# Review of modelling of road casualties in The Netherlands

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# Report documentation


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# Foreword

This review was carried out under the guidance of a steering committee of SWOV staff which comprised the following people: Siem Oppe, Bob Roszbach, Paul Wesemann, Peter Polak, Martha Brouwer and Frits Bijleveld.

The advice and direction of these people was greatly appreciated.
In particular, the author would like to thank Siem Oppe for his comments and help throughout the project, Frits Bijleveld for carrying out most of the statistical analysis rapidly and efficiently, and Paul Wesemann and Martha Brouwer for arranging the provision of data and for general advice.
The author also wishes to thank Ton Blokpoel and his colleagues for the timely provision of the large sets of complex data on which the analysis was based.

Finally, the author would like to thank the Research Director of SWOV, Fred Wegman, and the Director of MUARC, Professor Peter Vulcan, for arranging my visit to The Netherlands to make this project possible.

# 1. Introduction

The SWOV Institute for Road Safety Research in The Netherlands invited the author to undertake a review of existing and potential new activities at SWOV aimed at modelling time-series of road casualties (deaths and injuries) and casualty accidents. It was proposed that the review should cover the following areas:

- Macroscopic models of traffic and traffic safety. Recent work at SWOV has attempted to apply the general models developed by Oppe (1991a, 1991b) to disaggregated sub-groups of total road casualties in The Netherlands (Oppe & Bijleveld, 1996). Current work is experimenting with structural state space models (Harvey, 1989) for traffic growth and casualty risk per kilometre in each sub-group, with a view to combining these into a comprehensive total model of the situation.

- Explanatory models of road casualty trends. The macroscopic models used by SWOV to date, do not offer much explanation for trends in road casualties, apart from the contribution of traffic growth. It is considered that SWOV should be in a position to explain the relative contribution of the various road safety programs and other socio-economic factors to road casualty trends in The Netherlands, especially after each of the years 2000 and 2010 since the Dutch government has plans for substantial reductions in road casualties over the periods leading up to these years.

- Recommendations for further work by SWOV. It was envisaged that during the review a number of directions of profitable research may be commenced, but tempered by the availability of data, especially in the area of explanatory models. Recommendations for continuation of this research, or other potentially profitable directions, should be included in the review.

# 2. Background

Monash University Accident Research Centre (MUARC) undertook a series of evaluation studies in the early 1990's aimed at assessing the impact of each of a number of programs which were part of the Victorian Road Safety Strategy, launched in September 1989 (Cameron, Newstead & Vulcan, 1994). In general these evaluations made use of ARIMA and/or multiple regression time-series models of an appropriate group of casualty accidents considered the target of the program, with an intervention term representing the impact of the program from the time it commenced. The approach was that of *intervention analysis* (Box & Tiao, 1975), with the addition that accidents in an unaffected part of the state (of Victoria) or in another state (New South Wales) were analysed the same way in parallel as a *control* comparison to measure the effects of factors not included specifically in the time-series models. A measure of economic activity (unemployment rate) was included as a specific *covariate*, because the Victorian economy deteriorated substantially from mid-1990 to 1993 and previous research had shown the level of road casualties to be associated with economic conditions (Partyka, 1984; Thoresen, et al., 1992). A considerable amount of understanding of The nature of the various time-series of casualty accidents and factors affecting them was gained from this somewhat traditional style of evaluation research.

Subsequent work developed models where at least one measure of the program activity was included as a covariate in addition to unemployment rate and, in some circumstances, other relevant social factors (eg. alcohol sales). The principal motive for this approach was The need to assess the contribution of the mass media publicity (mainly television-based) supporting the two major enforcement programs (ie. random breath testing and speed cameras) which previously had been evaluated as part of those programs. Fortunately there was sufficient (and not strongly correlated) monthly variation in the enforcement and publicity activities to make this feasible. The models were multiplicative in form and were fitted by multiple linear regression after taking logarithms of the monthly accidents and explanatory variables. Simple variables representing fixed trends and monthly fluctuations were also included as covariates. The rationale and detailed results are given by Cameron et al. (1994) and Newstead et al. (1995).

An important theoretical development was provided by Newstead who showed that multiplicative models fitted to accident frequencies, each representing a mutually exclusive sub-group of the total accidents, could be combined in a way to show the estimated contribution of each explanatory factor to the overall change in the total accidents (Newstead et al., 1995). Initially, models were developed and combined for four sub-groups of serious casualty accidents in two regions (Melbourne and country Victoria) and during two times of the week ("high alcohol hours" and "low alcohol hours" - essentially night and day hours). Accidents involving all types of road users were in these sub-groups, but subsequent work (using ten sub-groups) allowed pedestrian, bicycle and motorcycle accidents to be modelled separately and hence included explanatory factors relevant only to each of these types of accident (Gantzer, Newstead & Cameron, 1995). Newstead's method was used to combine the results from the ten sub-groups of accidents in the same way as the models for the four sub-groups. The 'ten sub-group analysis' was able to show the contributions of the road safety programs specifically related to pedestrian, bicycle and motorcycle accidents, whereas the initial analysis could not.

The analysis methods developed in Victoria appear to represent an approach which could be applied to any reasonable disaggregation of total accidents in a jurisdiction. The sub-groups should be chosen because of their specific relationship to road safety programs targeted at the accidents in each sub-group (and perhaps because of relationships with any socio-economic factors specifically relevant to the sub-group). The emphasis should be on appropriate sub-groups for which good explanatory models can be developed (bearing in mind the increased proportional chance variation in accident frequencies as the sub-group becomes smaller), because Newstead's method can be used to combine the results of any number of groups. Models may exist or be sought for only a sub-set of the total accidents in a jurisdiction (eg. accidents on motorways), but there is no barrier to combining the separate models to provide an overall picture at whatever level required. The only barrier appears to be that the models must be multiplicative in form; however a considerable amount of past research has found this to be an appropriate form for road accident series (Hakim et al., 1991; Pettit, 1992; and above Victorian references).
Hakkert & McGann (1996) have defined three broad groups of models of road safety trends, as follows:

*"Macro-models describe the development of the road safety situation on a highly aggregated level, generally using national statistics. The models mostly present a description of the trend over time without pretence of giving any explanation for details of change. Meso-models try, still on an aggregated level, to include some explanatory variables. Micro-models attempt to introduce more explanatory variables and generally treat only a small segment of the overall safety picture."*

The Victorian models in four sub-groups appear to be good examples of meso-models, but the ten sub-group models are perhaps bordering on micro-models. Hakkert & McGann go on to write:

*"A promising direction for future development seems to be the aggregation of many small scale micro-models relating to various aspects and bundling of them into aggregated meso-models. It may eventually become possible to aggregate those one step further, developing macro-models which fit the reality and which might be used for some limited forecasting [at the national level]."*

# 3. Macroscopic models

## 3.1. Aggregated models

The macroscopic model developed by Oppe (1991a; 1991b) for annual trends in road fatalities in The Netherlands and other countries has been well established. It is based on a theory that suggests that societies learn to control the undesirable consequences ('unsafety') of their road transport systems in such a way that exponential learning occurs with time (t), i.e. the number of fatalities (Ft) , in year t, per unit of traffic, (Vt) vehicle kilometres, follows a negative exponential function:

$$Ft / Vt = A\ e^{-Bt} \quad (1)$$

The number of fatalities per se is modelled by multiplying the above function by a separate model for the growth of traffic over time. Oppe (1991a; 1991b) has suggested that traffic grows according to a logistic function with time.

