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Fatal Crashes Involving Young Male Drivers: A Continuous Time Poisson Change-Point Analysis

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Abstract

Background: In an effort to reduce road trauma, the New Zealand government implemented a series of intervention programs over the last decade, with young male drivers as the main target audience. Previous research, however, found little or no evidence that these programs had any impact on this group of drivers despite an apparent decrease in their crash involvement.

Objective: To determine the approximate time when the decrease in the number of fatal crashes involving young male drivers occurred.

Method: A Poisson change-point estimator was used to locate the most likely point where a decrease in the average number of monthly crashes had occurred.

Results: The most likely time of change was found to coincide with the time when the Transport Act of 1992 was debated and passed in parliament. The publicity given to the issue and the government's signal of impending actions were sufficient to induce a significant change in the behaviours of young male drivers.

Implications: This result can partially reconcile the difference between the apparent reduction in the number of fatal crashes involving young male drivers and the inability of previous studies in finding a significant impact of the various intervention programs since the change occurred prior to the actual implementation of the programs. Nevertheless, it was argued that the implementation of the programs subsequently was necessary in sustaining the reduction.

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Introduction

Road crashes have been a worldwide public health and safety concern for several decades and despite the apparent success in reducing the number of fatal crashes in general, crashes involving young male drivers continue to be a major social problem.[1] Of particular concerns are the crash risks associated with speed and alcohol. In New Zealand, for example, males aged between 18 and 30 were involved in 50% of the drink driving crashes in 1995 and of these, the 18-21 year olds were predominant.[2] Similarly, 80% of all speeding drivers were male with the worst offenders in the 18-21 year age bracket.[2]

In an effort to reduce the road trauma, the New Zealand government amended the Transport Act in December 1992 to allow for a program of stronger interventions to be implemented. It also allocated a budget of more than NZ$50 million to support the Supplementary Road Safety Package (SRSP) that was targeted at this group of risky drivers.[2] First, Compulsory Breath Testing (CBT) was introduced in April 1993. Second, the speed camera program went into operation in October 1993. Last, in October 1995, the Land Transport Safety Authority (LTSA) began telecasting a series of hard-hitting advertisements to supplement the enforcement efforts. The increases in police enforcement were made possible by an increase in the budget of NZ$5.1 million per year under the SRSP that also allocated $7.1 million per year for the publicity campaign on speed and alcohol.[2]

Besides the substantial budget involved, these programs also attracted much attention in both the media and academia because of the ethical concerns relating to the use of fear-based publicity campaigns, the revenue-raising purpose of the programs, and more importantly, the effectiveness of the programs.[3] Despite the apparent decrease in the number of fatal crashes involving young male drivers, previous research found little or no evidence that these programs had any impact on this group of drivers.[4] This paper will add to the current knowledge by finding the most likely point where a decrease in the average number of monthly crashes had occurred and to reconcile the difference between the result of previous studies and observed data.

Method

In contrast to the conventional approach where structural change is imposed on the model and tested, the technique of 'continuous time estimation of a change point for a Poisson process' will let the data determine when a significant change in the time-series occurs. This approach is particularly useful where a series of intervention programs are announced to the public, debated, passed by the legislative bodies or sanctioned by policy-makers and subsequently implemented at different but relatively close intervals. Besides the difficulties in defining when or what to test, the number and closeness of the intervention variables may frustrate any effort in trying to disentangle them. Knowing when the change point is will provide some directions to disentangle the confounding effects of the various steps in the programs.

Since the crash data used is more likely to be Poisson distributed,[5,6] the Poisson change point estimator[7] is selected for this analysis instead of several other recent developments that are based on other types of distribution.[8,9] The disadvantage of this method is that it locates only one change-point. However, this restriction is not as important if the objective is to find out if and when a significant reduction in crashes began in a time series. Last but most important, the software is available without cost to other applied researchers.[10]

The Poisson distribution assumes that the number of occurrences of an event during a given time interval satisfy three criteria. First, the probability of more than one success in a very short interval is negligible. Second, the probability of an occurrence in a short time interval is proportional to the length of the time interval. Last, the number of occurrences in non-overlapping time intervals are independent.[11] The Poisson distribution is therefore widely used to model count data (0,1,2,...,N) which are discrete and non-negative, especially when the numbers are small, such as the number of fatal accidents per month.

The conceptual framework underlying most Poisson change-point estimators used is quite simple. Suppose a series of data, $x_1, x_2, ..., x_T$, are observed in T time periods and the data can be described by a Poisson distribution. Further, suppose that a change in the distribution occurred at time $t = \tau$ such that the mean of the distribution changed from λ_1 to λ_2. Let $L(\lambda_1, \lambda_2, \tau \mid x_1, ..., x_T)$ be the likelihood or probability function for the unknown parameters given the sample of data observed. The estimates for λ_1, λ_2 and τ will be chosen to maximise this probability.

Since the likelihood function over τ is not smooth, the usual Normal (bell-curve) theory may not be applied to the maximum likelihood estimator for asymptotic interval estimates.[7] As a result, interval estimation usually involves complex procedures that are based on some additional conditions and are thus beyond the scope of this paper. More importantly, the point estimator used is sufficient to achieve the purpose of this paper since it provides valuable information on the approximate time when a change is most likely to have occurred. Readers who are interested in interval estimates are encouraged to follow up on the references provided.[7,8,9,12,13]

Results

Figure 1 shows the number of fatal crashes per month in New Zealand, between January 1990 and December 1997, that involved at least one male driver under the age of 25. The change-point was estimated to be around December 1992, the mean crash rate before the change was estimated to be 19.51 and corresponding rate after the change was estimated to be 13.77 fatal crashes per month. This decrease translates into a 29.42% decrease in the average number of fatal crashes per month that involve a young male driver.

Discussion and Conclusion

Despite the success in reducing fatality on the road in many countries, significant concerns remain regarding the resistance of young male drivers to most intervention programs. For example, using monthly data from January 1988 to December 1996, an earlier study estimated several Poisson regression models for drivers of different sex and age groups in New Zealand.[4] The study found that neither the implementation of the CBT, speed camera or advertising campaign had any significant impact on the number of speed and alcohol related fatal crashes involving male drivers aged 24 and below. The programs, nevertheless, had significant but different effects on other drivers including females aged between 25 and 34 years old, males aged between 25 and 34 years old and males aged between 35 and 54.

This study, however, found that the same series of intervention programs implemented in the last decade was effective in reducing the number of fatal crashes involving young male drivers in New Zealand. This problem is therefore not as intractable as many transport policy makers thought would be. More importantly, this study found that the change in the crash rates had most likely begun when the Amendments to the Transport Act were debated and passed in parliament. This result indicates that the publicity given to the issue and the government's signal of impending actions were sufficient to induce a significant change in the behaviours of young male drivers. Nevertheless, the ability to sustain the change would depend, to a large extent, on the actual implementation of the interventions proposed.

This result can partially reconcile the difference between the apparent reduction in the number of fatal crashes involving young male drivers and the inability of previous studies in finding a significant impact of the various intervention programs. Since the reduction in road crashes began much earlier, the actual implementation of the various road safety programs had not resulted in any significant reduction despite its importance in maintaining that reduction.

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Figure 1:
Fatal Crashes Involving Young Male Drivers