CHAPTER 6: EVALUATION OF ROAD SAFETY IMPROVEMENT INTERVENTIONS

6.1 INTRODUCTION

Road safety improvement interventions take place annually and the evaluation thereof is essential to determine whether the intervention had the desired result (*AUSTROADS* 1988).

The purpose of this chapter is to describe the need for evaluation and to identify the different elements of the evaluation of road safety improvement interventions.

6.2 THE NEED FOR EVALUATION

AUSTROADS (1988) provides reasons why the evaluation of a road safety improvement intervention is necessary. It is to ensure financial accountability and to clarify that the intervention actually resulted in a reduction of accidents.

Expenditure on road safety has been significantly reduced as a result of limited resources. Evaluation of interventions ensures that funding is directed towards projects that will have the most direct impact on road traffic accidents. The second reason for evaluation is the clarification of the accident reduction. Road traffic accident numbers and severity are influenced by numerous factors, e.g. traffic volume changes, changes in population, etc. There may also be other effects that can merely cause a shift in the presentation of accidents like the risk homeostasis process that is described in detail in Chapter 11.

6.3 EVALUATION METHODS

Evaluation of road safety improvement interventions includes qualitative and quantitative indicators. Quantitative indicators includes the analysis and evaluation of accident data and qualitative indicators includes the evaluation of the human factor in terms of behaviour, attitude etc.

Chapters 7 to 9 deal with the different types of accident data analysis and statistical analysis and also provide some examples in terms of Arrive Alive 1. The evaluation of the human factor is discussed in Chapters 11 and 12.

6.4 Conclusions

The evaluation of road safety improvement interventions is necessary and there are a number of measures that can be utilised in this process. A number of key performance indicators were identified.

CHAPTER 7: ANALYSIS OF ACCIDENT HISTORY

7.1 INTRODUCTION

Accident statistics are quantitative measures that can be utilised to measure the effect of road safety campaigns. The purpose of this chapter is to define, describe and discuss the various elements in the analysis of accident statistics in the assessment of a road safety campaign. Analysis of accident data for road safety campaigns takes place on the macroscale (ITE 1982) where an analysis is made based on summarised data that only allows for generalised conclusions. These conclusions may lead to legislation or regulatory measures to alleviate the problem. Microscale analysis is done in a localised manner with accident reconstruction.

The purpose of this chapter is to serve as an introduction to the analysis of accident data, explaining accident data characteristics, concepts of measures and pitfalls, where applicable.

7.2 PROBLEMS WITH STATISTICAL ANALYSIS OF ACCIDENT DATA

A number of factors will influence the quality and interpretation of accident data (*AUSTROADS* 1988):

- Accident reporting criteria – In certain countries, only injury accidents are reported, in other countries insurance is not required and this leads to an underreporting of accidents where there were no serious injuries. The definition of a fatality differs from a death within 7 days after the accident in South Africa to 30 days in other countries[1] (*ITE* 1992). In the latter case it is essential that a uniform means of updating accident fatalities be implemented throughout the particular area or country that is investigated (*ITE* 1992).

- Coding effects – Changes can occur in the coding or classification of accident data or the accident report form can change, as has recently happened in South Africa.

- Biased data – Reporting on alcohol involvement in accidents in South Africa is low as previous legislation required a blood sample and a district surgeon to enable a positive indication on the accident report form.