Newstead et al. (1995) considered a variation of Smeed's Law (Smeed, 1968) for a model of annual fatality rates per 10,000 registered motor vehicles in Victoria during 1960 to 1992, a period during which a number of major road safety measures should have led to substantial improvements in the fatality rate. Smeed's Law suggests that, in stable circumstances, the fatality rate is negatively related to the growth in vehicle ownership per head of population. The model of Newstead et al. allowed the level parameter in Smeed's Law to change (decrease) in each of the years during which the major initiatives commenced, but between these years the underlying format of Smeed's Law remained constant.

This approach could also be applied to Oppe's negative exponential relationship for the fatality risk per vehicle kilometre in The Netherlands. The parameter, A, in the above function could be allowed to change in the years when major factors influencing risk commenced. It has been hypothesised that there may have been substantial changes in the following years:
- 1973 ('oil crisis');
- 1974 (maximum speed limits, blood alcohol content limit);
- 1975 (mandatory seat belt use, mandatory moped helmet use);
- 1978 (tachographs for heavy vehicles);
- 1987 (periodic inspection for cars more than three years old, blood alcohol tests replaced with evidential breath tests);
- 1988 (increased maximum speed limit);
- 1990 (administrative adjudication of traffic offenses);
- 1991 (simplified traffic laws);
- 1994 (speed governors for heavy vehicles).

### 3.1.1. *Modified Oppe risk function fitted to annual data*

A modified version of Oppe's negative exponential function for fatality risk was fitted to annual data for The Netherlands for 1950 to 1995 such that step changes in the parameter (A) were initially considered in each of the years

1973, 1974, 1975, 1978, 1988 and 1990. A log-linear model was fitted to the number of fatalities as a function of time (year) and dummy variables initially zero and taking value one from each of the above years, respectively, onwards. The coefficients of time and the dummy variables were estimated in the analysis, but the coefficient of logged travel was constrained to one. SAS was used to fit the model with an over-dispersed Poisson error structure for the fatality counts. The logarithm transformation of the fatalities fitted against (linear) time is essentially the same as fitting the modified exponential function using non-linear techniques, but has the advantage that the fatality count distribution can be more appropriately represented.

When the model was initially fitted, the time variable and three of the dummy variables representing the change years (1974, 1978 and 1988) were statistically significant at the 0.05 level or lower. The coefficients of all four variables were consistent with a decrease in the fatality risk. Each of the three non-significant change years was removed from the model in turn, and the resulting model included the three originally significant change years with stronger levels of significance. The largest coefficients were associated with the years 1974 and 1978. The fatality counts and fitted model (with 95% confidence limits) are shown in *Figure 1*. The step decreases in the model in 1974, 1978 and 1988 can be seen.

*Figure 2* shows the model fitted without any dummy variables representing change during the period. The deviance for this model, divided by the degrees of freedom, was 28.2 compared with 6.6 for the model in *Figure 1*, indicating that the modified exponential model fits the data substantially better than the unmodified model. (The deviance value for the modified model also indicates that still further improvement in the modelling is possible.) Thus there appears to be evidence that changes in the level of fatality risk occurred in The Netherlands in certain years, over and above the on-going reduction in risk to be expected each year from Oppe's negative exponential model. The analysis suggested that substantial reductions in risk occurred in (or around) the years 1974, 1978 and 1988. The factors explaining these changes in risk are not clear, but may include the oil crisis and a number of road safety initiatives taken during the 1970's and 1980's.

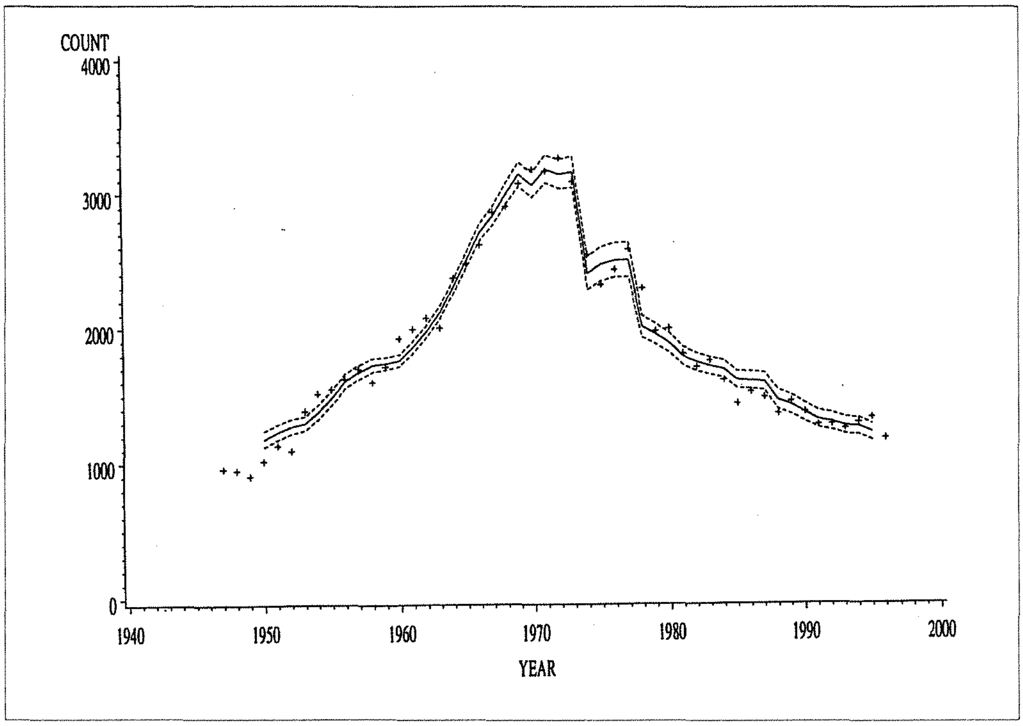


Figure 1. *Annual fatalities in The Netherlands modelled using the modified Oppe risk function with step changes in 1974, 1978 and 1988.*

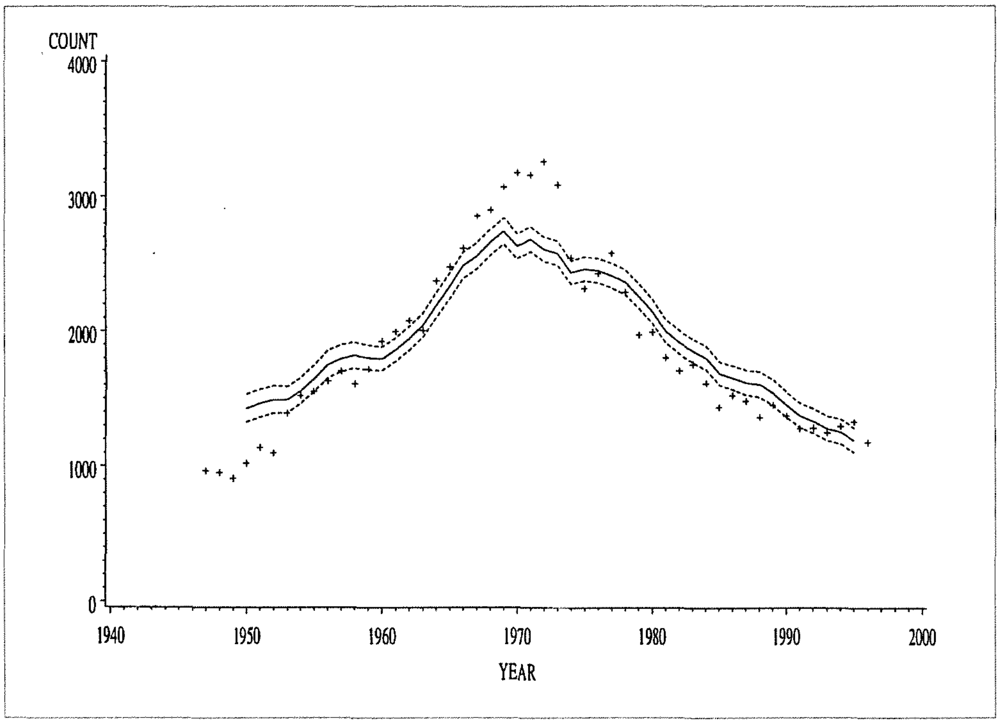


Figure 2. *Annual fatalities in The Netherlands modelled using Oppe's risk function without any step change factors included.*

### 3.1.2. *Data-driven estimation of the step change years*

The analysis described in § 3.1.1 relied on the correctness of the choices of the years in which it was hypothesised that step changes in risk may have occurred. The analysis tested whether there was evidence that a step change from a negative exponential relationship may have occurred in each specific year, and estimated the magnitude and direction of that change.

