The Epidemiology of Traffic Accidents and the Effect of the 1969 Breathalyser Law in Canada

Larry W. Chambers, Robin S. Roberts and Cameron C. Voelker.

The Canadian public is becoming 'hardened' to highway deaths and injuries ubiquitous in our society. In 1971, 5616 deaths were attributed to this cause (7), representing the fourth most common cause of death, following heart disease, cancer and cerebrovascular disease. Unlike the first three causes, motor vehicle traffic accidents seem targeted at Canadians with the greatest number of years ahead of them. That is, traffic deaths and injuries occur most frequently in younger age groups (7). Many Canadians felt our neighbours to the south demonstrated a 'hardness' towards death and injuries of their younger people in a remote Far Eastern War in the 1960s. The Canadian public seems to be demonstrating a similar insensitivity to proportionally even greater numbers of deaths and injuries occurring on Canadian highways (6,7,8).

Attempts to reduce the carnage caused by traffic accidents have concentrated on the legislative approach through the compulsory addition of certain safety features in automobiles (for example, seat belts), the introduction of more stringent penalties for driving offences, and, in particular, amendments to Canada's Criminal Code regarding impaired driving. The basic Criminal Code Sections related to impaired driving are Section 234, which prohibits "Driving while ability to drive is impaired", Section 235, "Failure or refusal to provide sample of breath where (there exists a) reasonable belief of commission of offence under Section 234", and Section 236, "Driving with more than 80 mgs of alcohol (per 100 millilitres) in blood". Other sections clarify technicalities and terminological intent of these three. Section 236 only came into effect in 1969 (1). This amendment gave the police power to arrest a driver on the basis of a positive breathalyser test, or for refusal to submit to such a test. The list of measures adopted to curb motor vehicle accidents will grow over time as will the need to assess their effectiveness.

This paper describes an epidemiologic approach to evaluating accident prevention programmes and uses the breathalyser amendment, Section 236, as a model application. Its prime objective is not to state categorically the level of success or

1Division of Community Medicine, Faculty of Medicine, Memorial University of Newfoundland, St. John's, Newfoundland, Canada.

21968 was the worst year for the United States in the Vietnamese War as 14,592 Americans were killed that year in Vietnam. This represents a death rate of approximately 7 per 100,000 (the 1968 United States population was 200,619,000). In 1971, there were 5616 deaths from traffic accidents in Canada representing a death rate of approximately 26 per 100,000 (the 1971 Canadian population was 21,568,310).
failure of the breathalyser in reducing traffic accidents for too short a period has elapsed since its introduction to permit an unequivocal answer. Rather, the purpose of this paper is to suggest an appropriate epidemiologic evaluation, in contrast to more traditional methods, that permits an on-going assessment of the effectiveness of this or other innovations in traffic safety.

EPIDEMIOLOGIC EVALUATION OF TRAFFIC ACCIDENTS

Indices used to assess the effect of traffic accident prevention programmes must be designed to gage accurately the change between periods before and after the introduction of a programme. The relevance of before/after comparisons is dependent upon the appropriateness of the health outcomes chosen and measured by such indices.

In the present analysis, the classic epidemiologic measures of disease frequency, incidence rate, mortality (or death) rate, and case fatality rate, are used as indices to assess a traffic safety innovation’s total impact on the health of a community. These rates are defined as follows: Incidence Rate is the total number of deaths and injuries from motor vehicle traffic accidents over a specific period of time divided by the population of the community at risk during the same period of time; Mortality Rate is the total number of deaths from motor vehicle traffic accidents over a specific period of time divided by the population of the community at risk during the same period of time; and, Case Fatality Rate is equal to the total number of deaths from motor vehicle traffic accidents over a specific period of time divided by the total number of injuries and deaths from motor vehicle traffic accidents during that same period of time (Figure 1) (2).

