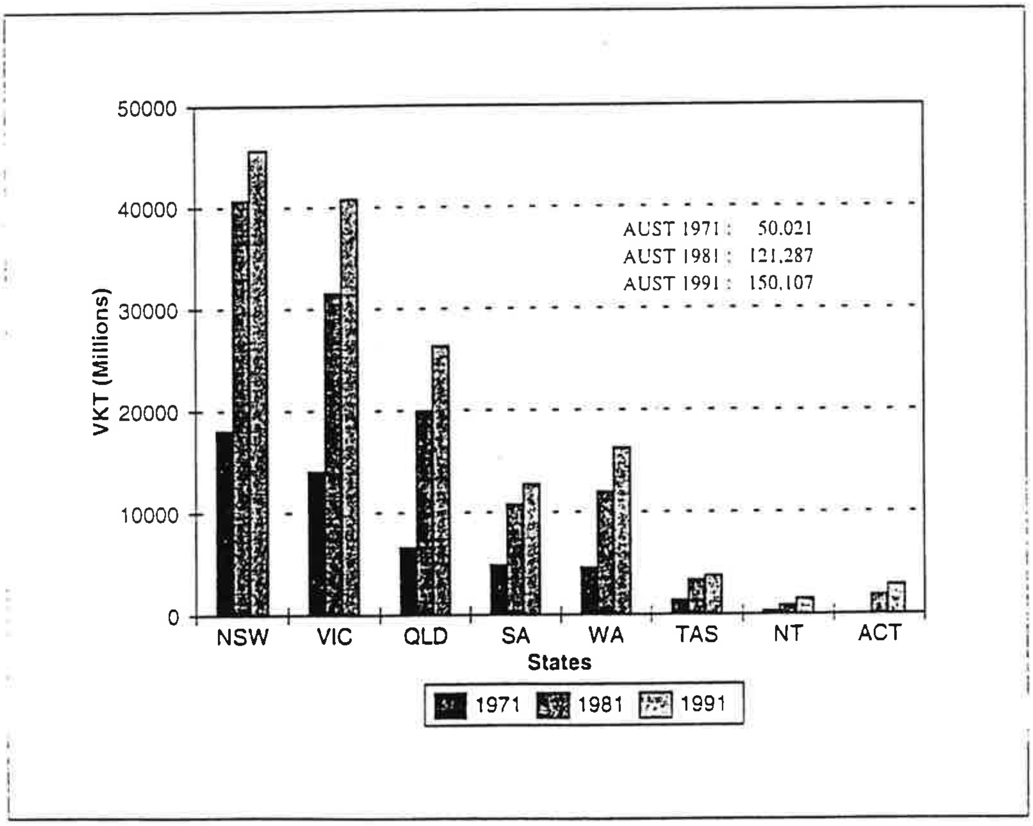

Figure 3.2:
Vehicle kilometers travelled (VKT) in millions, 1971-1991

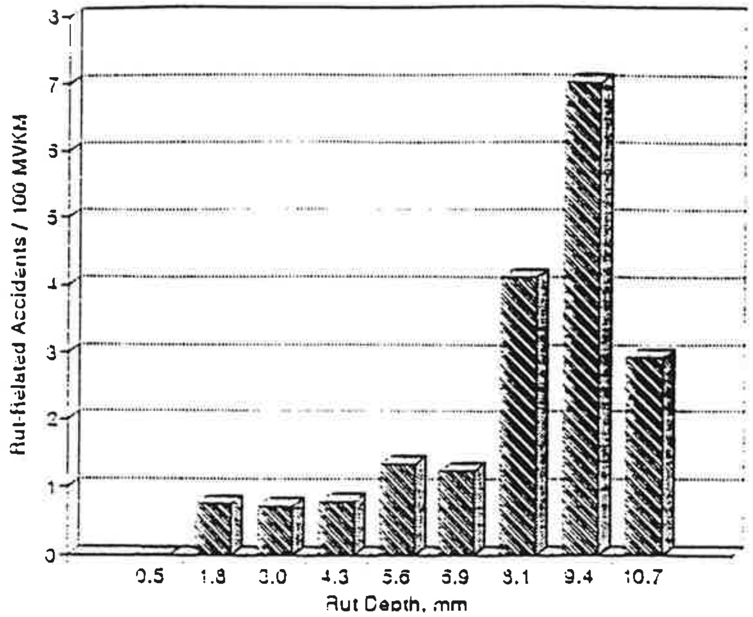

Figure 4:
Use of accident rates

WHAT IS THE PROBLEM?