There was difficulty in choosing the years in which a step change was hypothesised, and the years chosen represented those in which factors potentially responsible for substantial changes in risk came into effect. It would be better if the data itself, without any imposition of external decisions regarding the step change years, could be used to fit a general version of the modified Oppe risk function in which steps could occur in unknown and unspecified years.

Such a model fitting process was attempted over the years 1950 to 1995 by allowing first the possibility of a step in each year and, if this step is statistically significant, including this step in the model specification, then considering the statistical significance of a step in each other year, and so on. If there was evidence of a step one year and a step in the reverse direction in the next year, then the initial step was considered to be not a permanent step and both steps were removed from the model. Through such a procedure it was possible to allow the data to define the years in which there were substantial departures from the Oppe risk function and where a step change needed to be included in the model to represent reality.

A stepwise regression procedure was used to fit this model. A step in each year was allowed to enter the model if the statistical significance level of its contribution was less than 0.2, and was removed from the model if the significance level rose above 0.15. Two years in which the significance level of the step was not less than 0.1 (ie. 1977 and 1978) were subsequently discarded from the model. The final model included steps in 1953, 1960, 1970 (all increases in risk), 1973, 1975, 1979 (all decreases in risk) and 1994 (increase). The fitted model is shown in *Figure 3*. The deviance for this model, divided by its degrees of freedom, was 3.3 indicating that it fits the data even better than the modified Oppe risk function model in § 3.1.1 where the candidate step years were chosen from external considerations.

The data-driven approach indicated both positive and negative step changes in the Oppe risk function, in specific years none of which were the same as expected from a consideration of major changes affecting road safety in The Netherlands. Closer examination of the years chosen by the data is warranted to attempt to determine the underlying factors or programs which may have been responsible for these steps. If factors cannot be found to explain the apparent steps, then it may be appropriate to conclude that one or more steps are spurious outcomes of the method.

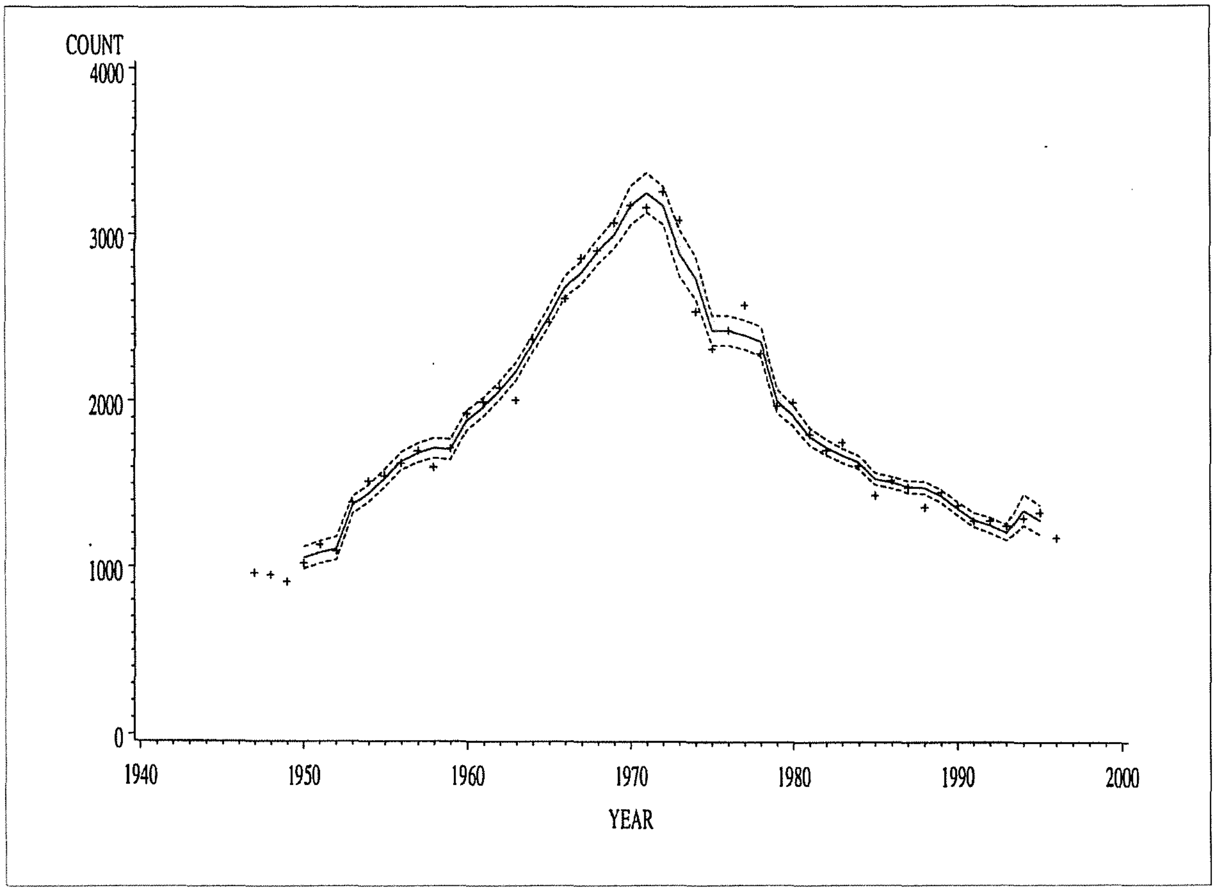


Figure 3. *Annual fatalities in The Netherlands modelled using the modified Oppe risk function with step changes in 1953, 1960, 1970, 1973, 1975, 1979, and 1994.*

### 3.1.3. *Modified Oppe risk function fitted to monthly data*

There is a danger that the close proximity of a number of the years in which major changes occurred in The Netherlands may have presented difficulty for the modified model when fitted to annual data, leading to poor estimates of the step changes (see § 3.1.1). A more sensitive modelling procedure could be achieved if the data were disaggregated into months or quarters. Monthly estimates of motor vehicle travel in The Netherlands are available since 1970. It is proposed that the modified model should be fitted to monthly fatality rates per vehicle kilometre for 1970 to 1995, with step changes in the level parameter in the starting month of each of the above initiatives. In this model there may also be a need to take into account seasonal variation in risk.

## 3.2. **Macroscopic models applied at the disaggregated level**

SWOV has also developed macroscopic models of road casualty trends (fatalities and hospital admissions) at the disaggregated level. The casualties have been disaggregated into road user type and age group. A similar conceptual approach has been used as with the aggregated models covering all types of road users. The number of casualties is modelled in two components: risk (casualties per kilometre travelled) and travel (kilometres travelled by each specific road user type and age group combination).

The risk function is assumed to be a negative exponential function of time in each case.

Travel data is available from the on-going CBS/OVG household travel survey which commenced in 1978. This information apparently suggests that the development of annual travel by motorised vehicles has been a logistic function of time, but that of non-motorised travel was kept constant per road user of each type because no reasonable functional form for the development of their travel trends was apparent (Oppe & Bijleveld, 1996). These functional assumptions have been used to project likely travel growth to the year 2000.