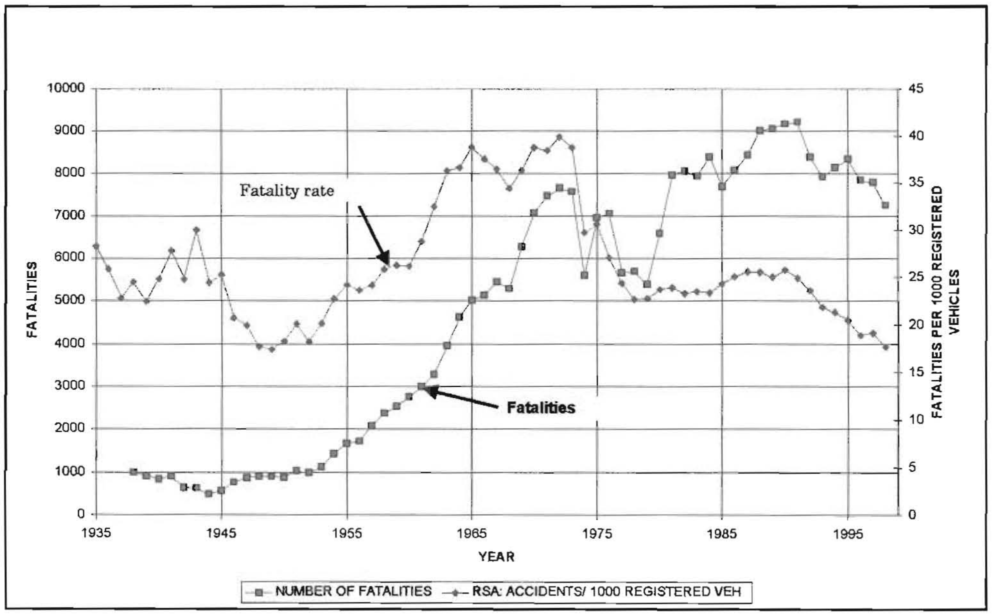
- Random fluctuations (refer to Chapter 8 and 9 for a detailed discussion).

7.3 MEASURES FOR ACCIDENT DATA ANALYSIS

Accident frequency, severity and rates are generally used to measure the safety performance of a country or area (*ITE* 1992).

7.4 ACCIDENT FREQUENCY

The number of accidents and/or fatalities can be used to measure the effectiveness of a campaign. However, it fails to take into account exposure that may change the result of the analysis significantly. Graph 7.1 shows the difference between the number of fatalities and the fatality rate per 1000 registered vehicles.



Graph 7-1: Number of fatalities and the fatality rate per 1000 registered vehicles for South Africa (after CSS 1999)

[1] A definition of the United Nations Organisation

7.5 ACCIDENT RATES

7.5.1 Population-based rates

Accident fatalities, injuries and numbers can be expressed in terms of the area population to provide a measure of public health to allow for the evaluation of target groups for public health funding. The values are static and do not take the amount of travel into account. Population-based rates can also be based on the number of licensed drivers, the number of registered vehicles or the length of road network (*ITE* 1990).

Typical population-based rates include:

- deaths or accident characteristic frequency per 100,000 area population;
- deaths or accident characteristic frequency per 10,000 registered vehicles;
- deaths or accident characteristic frequency per 10,000 licensed drivers;
- deaths or accident characteristic frequency per 1000 km of road network.

Note that the accident rate per registered vehicle population relates the accident experience to the number of vehicles that can be involved in accidents (Homburger, Kell and Perkins 1992).

7.5.2 Exposure-based accident rates

Exposure-based accident rates provide a measure of the extent of the risk exposure in the transportation system (ITE Homburger). Accident numbers or severity are typically expressed as rates to provide a measure in terms of unit of travel or per length of road in the road system (ITE 1992).

The standard equation for the calculation of accident rates is (ITE 1992):

$$Rate = \frac{Number}{Exposure}$$

where Number = fatalities, injuries, etc and

Exposure = the annual vehicle kilometres of travel, kilolitres fuel, etc.

7.5.3 Basic accident rates

Basic accident rates includes:

- degree of injury;
- number of fatalities per total number of accidents;
- number of fatalities and serious injuries per total number of accidents;
- involvement rates that describe the involvement of vehicle types, drivers, passengers, accident types, etc. in terms of the total number of accidents.

7.6 ACCIDENT SEVERITY AND COSTS

The accident rate can be adjusted to take into consideration the severity and related cost (*ITE* 1992). The Equivalent Accident Number (EAN) is a typical method used in South Africa. It gives weight to the different degree of injury accidents to express all the accidents in terms of no injury accidents. The emphasis on the fatal degree of accidents is, however, too large – in some cases the number of fatalities may be significantly lower than in the other types and degrees of injury accidents. This can result in a distorted representation of the accident data. ITE (1992) recommends that an average fatal-plus-injury average accident cost be used by combining the number of fatality and injury accidents.

The use of accident costs as a measure of effectiveness of road safety campaigns should be restricted to the analysis of alternative remedial measures, as the answers produced by these two methods will differ significantly (ITE 1992).