IN USING RATES, WE ASSUME A LINEAR RELATIONSHIP

ALSO DISCUSSED HAUSER (1995)
ANDREASSEN (1991)

IF RELATIONSHIP IS NOT LINEAR -- WE HAVE A PROBLEM

- RELATIONSHIP IS GENERALLY NOT LINEAR

OTHER ASSOCIATED PROBLEMS

- **ACCURACY OF VEHICLE-MILEAGE SURVEYS**
- **ACCIDENT SEVERITY PROBLEMS -- WHAT ACCIDENTS GO INTO EQUATION -- PROBLEM NOT LIMITED TO RATES**
- **REGRESSION PROBLEMS WITH RATES**

Figure 5

12. 2. INDICATORS ASSOCIATED WITH CRASHES, INJURIES AND FATALITIES (FIG.6)

12.2.1 Raw data indicators

For the purpose of monitoring or evaluating safety within a State, other geographic entity or group, it may sometimes suffice to study the trends in the raw data. Suitable time periods should be selected as there is a tendency to look at changes over very small time intervals (a weekend, holidays, a week). The random fluctuations in the crash and injury data over short intervals generally make such fluctuations meaningless. Even a month of data on fatalities within one State is not meaningful without applying statistical trend analyses.

A study of changes in the number of crashes or casualties may lead to the identification of an issue in need of further study. For such further study, it will quickly become necessary to look at more complex indicators, such as rates, which enable comparisons to be made and can allow for changes in exposure.

12.2.2. Crash and casualty indicators

The most widely used indicator of safety performance is the number of crashes, casualties or fatalities associated with the issue under observation. Most countries limit analyses to accidents with personal injury although some countries, including Australia, also report on property damage accidents where the damage exceeds a certain value. Comparisons between States or countries are generally limited to fatalities, which are the most accurately and consistently reported, and in some cases serious casualties (ones admitted to hospital). The present study is also limited to the above two classes. It is generally beneficial to weigh the various types of accidents or injury according to cost indices if these have been developed, as is the case for Australia.

12.2.3. *Rates*

The most commonly used crash and casualty rates used for comparisons and evaluations are the crash or injury rates per unit population, per number of motor vehicles or per unit vehicle distance travelled. Using population in the denominator generally produces meaningful output indicators although it should be remembered that large differences in output can stem from differences in population, age group, mix or geographical location (urban vs. rural). Such differences should be taken into account as much as possible to produce rates broken down into the separate meaningful categories.

Rates per unit distance travelled are much more problematic. Such rates are in wide use and have also been used in this study. They generally overlook the difficulty raised in the following section (Hakkert, Livneh and Mahalel 1976, Andreassen 1991, Hauer 1995).

The number of accidents or fatalities per million vehicle kilometres travelled (Million VKT), which is a widely used index of comparison, is generally decreasing over time. Vehicle kilometres are generally defined as the distance travelled per vehicle multiplied by the number of vehicles. Each additional vehicle-km causes a smaller and smaller increase in the number of accidents. This situation is described in Figure 7. The decreasing slopes of curves OA and OB represent the fact that the number of accidents per vehicle-km decreases with increased travel. The ratio of accidents per vehicle-km is given by the angle a. The meaning of an improvement in the level of safety is that for each amount of travel the amount of accidents is reduced. Therefore, curve OB describes an improvement in safety compared with curve OA. For each amount of travel, the resulting number of accidents will be smaller.