## 3.3. Structural state espace models

More recently, SWOV has been developing structural models in the tradition of Harvey (1989) for the disaggregated series of road casualties. This framework is more general than traditional time-series models which assume fixed parameters and functional forms. The framework can model the fatality, injury and travel series separately but simultaneously. It also has the potential to handle all of the disaggregations simultaneously, allowing a consistent approach to factors common to all series (eg. seasonal patterns in the injuries, trends in travel, etc.), thus avoiding the problem of inconsistencies with the aggregated models when the separate disaggregated models are summed.

SWOV has experimented with the application of structural models to data on fatalities and hospital admissions (two sources: police reports and hospital records) of car occupants aged 25 to 49 at the quarterly level (Bijleveld, 1997). The models appear to be very adaptive to short-term changes in the casualty series and hence appear suitable for short-term forecasting (one to two years). Structural models have the advantage that it is possible to decompose the model into components representing the separate contributions of each term in the model. However, such models are perhaps less suitable for long-term forecasting and the macroscopic models are more suitable for this purpose.

# 4. Explanatory models

## 4.1. Rationale

The macroscopic models described in § 3.1 and § 3.2 appear to be principally aimed at forecasting trends in road casualties in the long-term future (5-15 years). The structural models in § 3.3 are also aimed at forecasting but, because of their ability to adapt to recent changes in trend, will perhaps be more suitable for short-term forecasts (up to about two years). While both of these modelling approaches are based on disaggregations of total road casualties, travel and risk, they do not attempt to offer explanations for past trends (apart from the important role of changes in travel growth) in the same way as the aggregated macroscopic models (Oppe 1991a, 1991b) did not.

The Dutch government has set the following quantitative targets for road safety: a 25% reduction in the number of road deaths and injuries by the year 2000 (compared with 1985 levels) and a further reduction of 50% and 40% in deaths and injuries, respectively, by the year 2010 (Wegman & Goldenbeld, 1996). These targets are very substantial reductions and there will be a need for broad-ranging and effective road safety programs which reduce road casualties in the short-term and maintain the reductions over the medium- to long-term. It has been suggested that large-scale police surveillance programs will need to be implemented in The Netherlands to achieve these targets (Wegman & Goldenbeld, 1996). Experience in Victoria (and elsewhere) suggests that appropriately-structured drink-driving and speeding enforcement programs, supported by high-profile mass media publicity, can achieve 26-29% reductions in serious casualty accidents per annum over periods of at least 4-5 years (Cameron et al., 1994; Cameron, Newstead & Gantzer, 1995). SWOV has estimated that a police surveillance program which aims to increase seat belt use, reduce drink-driving and fine speeders through the use of speed cameras, could reduce road deaths in The Netherlands by 180 per year or approximately 15% (Wegman & Goldenbeld, 1996).

It is important to note that the Dutch road safety targets are reductions in the number of road casualties, not the casualty rate per kilometre of travel. Thus any increase in road travel in future years will make the targets harder to achieve. (Programs which aim to change travel patterns from modes with relatively high risks per kilometre to those with lower risks are perhaps an exception to this rule.) If there is an economic boom in The Netherlands during the next fifteen years, it is likely that motorised travel will increase at a faster rate (currently estimated as 1% per annum, at most, up to the year 2000) and that certain forms of discretionary travel will increase more so. Discretionary motorised travel may include travel at night and by young drivers, both of which are likely to be associated with relatively high risks per kilometre. During an economic boom, increases in alcohol sales per capita may also occur, perhaps resulting in higher levels of drink-driving on the road. It is possible that any such increases in travel, especially relatively large increases in high risk travel, may result in the effective road safety programs planned for implementation in The Netherlands during the next five to fifteen years appearing to be ineffective (or perhaps less effective than they really are) in terms of contributing towards achieving the Dutch road safety targets.

This is because, perhaps to a large extent, the growth in travel may off-set the reduction in casualty accident risk per kilometre due to the effective programs. It may not be sufficient to monitor travel growth (as is currently done at an aggregated level) and simply discount this in assessing the changes in road casualty numbers. Relatively large increases in high risk travel in sub-groups may not be apparent, as may not any increases in the intoxication levels of drivers. For a full understanding of the relative contributions of the road safety programs and other socio-economic factors to the decreases and increases in road casualty levels during the next fifteen years, there will be a need to develop explanatory models. It is envisaged that this type of 'explanation' will be needed at least at times when performance in achieving the road safety targets for the year 2000 and 2010 is being reviewed, and perhaps at key times in the interim.

It has been found in Victoria that, in addition to an exponential trend (perhaps representing regular travel growth under stable circumstances), the explanatory models needed to include a measure of economic activity (unemployment rate) and also an index of alcohol sales in the case of the models of 'high alcohol hour' accidents. It has been suggested that these two factors may represent changes in discretionary travel and the proportion of drivers who were intoxicated. There may be a need to include at least these two socio-economic factors, in addition to aggregated motor vehicle travel and variables representing the future road safety programs, in any explanatory models to be built for The Netherlands. From models with all these factors taken into account, it is expected that the real contribution of the future road safety programs will be seen, including the overall contribution at the national level if the separate models are aggregated using Newstead's method.

## 4.2. Proposed demonstration projects

It was decided in conjunction with SWOV staff that two projects should be considered which would demonstrate the application of explanatory models to the Dutch situation and also be of value in themselves. These projects should cover:

- Casualty accidents in The Netherlands as a whole, based on models for disaggregated parts of the total, as functions of monthly variations in relevant socio-economic factors during 1987-1996.
- Accidents on motorways (including material damage only accidents) subjected to special speed enforcement operations during 1993-1996.

In the first of these proposed demonstration projects, it was considered that casualty accidents, rather than all accidents reported to the police, should be the focus. This was because of the intrinsic importance of road casualties to the Dutch policy-makers (the road safety targets are defined only in terms of reductions in deaths and injuries) and because previous experience in developing jurisdiction-wide models in The Netherlands and in Victoria had been confined to trends in casualties or casualty accidents (or severe sub-sets of these, such as the killed and seriously injured).

However the focus of the second demonstration project was deliberately made broader. This was because the motorways subject to the speed enforcement operations, although carrying substantial volumes of traffic, still experienced relatively small numbers of casualty accidents per week or month. Thus the proportion of chance, and hence unexplainable, variation in the casualty accident frequencies would have been too great to allow satisfactory explanatory models to be developed. Instead, it was proposed that the models would be based on all accidents reported to the Police in this case.

It should also be noted that, at least in the short term, it was considered necessary that the demonstration projects should be based on available data on road accidents registered with the Dutch police, fully recognising that there is substantial under-reporting of accidents to this source. If more complete data on total road casualties and accidents were to become available through the integration of police reports and hospital records, then it is likely that this data would be a better basis for the proposed demonstration projects.

## 4.3. Models for casualty accidents in The Netherlands

Progress in road safety in The Netherlands during the 1990's has been characterised by a relatively constant number of annual fatalities in the range 1,250-1,350 (except for 1,180 in 1996) and a leveling-off of the fatality risk per million motor vehicle kilometres. It is understood that there have not been any major road safety initiatives likely to have had broad-ranging immediate effects during recent decades, especially the last one. In contrast, during the 1970's there were a number of new laws relating to speeding (maximum speed limits: February 1974), alcohol (0.5 pro mill blood alcohol content: November 1974), seat belt use (mandatory in front seats: June 1975) and moped helmet use (mandatory: February 1975). In addition, the oil crisis commenced in 1973 and apparently had an effect on travel and speeds. There may also have been general effects due to the replacement of blood alcohol tests with evidential breath tests (1987), perhaps leading to increased alcohol surveillance, and due to the increase in the maximum speed limits (May 1988), which was accompanied by heavy speed enforcement and massive publicity.