TOTAL NUMBER OF DEATHS AND INJURIES FROM MOTOR VEHICLE TRAFFIC ACCIDENTS OVER A SPECIFIC PERIOD OF TIME

INCIDENCE RATE = -----------------------------
THE POPULATION OF THE COMMUNITY AT RISK DURING THE SAME PERIOD OF TIME

TOTAL NUMBER OF DEATHS FROM MOTOR VEHICLE TRAFFIC ACCIDENTS OVER A SPECIFIC PERIOD OF TIME

MORTALITY RATE = -----------------------------
THE POPULATION OF THE COMMUNITY AT RISK DURING THE SAME PERIOD OF TIME

TOTAL NUMBER OF DEATHS FROM MOTOR VEHICLE TRAFFIC ACCIDENTS OVER A SPECIFIC PERIOD OF TIME

CASE-FATALITY RATE = -----------------------------
TOTAL NUMBER OF INJURIES AND DEATHS FROM MOTOR VEHICLE TRAFFIC ACCIDENTS DURING THAT SAME PERIOD OF TIME

Figure 1  Definitions of incidence, mortality and case-fatality rates.
These epidemiologic measures are proposed in preference to traditionally adopted “casualty rates” (3, 5) for a number of reasons. Firstly, an index such as “casualties per 100 million vehicle miles” has an inappropriate denominator to correct for changes in the level of population risk when 22 to 25 per cent of fatalities occur in pedestrians. Secondly, such an index may not describe the true impact on the population's health of a traffic safety innovation such as the breathalyser since the index would remain unchanged if fatalities were reduced only as a result of deterring people from driving.

Finally, epidemiologic measures have inherent advantages in describing the mode of action of an effective traffic safety innovation by being able to separate preventive effects (that is, a reduction in incidence rate) from a measure’s ability to reduce the severity of resulting injury (that is, a reduced case fatality rate) and further that mortality rate is the most appropriate index of road fatality.

These three components of the effect are clearly not independent since the three measures share the relationship: Mortality rate = incidence rate \( \times \) case fatality rate. From this relationship it is apparent that mortality rate will be affected by changes in either or both the incidence and the case fatality rate. The separation of these two potential effects leads to a more meaningful explanation of any change in mortality resulting from an implemented programme. Such indices could thus better distinguish between the effects of programmes having different primary foci – for example, accident prevention programmes, improved automobile safety features and the long-term improvement of patient care techniques.

Motor vehicle traffic accident data were obtained from Statistics Canada's “Quarterly Reports of Motor Vehicle Traffic Accidents” (9) for the years 1963 to 1971. The period between 1963 and 1969 seemed sufficient time to establish trends of motor vehicle traffic accidents prior to the introduction of the breathalyser law. Data in these quarterly reports are based on police records of personal injury accidents. Minor accidents or accidents where those injured left the scene of the accident may not have been reported. However, injury reported by police serves as a useful and fairly constant definition for the occurrences of the 'disease event'. Deaths and injuries were abstracted for three-month periods (quarter year) by hour of the day of the accident in order to attempt to describe as fully as possible patterns of motor vehicle traffic accidents. For example, if the breathalyser law was effective, one would expect only those hourly rates to change which coincided with times when the consumption of alcoholic beverages was high. Such a “gradient of effect” with consumption habits would be weighty evidence of the breathalyser’s efficacy.

As mentioned earlier, any initial conclusions made from this analysis must be weighed against the limitations of the presently available data. Canada’s breathalyser law was in universal effect for all of the first quarter of 1970. Because of routine delays in reporting from some provinces, Statistics Canada has only published data on motor vehicle traffic accidents up to the first quarter of 1971, and at the time of this writing it is not clear when more data will be forthcoming. Also, these data are limited because provinces tend to be unable to agree on a common format for reporting motor vehicle traffic accidents and Statistics Canada data are always limited to the lowest

\[3\text{This relationship holds exactly if the traffic accident deaths are attributed to the time period in which the accident occurred rather than the time period in which the death occurred (the current reporting practice). Since almost all traffic accident fatalities occur within the first week after the accident the effect of a time lag on quarterly mortality rates is negligible and thus the relationship is appropriate.}\]
common denominator of the breakdown of data provided by each province. For example, some provinces (Manitoba and Quebec) did not report some quarters and others such as Ontario, reported traffic accident data in much more detail than did other provinces.

METHODS

Population estimates for the years 1963 to 1971 were required in order to calculate motor vehicle traffic accident mortality and incidence rates for those years. These yearly population estimates were obtained from Statistics Canada (10). Quarterly estimates were then calculated. When provinces had failed for certain quarter years to report to Statistics Canada their motor vehicle traffic accident data, corrections were made so that a true population at risk was established.