It can be seen from Figure 7 that the number of accidents per vehicle-km by itself does not indicate a higher or lower level of safety, without further knowledge of the shape of the curves or our position along them. For a given amount of travel, curve OA produces a greater amount of accidents than OB and has therefore an inferior level of safety. For different amount of travel, wrong conclusions can be obtained from the use of the ratio accidents per vehicle-km. Point C, having a smaller slope than D ($a < b$) is worse than D from the overall safety point of view, but the fact that the number of accidents per vehicle-km travelled is less, is helpful. Each vehicle will be involved in fewer accidents, although the greater number of vehicles will mean more accidents. Only for the case of a linear relationship between travel and accidents, can the level of safety be described by this ratio. However, in such a case the absolute number of accidents can describe the situation as well.

It is, by now, fairly well established that over the whole range of practical traffic volumes, the shape of the curve is not linear (Hauer 1995).

A further problem with the use of vehicle-distance travelled is the basic accuracy of measurement. Vehicle distance travelled is generally assessed from relatively small surveys of odometer readings, from fuel consumption estimates or from traffic volume counts. These measures are prone to large errors.

Using the number of vehicles as denominator at first glance seems to circumvent the problem described above. It does, however, depend on the circumstances.

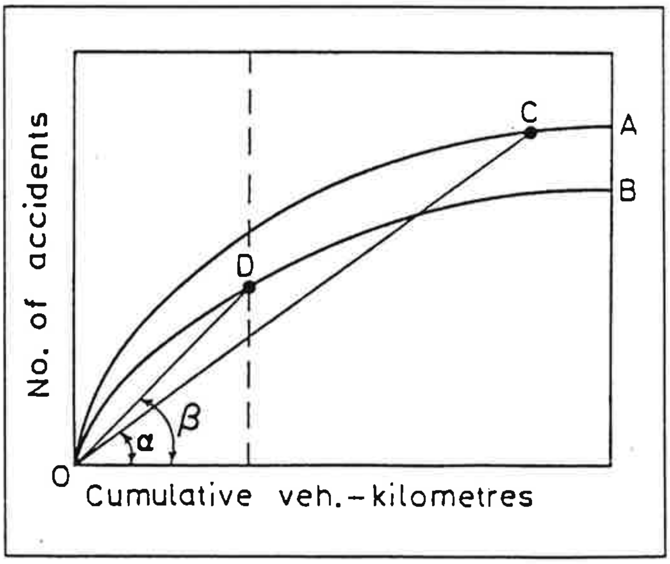

Figure 7:
The relationship between number of accidents and cumulative vehicle-kilometres travelled.(Source: Hakkert, Livneh and Mahalel 1976).

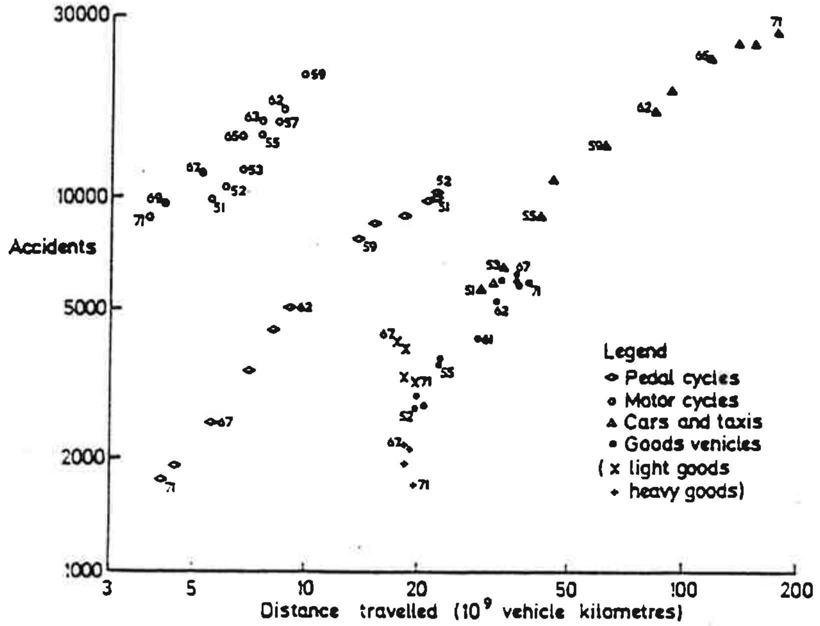

Figure 8:
Level I models (Smeed,1974)