However it is understood that there have been gradual improvements in the road infrastructure and patterns of road use which have led to reductions in road casualty risk, but their effects cannot be expected to be seen as a substantial discontinuity in risk. These factors include the increased use of the relatively safe motorways as a proportion of all travel, rising from about 5% to 33%, and movement away from the relatively unsafe moped and bicycle modes of travel to safer modes.

Notwithstanding the absence of major initiatives with broad-ranging immediate effects during the last decade, it would be valuable to develop explanatory models of road casualties in The Netherlands as functions of relevant socio-economic factors. If this can be done, it would set the scene for the extension of these models to include terms representing the new road safety programs to be introduced during the next 15 years. If a program involves new legislation, then it may be appropriate for the extended models to use a term representing a change in level of the accidents (either long-term or short-term). If the program involves enforcement and/or mass media publicity, then appropriate terms would be monthly measures of the intensity of the enforcement (eg. hours of operation or number of offences detected) or the publicity (eg. total television rating points or number of radio broadcasts). This type of data on each new road safety program will need to be recorded systematically in the future (if it is not already) in order to make the explanatory models ultimately feasible, so far as representing the relative contributions of the programs.

### 4.3.1. *Monthly models and explanatory factors*

At this point in time it is proposed that explanatory models will be developed to represent monthly variations in the number of serious casualties in The Netherlands during the period 1987 to 1996. (Serious casualties were chosen because the most satisfactory Victorian models have been based on this sub-set of casualties, and furthermore it is understood that the monthly numbers of casualties in The Netherlands tend not to vary so much, perhaps due to constraints on police resources for accident reporting.)
The explanatory factors proposed for initial consideration on the basis of monthly data are:

- Travel (kilometres) by mode of transport, from the CBS/OVG daily travel survey.
- Motor vehicle travel outside urban areas, by four regions of The Netherlands, estimated from traffic counts.
- Unemployment rate.
- Gross National Product (GNP).
- Alcohol sales.
- Weather (amount of rainfall, snow and average maximum temperature).
- Trend.
- Seasonality.

It may also be necessary to include a term to represent the effects of the increased maximum speed limit in May 1988. (Residuals from the models should be examined to establish whether any other major traffic management or road safety initiatives during the period should be taken into account, even though little or no effects are anticipated at this stage.)

The trend factor will represent the aggregate effect of a range of factors making positive and negative contributions to the numbers of serious casualties, but changing in such a gradual way that there was insufficient monthly variation to make it feasible for statistical techniques to find any relationships with serious casualties during 1987 to 1996. These factors include:

- Increased proportion of total travel on motorways.
- Changes in travel mode mix away from unsafe modes.
- Changes in the population age distribution, especially the decrease in the proportion of teenagers and young adults.
- Changes in driver licensing rates, including the decrease in numbers of new licences and novice drivers, and the increased rate of licensing among women.
- Other general road and transport infrastructure changes.

These and other factors are embodied in the trend factor. It may be feasible using different analysis methods on data over longer periods to separate the contributions of these factors from the trend. Newstead et al. (1995) were able to separate the effects of a long-term accident black spot treatment program from the trend component of the explanatory models developed in

Victoria, and thus show the relative contribution of that program along side the contributions of the programs which had been explicitly modelled.

### 4.3.2. *Disaggregation of road casualties*

It is proposed that models be sought for road casualties in sub-groups of the total defined by the following factors (in priority order, aiming to balance the specific focus of each model with the number of models needed to be found):

- Road user type (vehicle occupant, motorcyclist, moped rider, bicyclist, pedestrian).
- Urbanisation (urban area, outside urban area).
- Time of day ('high alcohol hours' period, 'low alcohol hours' period - defined as in § 4.3.3).

If successful models are developed for sub-groups, and they are multiplicative in form, then it is proposed that Newstead's method be used to combine them (or at least a meaningful group of them). This analysis would then be expected to show the relative contributions (positive or negative) of each of the socio-economic factors and weather patterns to the changes in road casualties trends in The Netherlands during 1988-1997, compared with the situation in 1987.

It is also possible to disaggregate the road casualties by a number of other important factors which may be better related to the explanatory factors. Alternative sub-groups could be defined by:

- Region of The Netherlands (eg. North, South, East, West).
- Category of road (ie. motorway, other roads outside urban areas, inside urban areas). Speed limit could be used to define these roads in the accident data.
- Age group.
- Sex.

Initially it was decided to disaggregate the data by road user type, urbanisation and time of day (and in practice only the first two factors were used in the analysis described below).

### 4.3.3. *Available data*

Monthly data on all of the potential explanatory factors were available, except that Gross National Product was only available quarterly and alcohol sales only annually (the values in each of these series were used for each month in the respective quarter or year). Monthly data on unemployment rates was not available for 1987, and since this was considered to be potentially a key explanatory factor, all of the analysis was based on data from January 1988 to December 1996.

Estimates of motor vehicle travel outside urban areas were available in index form (from two different base years) for each of four regions. The indexes were brought to a common year basis (1980=100) and the four regional indexes were averaged. *Figure 4* shows a comparison of this data (rescaled to 10,000 in 1980) against the motor vehicle travel estimates (all areas) obtained from the daily travel survey. While the two series are not directly comparable because they cover different areas, the absence of the regular seasonal pattern seen in the traffic count estimates, so far as the travel survey estimates are concerned, casts some doubt on the reliability of the monthly variation in the survey estimates.

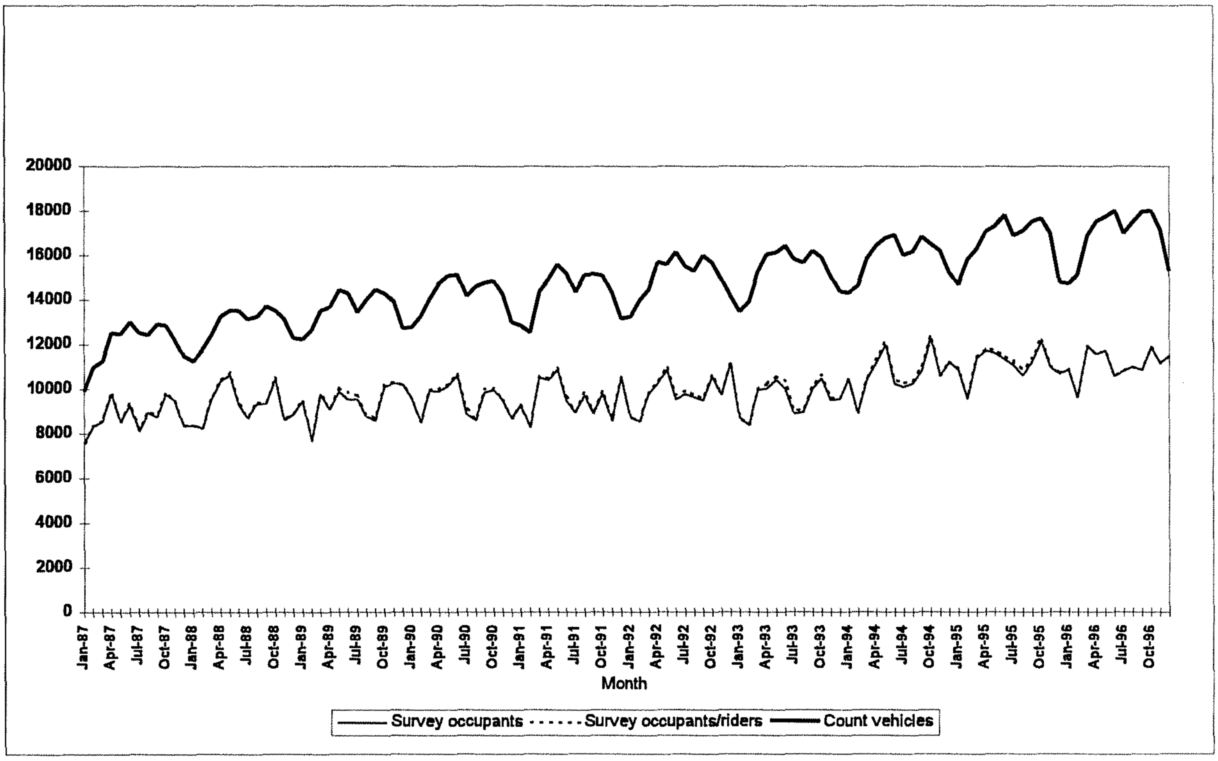


Figure 4. *Comparison of motor vehicle travel estimates from CBS/OVG survey (NL) and traffic counts (outside urban areas).*