Incidence, case-fatality and mortality rates for each quarter were computed for the total day and also for four periods during the day: 6 a.m. to 12 noon; 12 noon to 6 p.m.; 6 p.m. to 12 midnight; and 12 midnight to 6 a.m. The number of people killed or injured were not reported by hour of day, necessitating the use of accidents involving death or injury as a surrogate in an attempt to relate the effect of the breathalyser on alcohol consumption patterns. Although this is a less satisfactory approach it should exhibit similar trends to the desired data. The ‘total day’ incidence, case-fatality and mortality rates were calculated using the appropriate data and were plotted over time.

As any programme of accident prevention may have effects on either or both the incidence and the case fatality rates and since these, together, affect mortality rate, separate models were constructed for incidence and case fatality. Two regression models were fitted to the incidence and case fatality data explaining the variation in terms of (a) a mean rate, (b) seasonal effects, (c) linear time trend, and (d) breathalyser effect (Appendix A). A regression model was fitted to the total rates and to the rates for the four periods during the day.

The product of the predicted values for incidence and case-fatality was used as an estimate of mortality in each quarter. This method was chosen after observing linear trends in both incidence and case-fatality rates but a non-linear trend in mortality rate (Figure 2). It was reasoned that this is to be expected because mortality rate is equal to the product of the incidence and case-fatality rates. Further, since each of these rates exhibit apparent linear trends with time, their product will be quadratic with time. Since only two of the three rates could be independently modelled, the variation in the third should be explained by the appropriate combination of the predicted values of the other two.

Finally, the mortality in the post breathalyser period was examined in the five quarters (three-month periods) after the introduction of the breathalyser law. Estimates were calculated of the mortality rate that would have been expected if the breathalyser had not been introduced. This was achieved by extrapolating the mortality estimates beyond the last quarter of 1969 but with the breathalyser effect removed. The difference between these predictions and the mortality estimates including the breathalyser effect was calculated. The differences between the observed mortality rate and the mortality estimates without the breathalyser were then summed over the last five quarters. This latter step provided an estimate of the number of lives saved by the breathalyser law, during the fifteen months after its introduction.
THE THREE MEASURES ARE NOT INDEPENDENT SINCE
\[ M = I \times C \times F. \]

Figure 2  *Relationship between incidence, case fatality and mortality rates.*

**RESULTS**

Figure 3 shows the plots of ‘total day’ incidence, ‘total day’ case-fatality and ‘total day’ mortality. It was apparent from these graphs that the variation in all three measures was highly seasonal and thus a seasonal effect was a necessary component of the model. The incidence rate of injury from traffic accidents had been increasing fairly steadily over the time span of the data, whereas case-fatality rates appear to change at about the end of 1965. As a result, it seemed appropriate to model the longer time trends in these two rates with a linear trend based on the post-1966 data only. Inspection of the trend in the mortality rate over time supports a possible non-linear relationship.

The detailed results of the regression analysis are contained in Appendix A. The linear models provide good predictions of incidence and case-fatality both for the total rates, and for the rates broken down by the time period. For the model of total incidence rate, the breathalyser’s introduction corresponds to a significant drop in incidence rate of 9.2 per 100,000 per quarter. The individual time period models show that this reduction is achieved mainly during the 6 p.m. to 12 midnight and 12 midnight to 6 a.m. periods, those times during which most alcohol is consumed. The model of total case-fatality rate also shows a reduction of 0.11 per cent after the breathalyser’s introduction, although this effect is not quite statistically significant \((p \geq 0.10\) single tailed test). The reduction appears to be mainly achieved in the afternoon and evening periods.

The effects of the breathalyser law on mortality are illustrated in Figure 4 in which the actual and predicted mortality rates are displayed. The overall fit is good,
DISCUSSION

Measurement of the breathalyser's impact on traffic accidents should be, in some ways, easier to demonstrate than when measuring the impact of other traffic safety innovations for two reasons: (a) the breathalyser law is unique as a preventive measure in that it came into effect at a specific point in time on the day the Bill was enacted; and, (b) the breathalyser law was applied universally through the Criminal Code of Canada, to all Canadian drivers. The introduction of seat belts and vehicle safety corresponding to a 95.6 per cent explained variation. In the last five quarters of the graph in Figure 4, we have added the mortality rate that would have been expected if the breathalyser had not been introduced (the dotted line). The difference between these predictions and the model's predictions including the breathalyser effect represents an average reduction of 0.46 deaths per 100,000 population per quarter. The sum of the differences between the observed mortality rate and the model's predictions without the breathalyser for the last five quarters represents a statistically significant reduction of 8.2 per cent or 487 deaths for Canada as a whole.