7.7 TRENDS

Accident data contains two components. The first is a portion that is related to external factors like the economy, vehicle population, population, etc. that show time related changes (i.e. trends). The second is the portion that describes the randomness of accident occurrence. The second is a random fluctuation around the first. It is difficult to identify the deterministic element of the accident data as a large number of variables can influence accidents. Frith and Toornath (1982), Pant *et al* (1992) and Hakim (1991) list a number of variables that can influence accidents and their outcomes:

- vehicle composition and traffic volumes;
- driving behaviour and changes in the driver population;
- population composition and the number of young drivers;
- violence and aggression;
- vehicle inspections;
- vehicle safety improvements;
- motorcycle crash helmets;
- improved roads;
- traffic management;
- vehicle occupancy;
- season (holiday), recreational and tourism travel;
- climate (especially wet weather);
- light conditions (number of daylight hours);
- socio-economic factors;
- economic factors and changes in fuel prices;
- legislation;
- driving under the influence of alcohol and drugs;
- use of seatbelts;
- traffic volumes.

AUSTROADS (1988) lists a number of reasons why, apart from road safety campaigns, changes in the accident rate can occur. It includes: changes in the safety of cars, changed legislation, improved driver education, improved health care systems, emergency services, etc.

The analysis of long-term trends of accident data from the National Safety Council in the USA proved that accident fatalities reflect economic, population and vehicle population growth. The trends can be explained by three theories. The first theory is that road users become more "roadwise" as motorization improves and therefore fatalities reduce. The second theory is that public demand for a safer road system increases as motorization improves. The road safety professionals then implement safety measures that reduce fatalities. The third theory is that economic recessions, legislation based on safety, road building projects and other discrete events contribute to cause a long-term fatality reduction. Even in North America, where the deterioration of the road infrastructure continued and smaller passenger cars were introduced to the road system, this downward fatality trend continued (*ITE* 1992).

Carter and Homburger (*ITE* 1982) note that seasonal effects are also typical of accident data and that the summer travel peak is associated with an increase in accidents. They also proved that the age distribution of those injured or killed in road traffic accidents reflect the variations in exposure rates, the unsafe driving strategies of young drivers, etc. and is not representative of the age distribution of the population or driving population.

7.8 ACCIDENT TYPES

Accident data can be represented per accident type. It allows for a more detailed analysis of accident patterns. In the case of road safety campaigns, some of the accident types (e.g. head-on, etc.) can indicate whether changes in risk or shifts in risk took place. Refer to the case study of the drinking-and-driving campaign of British Columbia in 1977 as described in Chapter 11.

7.9 RISK INDICES

A risk index can be calculated for age or sex groups of those killed, injured or involved in road traffic accidents (*ITE* 1990). It can be computed using the following equation:

$$RI = \frac{\%\_Accident\_involvement\_in\_group}{\%\_Population\_in\_group}.$$

This method, however, does not take the exposure of the particular age group into account.

7.10 Conclusions

Accident data can be analysed by using accident frequencies and rates. Each of the different methods describes an area-specific characteristic, e.g. the accident rate per registered vehicle population that relates the accident experience to the number of vehicles that can be involved in accidents. In the evaluation process a description of the limitations of the particular methods should be included for the benefit of the reader. The methods described in this chapter have limitations as data between periods is compared but no indication is given of the significance of changes – there is therefore a need for statistical analysis.

CHAPTER 8: STATISTICAL ACCIDENT ANALYSIS

8.1 BACKGROUND

Accident data is often analysed in the evaluation of road safety improvement interventions. The portion of change in accident numbers or rates during the campaign is often the primary measure used to determine the short-term success of a road safety improvement intervention. This chapter describes the statistical analysis of accident data and the problems associated with the use of statistical analysis on accident data.

8.2 ACCIDENTS AS A RANDOM EVENT

A series of accident data consists of two elements, namely, the deterministic and the random elements. The random element of accident data follows a Poisson distribution. The Poisson distribution is described by a discrete random variable that takes on integer values like 1,2,3, etc.

The probability P(x) of exactly x occurrences in a Poisson distribution can be calculated as follows: $P(x) = \frac{\lambda^x e^{-\lambda}}{x!}$ where lambda is the mean number of occurrences per interval (Levin and Rubin, 1991).