The casualties were grouped into two periods of the week on the basis of an analysis of alcohol presence for killed and hospitalised casualties from accidents in six hour periods during 1996 provided by SWOV (Mathijssen, personal communication). The 'high alcohol hours' were defined as those where alcohol was present in at least 5% of the casualties during each six hour period, and are listed below:

- Monday 22.00 to 03.59 Tuesday
- Tuesday 16.00 to 03.59 Wednesday
- Wednesday 22.00 to 03.59 Thursday
- Thursday 16.00 to 09.59 Friday
- Friday 16.00 to 09.59 Saturday
- Saturday 16.00 to 09.59 Sunday
- Sunday 16.00 to 03.59 Monday

However, the absence of alcohol sales data at a monthly or quarterly level led to the decision not to attempt to model the serious casualties disaggregated by time of day. However, 'alcohol sales' was found to be a strong predictor of variations in high alcohol hour serious casualty accidents in Victoria, and if monthly or quarterly alcohol sales data become available for The Netherlands, this decision should be revisited.

### 4.3.4. *Preliminary analysis*

Pearson correlation coefficients were calculated between each pair of variables to be considered in the modelling, including the monthly numbers of serious casualties by road user type and urbanisation, and also for each of the potential explanatory factors (excluding the traffic count-based motor vehicle travel estimates outside urban areas). Notable significant correlations were:

- Positive correlations between number of casualties and monthly travel, for motorcyclists, moped riders and bicyclists, but not for motor vehicle occupants, and a negative correlation of the same type for pedestrians.
- Motor vehicle occupant travel and pedestrian travel both strongly and positively correlated with GNP.
- Bicycle, motorcycle and (to a lesser extent) moped travel strongly positively correlated with temperature.
- Unemployment rate positively correlated with GNP, and alcohol sales strongly negatively correlated with GNP - the opposite of what had been found in Victoria in each case.

### 4.3.5. *Monthly casualties modelled against explanatory variables*

Following experience in Victoria and elsewhere, a multiplicative model was sought for each series of serious casualties, by type of road user, as a function of the available explanatory variables. The models were fitted after logarithm transformations of the casualty series and some explanatory variables. Since the average number of rainy days in the month and the average temperature took zero and negative values, respectively, constants of 0.01 and 5 were added to the respective series before transformation (these values were arbitrarily chosen).

The trend was represented by a simple increasing count (effectively an exponential trend for the casualties before transformation) and the regular monthly variation was represented by eleven dummy zero-one variables.

The SAS GENMOD procedure was used to fit a log-linear model with an over-dispersed Poisson error structure for the serious casualty counts. The output produces the estimated regression coefficient of each of the logged explanatory variables (ie. the coefficients are estimated "elasticities") and of the trend and each monthly dummy variable. A test of the significance of each variable (if it entered the model after all other variables were already present) is also provided. The significant variables ($p < 0.15$) in each of the initial models are shown in *Table 1.*

The absence of a statistically significant contribution of the travel estimate (based on household surveys) to the monthly variations in the serious casualties of most road user groups, excepting moped riders and bicyclists, was surprising given previous SWOV research which had displayed a fundamental link between travel and road deaths, at least on an annual basis.

| Road user type<br>Explanatory variable | Estimated coefficient | Chi-square (d.f.) | Significance level |
|---|---|---|---|
| *Motor vehicle occupants* | | | |
| Trend | - 0.0038 | 2.61 (1 df) | 0.1061 |
| Month | [11 coeffs.] | 16.71 (11 df) | 0.0735 |
| Unemployment rate (logged) | 0.2152 | 3.27 (1 df) | 0.0708 |
| No. of rain days (logged) | 0.0153 | 5.03 (1 df) | 0.0249 |
| *Motorcyclists* | | | |
| Trend | 0.0099 | 4.14 (1 df) | 0.0420 |
| Month | [11 coeffs.] | 76.66 (11 df) | 0.0000 |
| Alcohol sales (logged) | -3.5867 | 3.95 (1 df) | 0.0470 |
| GNP (logged) | -3.4519 | 2.20 (1 df) | 0.1382 |
| No. of rain days (logged) | -0.0344 | 3.89 (1 df) | 0.0485 |
| Temperature (logged) | 0.9491 | 37.57 (1 df) | 0.0000 |
| *Moped riders* | | | |
| Trend | -0.0097 | 8.02 (1 df) | 0.0046 |
| Month | [11 coeffs.] | 50.38 (11 df) | 0.0000 |
| Unemployment rate (logged) | 0.5915 | 14.11 (1 df) | 0.0002 |
| Alcohol sales (logged) | 5.2894 | 17.11 (1 df) | 0.0000 |
| GNP (logged) | 4.3933 | 6.80 (1 df) | 0.0091 |
| No. of rain days (logged) | -0.0248 | 6.07 (1 df) | 0.0137 |
| Temperature (logged) | 0.3960 | 22.35 (1 df) | 0.0000 |
| Moped travel (logged) | 0.0721 | 2.37 (1 df) | 0.1235 |
| *Bicyclists* | | | |
| Trend | -0.0114 | 19.40 (1 df) | 0.0000 |
| Month | [11 coeffs.] | 48.41 (11 df) | 0.0000 |
| Unemployment rate (logged) | 0.2337 | 3.84 (1 df) | 0.0500 |
| GNP (logged) | 3.7829 | 8.67 (1 df) | 0.0032 |
| Temperature (logged) | 0.2997 | 20.76 (1 df) | 0.0000 |
| Bicycle travel (logged) | 0.3822 | 11.35 (1 df) | 0.0008 |
| *Pedestrians* | | | |
| Trend | -0.0058 | 3.40 (1 df) | 0.0651 |
| Month | [11 coeffs.] | 66.62 (11 df) | 0.0000 |
| Temperature (logged) | 0.1944 | 9.05 (1 df) | 0.0026 |

Table 1. *Statistically significant variables in the log-linear models of monthly serious casualties as a function of explanatory variables, by road user type.*

Because of prior concern about the reliability of the monthly travel estimates based on the surveys (see § 4.3.3), it was decided to re-examine the models in two ways:

1. Making use of the traffic count-based estimates of motor vehicle travel outside urban areas as a potential explanatory factor for the monthly

serious casualties of vehicle occupants in accidents outside urban areas (§ 4.3.6 below)

2. Attempting to develop models on the basis of pooled quarterly data on the serious casualties in each road user group and on the explanatory variables used above, including the survey-based travel estimates for each quarter (§ 4.3.7 below)

### 4.3.6. *Modelling using motor vehicle travel estimated from traffic counts*

A model of monthly serious casualties of motor vehicle occupants and motorcycle riders involved in accidents outside urban areas, was fitted to the same explanatory variables used in § 4.3.5, except that the travel estimates were an index series based on traffic counts (covering all forms of motor vehicle). The travel estimate was not statistically significant in this model. The only significant variable apparently related to these casualties was unemployment rate, with an estimated coefficient of 0.1761 and significance level, $p = 0.1347$.