Figure 3  Incidence, case-fatality and mortality rates for motor vehicle traffic accidents in Canada from 1963 to 1971.
features may well have affected the statistics although these factors were not applied universally nor were they introduced at a single point in time. Their gradual influence spans both the period before and after the breathalyser amendment and therefore may be contributing to the longer term movements in incidence, case-fatality and mortality. It is therefore unlikely that they can fully explain decreases in the post-breathalyser period revealed by the above analysis.

The classical epidemiologic measures of disease frequency applied to deaths and injuries from traffic accidents add a new dimension to the description of the phenomena. Our analysis has revealed that both the rate of injury (incidence) and the relative severity of injury (case-fatality) have strong seasonal fluctuations, the patterns of which are repeated over time with remarkable constancy. In addition, the long term trend of incidence is to increase and of case-fatality to decrease. Thus, while likelihood of injury from a traffic accident is increasing for the population at large, injuries sustained are becoming less severe, presumably reflecting the steady improvement in automobile safety features and road designs. These two longer term trends have conflicting effects on the mortality rate which, while arising steadily in the early part of the decade, appears to have levelled out by 1966. This is reflected in the model of mortality rate which predicts a slight downward movement in rate during the period immediately prior to the introduction of the breathalyser law.

The effectiveness of traffic safety measures based on changes in legislation is dependent on the enforcement of the new legislation. One could say that the initial effect of the breathalyser law has waned in Britain due to the fact that the total number of breathalyser readings taken in Britain averages out to only one per policeman per year (4). On the other hand, some have argued that the most one can expect is a substantial initial reduction in traffic accidents from breathalyser legislation. If this is so, then one logical next step that government could take after its first breathalyser law would be to decrease the milligram per 100 millitres level from the originally set level. For example, the legal blood alcohol level of 80 mg/100 ml could be lowered to
SUMMARY AND CONCLUSIONS

Classic epidemiologic indices have been applied to deaths and injuries from traffic accidents before and after the introduction of Canada’s breathalyser law. The disease frequency measures incidence, case-fatality, and mortality focus on the breathalyser’s health impact in relation to all the people at risk in a community over a specific period of time. This particular feature of these indices permits an ongoing community health assessment of the effect of the breathalyser law or other innovations in traffic safety.

A major hypothesis of this analysis has been that any programme of accident prevention may have effects on either or both the incidence and case-fatality rates and that these, together, affect mortality rate. The findings here have suggested that the introduction of the breathalyser law corresponded to reductions in both the incidence of injury (the greater reductions in incidence occurred during the “heavy drinking” periods of 6 p.m. to 12 midnight and 12 midnight to 6 a.m.) and the case-fatality rate, producing a magnified downward movement in mortality rate. The indicated magnitude of this effect represented a reduction of 487 deaths in Canada as a whole during the first five months in which the law was in effect.

As mentioned above, the prime objective of this paper has not been to state categorically the level of success or failure of the breathalyser in reducing traffic accidents. Rather, the purpose of this preliminary analysis has been to demonstrate the use of an appropriate epidemiologic evaluation that permits an on-going assessment of the breathalyser (or other innovations in traffic safety). All observations have been made taking into account that a short period has elapsed since its introduction. These findings in Canada may represent the initial “shock” effect of the law which appears to have occurred in Britain. And, like the British experience, the magnitude of the initial effect may taper out over time. Future evaluation of the Canadian experience will not be possible until the data become available.

APPENDIX A.

LINEAR REGRESSION MODELS

The linear regression models of incidence and case fatality rate were similar. For illustrative purposes, the incidence model is described below;

The model was of the form,

\[ Y_{jk} = M + j.T + S_k + X \cdot B. \]

Where

- \( Y_{jk} = \) Incidence rate in the jth year and the kth quarter
- \( M = \) Mean incidence rate (year zero)
- \( T = \) Linear trend effect with year j
- \( S_k = \) Seasonal effect for quarter k
- \( X = \) A dummy variable given the value of zero for pre-breathalyser years and unity for post-breathalyser years
- \( B = \) The breathalyser effect

Also, \( j = 1, 2 \ldots \ 6 \) (for years 1966 - 1971)

\[ k = 1, 2, 3, 4 \] (for each quarter)

\[ \sum_{k=1}^{4} S_k = 0 \]
60 mg/100 ml. Perhaps such an amendment to the original breathalyser law would elicit a response to traffic safety in a country seemingly otherwise insensitive to less universally applied preventive measures.