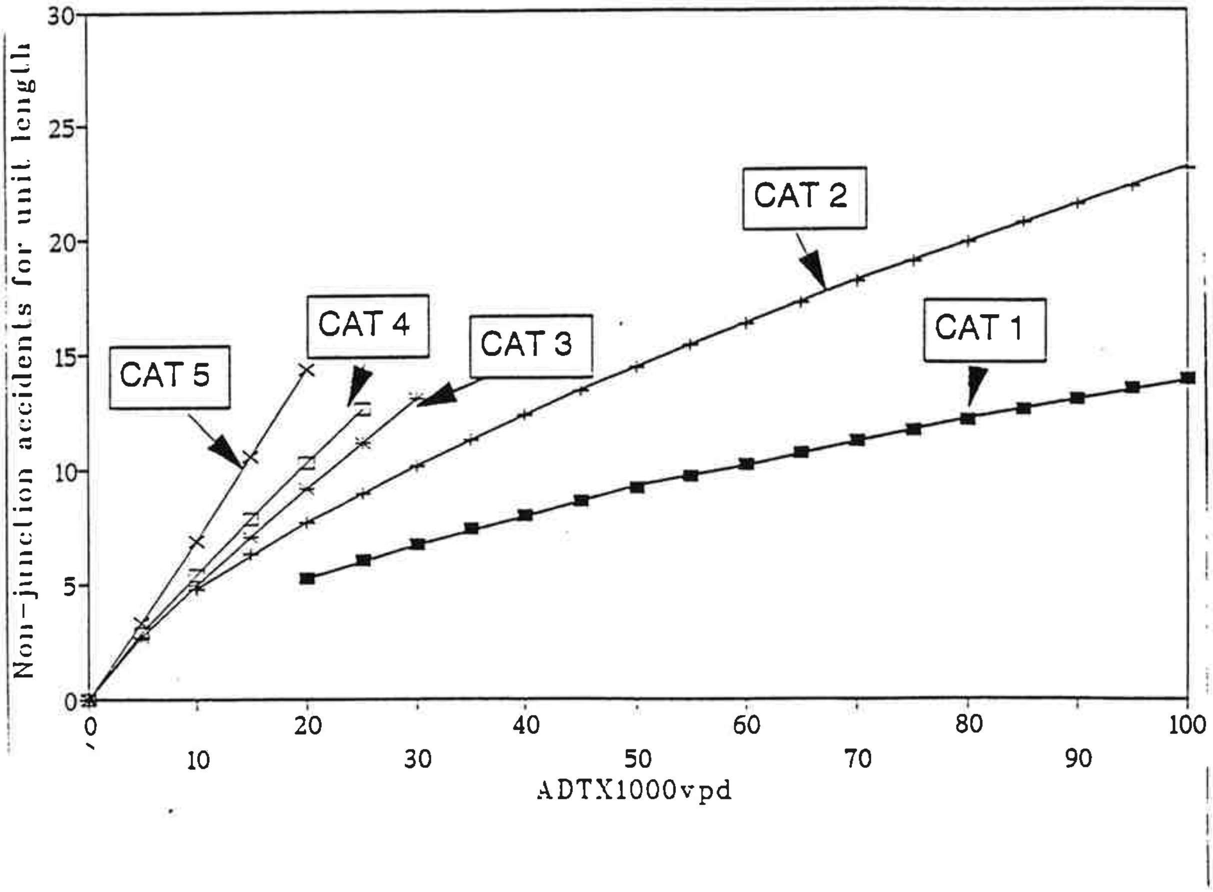

Figure 9:
Level II models (Häkkert et al. , 1995)

Level III models

Some recent flow models

Freeways

4-lane freeways (Canada) (Persaud, Dzbik, 1993)

m = 0.147 (AADT(1000)1.135

m = 0.00145 (hourly flow/1000)0.717

m = expected no. of accidents

Intersections

4-arm roundabouts

Level I - $\lambda_{total} = kQ^{0.68}$ (Maycock, Hall, 1984)

λ_{total} = exp. no. of acc. per year

Q = product of toatal entering flows

Level II

λ_{e-c} = kQ 0.68 x Q 0.36

e - c = entering - ciculating

Level III

$\lambda_{e-c} = 0.046Q^{0}$