Thus the potentially more reliable estimate of travel based on traffic counts did not appear to offer any greater explanatory value regarding monthly variation in motor vehicle occupant and motorcycle rider casualties outside urban areas than did the survey-based travel estimates for these road users.

### 4.3.7. *Quarterly casualties modelled against explanatory variables*

The analysis in § 4.3.5 and § 4.3.6 was repeated after pooling the data into quarters, by either summing the values or averaging them as appropriate. The trend was represented by a simple count variable for each quarter and the quarterly variation was represented by three zero-one dummy variables. The results of the modelling of the quarterly casualties are shown in *Table 2*.

| Road user type<br>Explanatory variable | Estimated coefficient | Chi-square (d.f.) | Significance level |
|---|---|---|---|
| *Motor vehicle occupants*<br>No statistically significant ($p < 0.15$) variables included in the model | | | |
| *Motorcyclists* | | | |
| Trend | 0.0356 | 4.48 (1 df) | 0.0344 |
| Quarter | [3 coeffs.] | 30.23 (3 df) | 0.0000 |
| Unemployment rate (logged) | -0.3708 | 2.28 (1 df) | 0.1310 |
| Alcohol sales (logged) | -3.5743 | 2.92 (1 df) | 0.0873 |
| GNP (logged) | -4.2938 | 2.52 (1 df) | 0.1125 |
| Temperature (logged) | 1.1329 | 13.28 (1 df) | 0.0003 |
| *Motor vehicle occupants & motorcycle riders outside urban areas* *<br>No statistically significant ($p < 0.15$) variables included in the model | | | |
| *Moped riders* | | | |
| Trend | -0.0316 | 4.02 (1 df) | 0.0450 |
| Quarter | [3 coeffs.] | 8.32 (3 df) | 0.0399 |
| Unemployment rate (logged) | 0.6384 | 7.22 (1 df) | 0.0072 |
| Alcohol sales (logged) | 4.3483 | 5.05 (1 df) | 0.0246 |

| Road user type<br>Explanatory variable | Estimated coefficient | Chi-square (d.f.) | Significance level |
|---|---|---|---|
| GNP (logged) | 4.3254 | 2.87 (1 df) | 0.0905 |
| No. of rain days (logged) | -0.0923 | 3.86 (1 df) | 0.0495 |
| Temperature (logged) | 0.4854 | 5.28 (1 df) | 0.0216 |
| *Bicyclists* | | | |
| Trend | -0.0360 | 9.80 (1 df) | 0.0017 |
| Quarter | [3 coeffs.] | 7.69 (3 df) | 0.0528 |
| Unemployment rate (logged) | 0.2895 | 2.61 (1 df) | 0.1060 |
| GNP (logged) | 4.2959 | 4.97 (1 df) | 0.0258 |
| Temperature (logged) | 0.4706 | 6.37 (1 df) | 0.0116 |
| *Pedestrians* | | | |
| Trend | -0.0270 | 5.46 (1 df) | 0.0195 |
| Quarter | [3 coeffs.] | 13.27 (3 df) | 0.0041 |
| Unemployment rate (logged) | 0.5321 | 4.91 (1 df) | 0.0268 |
| GNP (logged) | 3.3786 | 2.41 (1 df) | 0.1207 |
| Temperature (logged) | 0.1989 | 2.56 (1 df) | 0.1097 |
| Pedestrian travel (logged) | -0.7351 | 5.79 (1 df) | 0.0161 |
| * Using travel estimates based on traffic counts (covering all forms of motor vehicle) | | | |

Table 2. *Statistically significant variables in the log-linear models of quarterly serious casualties as a function of explanatory variables, by road user type.*

In the quarterly analysis, only the monthly pedestrian travel was apparently a statistically significant contributor to monthly variation in (pedestrian) casualties, but its sign was negative and this was counter-intuitive. In general, the apparent contribution of the travel estimates to the casualty variation was weaker at the quarterly level than at the monthly.

### 4.3.8. *Modelling giving priority to travel as an explanatory variable*

The simple correlation analysis had found positive correlations between number of casualties and monthly travel, for motorcyclists, moped riders and bicyclists (§ 4.3.4). It was considered that the travel estimates offer a fundamental explanation for variations in road casualties and that they should be given priority for inclusion. It was suggested that the general exclusion of the travel estimates from the final models shown in *Table 1* and *Table 2* (especially the quarterly models) may be partly artefactual due to the relatively high correlations of some of the other explanatory variables with the travel estimates.

The analyses leading to the models in *Table 1* and *Table 2* were repeated in a stepwise format in which the variables were allowed to enter the model in the following set order (and order within the sets):

1. Travel estimate for the specific road user group (survey-based figures).

2. Socio-economic variables:
- GNP [generally the strongest socio-economic variable previously].
- Unemployment rate [the second strongest variable].
- Alcohol sales [the weakest, perhaps due to only annual data being available].

3. Weather variables:
- Temperature [generally the strongest weather variable previously].
- Number of rainy days [the weaker weather variable previously].

4. Systematic variables:
- Trend.
- Seasonality (monthly or quarterly dummies, depending on the data modelled).

The significance of the contribution of each of these factors, *after* the contribution of all other factors higher on the list when they have been entered into the model, can be tested by the reduction in the unexplained variation in the monthly casualties. The significance levels for each factor, for each road user group model, are shown in *Table 3* and *Table 4*.

| Explanatory variable | Motor vehicle occupants | Motorcycle riders | Occupants and riders outside urban areas | Moped riders | Bicyclists | Pedestrians |
|---|---|---|---|---|---|---|
| Travel | 0.5426 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | | | | | |
| GNP | 0.0008 | 0.2921 | 0.0073 | 0.0000 | 0.0000 | 0.0000 |
| Unemp. rate | 0.1870 | 0.0136 | 0.3998 | 0.1312 | 0.0038 | 0.1586 |
| Alcohol sales | 0.3226 | 0.0979 | 0.6313 | 0.0000 | 0.0013 | 0.0000 |
| | | | | | | |
| Temperature | 0.3267 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0032 |
| Rain days | 0.0004 | 0.0000 | 0.8119 | 0.1144 | 0.0493 | 0.1514 |
| | | | | | | |
| Trend | 0.0331 | 0.0001 | 0.7321 | 0.0019 | 0.0000 | 0.0000 |
| Month | 0.1169 | 0.0000 | 0.3450 | 0.0000 | 0.0000 | 0.0000 |

Table 3. *Statistical significance level of each explanatory variable when introduced into the log-linear models of* monthly *serious casualties.*

*Table 3*, read in conjunction with *Table 1* (which shows the significant variables in a model with all variables entered), shows the incremental contribution of each variable towards explaining the variation in monthly casualties. With the exception of motor vehicle occupants (all areas), the travel estimates initially offered significant explanation in the absence of other explanatory variables. At least one of the socio-economic variables offered further significant explanation, as did at least one of the weather variables after travel and the socio-economic variables had been included. With the exception of the casualties to motor vehicle occupants and motor-cycle riders outside urban areas, the systematic variables representing trend and seasonality offered even further significant explanation. The net result of the contributions of these latterly entered variables, was that travel retained a significant explanatory role only in the cases of moped riders and bicyclists (see *Table 1*).