The above constraint on the sum of the quarterly effects prevented overparameterization. As a consequence, only three seasonal effects were estimated, the fourth being calculated as the negative sum of these three estimates.

The Table below gives the coefficients associated with each of the effects in the model, the level of statistical significance of the coefficient, and the percentage of variation explained by the model. As an example of the interpretation of these figures consider the upper part of the first column in the Table representing the model for total incidence rate. The overall mean incidence of injury from traffic accidents corrected to the year 1968, was 226.12 per 100,000 population per quarter. Over the span of the data, the incidence rate has been increasing significantly by 4.31 deaths and injuries per 100,000 per year on average. Incidence in the first two quarters of any year under observation is significantly lower than the overall yearly average (by 48.65 and 8.86 respectively) whereas the rate in the last two quarters is significantly higher (by 39.29 and 18.22 respectively). Note that there are no significant levels attached to the fourth quarter effects as they are calculated from the first three quarters so that the sum of the seasonal effects is zero. The model suggests a statistically significant (p < 0.05, single tailed test) breathalyser effect causing the mean incidence rate to fall by 9.23 after the change in the law. The level of unexplained variation attributable to the model is 97.4 indicating an extremely good fit.

### TABLE A1  Regression coefficients and explained variation for the incidence and case fatality models

<table>
<thead>
<tr>
<th></th>
<th>TOTAL</th>
<th>12 midnight to 6 a.m.</th>
<th>6 a.m. to 6 noon</th>
<th>12 noon to 6 p.m.</th>
<th>6 p.m. to 12 midnight</th>
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<tr>
<td><strong>INCIDENCE MODEL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Rate (1968)</td>
<td>226.12</td>
<td>20.22</td>
<td>24.61</td>
<td>56.44</td>
<td>48.48</td>
</tr>
<tr>
<td>Yearly Trend</td>
<td>4.31**</td>
<td>0.64**</td>
<td>0.86**</td>
<td>1.35**</td>
<td>0.56*</td>
</tr>
<tr>
<td>1st. Quarter</td>
<td>-48.65***</td>
<td>-5.41**</td>
<td>-1.28**</td>
<td>-9.66**</td>
<td>-12.97**</td>
</tr>
<tr>
<td>2nd. Quarter</td>
<td>-8.86**</td>
<td>0.21</td>
<td>-3.44**</td>
<td>-2.04**</td>
<td>-0.46</td>
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<tr>
<td>3rd. Quarter</td>
<td>39.29***</td>
<td>3.29**</td>
<td>1.39**</td>
<td>5.70**</td>
<td>8.82**</td>
</tr>
<tr>
<td>4th. Quarter</td>
<td>18.22</td>
<td>1.91</td>
<td>3.33</td>
<td>6.00</td>
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<tr>
<td>Breathalyser</td>
<td>-9.23*</td>
<td>-2.35**</td>
<td>-0.24</td>
<td>-0.05</td>
<td>-2.14*</td>
</tr>
<tr>
<td>Explained Variation</td>
<td>(%)</td>
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<td>97.1</td>
<td>93.5</td>
<td>96.7</td>
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<tr>
<td><strong>CASE FATALITY MODEL</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Rate (1968)</td>
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<td>2.89</td>
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<td>Yearly Trend</td>
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<td>-0.11</td>
<td>-0.11</td>
<td>-0.17**</td>
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<tr>
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<td>-0.34**</td>
<td>-0.27**</td>
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<tr>
<td>2nd. Quarter</td>
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<td>-0.12</td>
<td>-0.19*</td>
<td>-0.20*</td>
</tr>
<tr>
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<td>0.68**</td>
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<tr>
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<td>-0.08</td>
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<tr>
<td>Explained Variation</td>
<td>(%)</td>
<td>89.7</td>
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<td>79.5</td>
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**NOTE:** Incidence is expressed as a rate per 100,000 population per quarter. *p < 0.05  
Case fatality is expressed as a percentage.  **p < 0.01  
***p < 0.001
REFERENCES


4. Newby R. F., (Road Research Laboratory, Buckinghamshire, England), Personal communication.