If the sample size of a Poisson distribution is large enough (greater than 1000), then it can be approximated by the normal distribution. For a normal distribution, the standard deviation is the square root of the value. For a 95% confidence interval, changes within two standard deviations from the mean can be attributed to random fluctuations. For example, an analysis of the number of accidents per year in South Africa will be as follows: during 1998, 511 605 accidents were recorded in South Africa, then $x = 511605$

And then the Standard deviation = $\sqrt{x} = 715{,}3$. For a 95% confidence interval, the interval of $x \pm 2 \times$ Standard deviation = 1431 accidents. This means that a change of 1431 accidents, 0,28% can be attributed to random fluctuations. In this regard, a change of, say 6%, in the accident data, does not necessarily mean that 5,72% of the change is significant in terms of its consequences (i.e. it is not necessarily because of the intervention but can be the result of another external factor).

8.3 ARIMA (*after* NETER, WASSERMAN AND WHITMORE, 1988)

More complex time series is characterised by *having memory*, i.e. it is influenced by other events in the series. The series is characterised by intercorrelation between events in the series. The autocorrelation coefficient is used to measure this correlation. Although accidents are random events, certain external factors that influence accident occurrence are not random and have a trend. More complex analysis can be used to identify the trend and quantify the random fluctuations around the trend line.

ARIMA refers to the autoregressive moving average model. This model is a combination of the autoregressive and moving average model. The autoregressive model expresses observations of a stationary time series as a function of earlier observations. The moving average model expresses observations of a stationary time series as a function of random disturbances in earlier periods and in the current time interval. The moving average, autoregressive model, and ARIMA model are shown in equations 8.2, 8.3 and 8.4 respectively.

Moving average model:

The moving average model for Y_t is $Y_t = \mu + \varepsilon_t$ (Equation 8.2)

where Y_t = Observations

t = Current time period

μ = Expected value of Y_t

$u_t, u_{t-1}, \ldots, t-q$ = Independent random disturbances in the time periods $t-1, \ldots, t-q$.

q = The order of the average model

ε_t = Error term that is expressed as a weighted moving average of the current disturbance u_t and the earlier disturbances u_{t-} , , , u_{t-q} with the weights $\theta_1, \ldots, \theta_q$.

Autoregressive model:

The autoregressive model for Y_t is $Y_t = \phi_0 + \phi_1 Y_{t-1} + \ldots + \phi_p Y_{t-p} + \varepsilon_t$

(Equation 8.3)

where

Y_t = Observations

$\phi_1, \ldots, \phi_p$ = Autoregressive parameters (parameters determining the dependence of Y_t on each of the p earlier values in the series)

p = Lagged values of the stationary time series (independent values) indicating the order of the time series model

ε_t = Independent value.

Note that Y_t is regressed on $Y_{t-1}, \ldots, Y_{t-p}$, i.e. therefor autoregressive.

ARIMA model: The ARIMA model of Y_t is $Y_t = \phi + \phi_1 Y_{t-1} + \ldots + \phi_p Y_{t-p} + u_t - \theta_1 u_{t-1} - \ldots - \theta_q u_{t-q}$ (Equation 8.4),

where u_t is independent. The model is of the order (p,q) because the autoregressive component is of the order p and the moving average is of the order q.

The ARIMA model is applied in five steps, namely:

- removing the non-stationary components in the data series;
- identifying the appropriate ARIMA model;
- estimating the parameters of the model;
- analysing the residuals;
- evaluating the forecasting performance of the model.

The non-stationary components such as trends or seasonal components have to be transformed to make the series stationary.

The identification of the appropriate ARIMA model is a complicated task as it not only involves the selection of an appropriate model but also the suitable order (p,q) of the model. Computerised analytical techniques can be used to assist the statistician.

The parameters of the ARIMA model are estimated from the available data for the stationary time series. It is normally done by using special routines in a computerised analysis (using for example a software package like SAS).

A residual analysis is necessary to check the aptness of the model. Should the residual analysis indicate that the model does not fit well, modification is necessary (Neter, Wasserman and Whitmore, 1988).

8.4 CONTRIBUTING VARIABLES

To prove that a road safety improvement intervention resulted in an accident reduction or severity reduction, it is necessary to evaluate the contributing variables (Godwin 1984).

8.5 CONCLUSION

The comparison of accident data through statistical analysis techniques to determine the amount of change brought about by the implementation of a road safety improvement intervention is problematic as random fluctuations and other variables can have an impact on the statistical significance of the change.