| Explanatory variable | Motor vehicle occupants | Motorcycle riders | Occupants and riders outside urban areas | Moped riders | Bicyclists | Pedestrians |
|---|---|---|---|---|---|---|
| Travel | 0.6820 | 0.0000 | 0.0003 | 0.0000 | 0.0000 | 0.0000 |
| | | | | | | |
| GNP | 0.0373 | 0.3948 | 0.0299 | 0.0165 | 0.0000 | 0.0000 |
| Unemp. rate | 0.3312 | 0.3203 | 0.4738 | 0.3733 | 0.0487 | 0.4570 |
| Alcohol sales | 0.3493 | 0.6942 | 0.5831 | 0.0007 | 0.0172 | 0.0000 |
| | | | | | | |
| Temperature | 0.3410 | 0.0000 | 0.0514 | 0.0000 | 0.0004 | 0.0000 |
| Rain days | 0.1859 | 0.0001 | 0.8108 | 0.7403 | 0.6354 | 0.2518 |
| | | | | | | |
| Trend | 0.0851 | 0.0017 | 0.7053 | 0.0047 | 0.0000 | 0.0000 |
| Month | 0.6669 | 0.0000 | 0.9513 | 0.0399 | 0.0528 | 0.0041 |

Table 4. *Statistical significance level of each explanatory variable when introduced into the log-linear models of* quarterly *serious casualties.*

Similar findings were apparent in the quarterly analysis when the incremental contribution of each of the explanatory variables (*Table 4*) was compared with their significance when all variables were considered (*Table 2*). However the explanatory contribution of the socio-economic and weather variables to the casualties of motor vehicle occupants (with and without motorcyclist casualties added) appeared to be less for their quarterly series of data compared with the monthly series. For these casualties, when all the explanatory variables were considered together, no one variable was significant (*Table 2*), but *Table 4* indicates that some variables offered significant explanatory contribution when they were first added to the model.

This tends to indicate that the models may be over-specified. It is possible that the socio-economic variables as a set may each be measuring related social variations in The Netherlands. There could also be a relationship between these socio-economic variations and variations in the amount of monthly travel in each of the modes. Weather variations, over and above normal seasonal fluctuations, may lead to different variations in economic conditions and hence also in the travel patterns which result from these conditions. There is a case for a closer examination of the inter-relationships between the explanatory variables considered in this study, and their potential for providing redundant information about the underlying factors with affect monthly and quarterly levels of serious casualties. When these relationships are better understood, there would be a case for re-examining the explanatory models given here and developing new models based on a more parsimonious set of explanatory variables.

## 4.4. Models for accidents on motorways

It is understood that a program of special speed enforcement was carried out on selected motorways in the central part of The Netherlands, mainly on the A2 between Amsterdam and s'Hertogenbosch, during 1993-1996.
The program was accompanied by public information campaigns, mainly through radio broadcasts, specifying the day, time and location of the enforcement operations. There were also warning signs indicating that special enforcement may be operating on the motorway.

A fuller description of the program has yet to be obtained. The following information is available describing the enforcement operations and public information during each day of the program:
- Number of vehicles exceeding speed limit (above the margin of 7 km/h at which a penalty is administered).
- Number of vehicles passing each enforcement site.
- Hours spent on speed enforcement, by type of enforcement operation.
- Date and time of the radio broadcasts.
- Locations and installation periods of the warning signs.

In addition, there is information on travel speeds on these and other motorways, from a continuous national survey covering at least eighty sites. It is understood that this information can be used to define periods when the motorways are congested or not. (The effects of the speed enforcement under congested conditions could be expected to be marginal and this should be taken into account in the analysis.)

It is proposed that models be sought for the weekly number of reported accidents on the enforced motorways during the period 1991-1996 (allowing three years' data before the program commenced to assist the model fitting). Appropriate sub-groups of the accidents should be defined when a fuller description of the program is available, but it is expected that separate models should be sought by:
- Time of day (day, night).
- Congestion condition (congested, not congested).
- Specific motorway (if the type of traffic on each varies considerably).

It is understood that the police have aimed to have a general effect on the speeds (and related accidents) along essentially the full length of each motorway included in the program, by operating almost continuous surveillance and supporting this with daily publicity. Immediate local effects on speeds at the surveillance sites are unlikely, because the speed cameras were operated covertly and the publicity did not announce the specific locations of the cameras. When the speeding fines were received by the offending drivers some 2-3 weeks later, some local effects at the camera site may have occurred but not greatly different from the general effect.

Against this background of the likely mechanism of the effect, it is proposed that the analysis unit be the number of reported accidents each week on the full length of each motorway. The objective should be to model the weekly variations in these accidents during 1991-1996 as a function of explanatory factors which measure variations in the key elements of the program (see below). The role of analysis of accidents on the motorways not included in the program are of secondary importance in achieving this objective. If, however, there is also an objective of reaching more definitive conclusions about cause-and-effect of any reduction in accidents on the enforced motorways, then a parallel analysis of the non-enforced motorways should be included.

The explanatory factors to be considered as weekly data are expected to be:

- Amount of passing traffic (as a measure of exposure).
- Hours of enforcement, for each type of enforcement.
- Number of drivers fined for speeding (speeding above the margin).
- Number of radio broadcasts which could be received in the region of the motorway.
- Number of warning signs operating on the motorway.

As in § 4.3, if successful models are developed in multiplicative form, then Newstead's method will be used to combine them to provide an overall view of the relative contributions of the enforcement operations (by type) and the public information activities to (any) changes in accidents on the motorways, relative to a period before the enforcement commenced.

# 5. Recommendations for further work

In this review report a number of issues has arisen which form the basis of recommendations for further work in the area of modelling of road casualties in The Netherlands (not necessarily in priority order). It is recommended that:

1. Explanations for the step increases and decreases in fatality risk per kilometre during specific years, which were found through the data-driven fit of a modified version of the Oppe risk function, be sought.

2. The modified Oppe risk function be fitted to monthly data, so that a number of major changes in the 1970's and 1980's can be better separated in time and the significance of their individual step changes can be better estimated. If possible, a data-driven analysis of the monthly data should be attempted.

3. In order to monitor specific casualty trends for safety management and evaluation, work on structural models at the disaggregated level should be continued because of its potential to provide a global and parsimonious framework which current modelling approaches, modelling each sub-group of casualties independently, cannot achieve.

4. Work on the development of explanatory models for trends in serious casualties in The Netherlands during the last decade should be continued along the following lines:
   - Additional explanatory variables should be sought to represent the road safety initiatives taken in The Netherlands and other important safety-related social changes, with a view to incorporating them in the models and thus allowing their influences on the overall safety situation to be seen.
   - The inter-relationships between the current set of explanatory variables should be closely examined with a view to eliminating any which provide redundant information and/or replacing them with variables which offer independent explanatory value.
   - Efforts should be made to obtain alcohol sales data at a monthly or quarterly level so that this key variable has an opportunity to explain variations in "high alcohol hour" serious casualties.
   - Estimates of motor vehicle travel for inside urban areas at a monthly or quarterly should be obtained (or estimated from current data, if appropriate) so that this data has an opportunity to explain variations in serious casualties in these areas.
   - Modelling of a similar type to that described in this report, preferably after the re-examination of the current explanatory variables, should be attempted for serious casualties which have been further disaggregated by urbanisation (inside urban areas v. outside urban areas) and time of day ('high alcohol hours' vs. 'low alcohol hours').

5. Newstead's method should be used to combine the explanatory models, either in their current form or after further development, to determine the relative contribution of each of the key explanatory factors to changes in total serious casualties in The Netherlands each year since 1988.

6. The proposed study aiming to develop models of accidents on motorways, as functions of enforcement and publicity levels, should proceed because of its intrinsic value and because of its ability to better illustrate the value of explanatory modelling in showing the relative contributions of the program components to any reductions in accidents.

7. If more complete data on total road casualties and accidents should become available through the integration of police reports and hospital records, then this data should be used as the basis of the modelling projects outlined in this report and any further work to be carried out as recommended in (4) and (6) above.

8. Due to the absence of a regular seasonal pattern in the CBS/OVG travel survey, estimates of monthly motor vehicle travel in The Netherlands, compared with the pattern seen in the estimates based on traffic counts (albeit only on roads outside urban areas), further research on the reliability of the data obtained from the travel survey should be undertaken.

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