The dynamic effects of Random Breath Testing on traffic accidents in Australian states

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Abstract

Background: Alcohol-involved traffic accidents are costly in terms of death, injuries and damage. Random Breath Testing (RBT) has been considered as an effective mean to reduce alcohol-related crashes. Although a number of studies on RBT have been conducted demonstrating its effectiveness, there are few of studies that assess the effect of RBT on traffic accident mortality using long-term time series analysis, especially, in different age groups.

Aims: This study aims to apply a sophisticated technique to examine the dynamic effects of RBT on age-specific traffic accidents in four Australian states, namely, New South Wales (NSW), Victoria (VIC), Queensland (QLD) and Western Australia (WA).

Methods: Long-term time series of age-specific traffic accident deaths in four Australian states were used to analyse the impact of RBT implementation. The methodology comprises five main stages to produce appropriate Autoregressive Integrated Moving Average (ARIMA) models with intervention dummies.

Results: The results of intervention analysis indicate that RBT has substantially reduced traffic accident mortality in all four states since it was introduced, particularly among 17-20 and 21-30 year olds. NSW received the biggest total net effect from RBT implementation on traffic deaths with estimated reductions of 1132 and 1267 for 17-20 and in 21-29 years old drivers respectively from 1983 to 2010. Traffic accident deaths of young drivers between 17 and 20 years old in VIC were reduced by an estimated 1099 from 1977 to 2010 following the implementation of RBT. In contrast, RBT produced no significant reduction in traffic mortality among 30-39 year olds.

Discussion and conclusions: Controlling for the declining trend in traffic accidents, the implementation of RBT has generated a huge effect, preventing an estimated 5309 traffic accident deaths in Australian four states over 27 years. This provides further evidence that RBT is an effective policy for reducing traffic accidents, particularly among young people.

Introduction

Traffic accidents represent a key cause of injury and death globally, and were the single largest cause of injury-related burden in the most recent global burden of disease (Lopez 2012). Alcohol is a key contributor to this burden, with around 40% of traffic deaths in Australia attributed to alcohol (Collins and Lapsley 2008). Random Breath Testing (RBT) is a widely used drink-driving countermeasure in many countries and is particularly common in Australia (Rowland *et al.* 2012). A meta-analysis on the effects of drink driving checkpoints was conducted by Erke *et al.* (2009), the authors found that drink-driving check points (include RBT) significantly reduced the number of vehicle crashes by a minimum of 17%. RBT can effectively deter social drinkers and problem drinkers, and the introduction of RBT in Britain could save at least 400 lives a years (Dunbar *et al.* 1987).

Random breath testing system aims to deter potential drink-drivers, by increasing their chance of being apprehended (or even just their perception of the likelihood that they'll be detected). This is implemented via the assessment of drivers' breath alcohol concentration (BAC, the limit may differ in difference countries based on traffic regulations) of drivers at randomly located check points (Homel 1993). Police are authorised to pull over motorists for breath testing and the test needs to be highly visible, unpredictable, supported with publicity and perceived to be ubiquitous (Rowland *et al.* 2012). RBT was first introduced in Victoria, Australia in July, 1976, but has now spread around the world (Solomon *et al.* 2011).

In Australia, RBT was implemented at the state level. Following Victoria in 1976, RBT was implemented in NSW in December 1982; WA in October 1988 and QLD in December 1988 (Henstridge *et al.* 1997). Early evaluations found that the introduction of RBT in NSW reduced all fatal accidents by 22% and alcohol-related accidents by 36 % (Homel 1993). Although a number of studies on RBT have been conducted, there are few studies that assess the effect of RBT on traffic accidents using long-term time series analysis (autoregressive moving average model, know as Box Jenkins (1970) approach), particularly focussing on the impacts in different age groups. The key Australian analysis (Henstridge *et al.* 1997) used time-series methods based on daily data to estimate the impact of RBT in NSW, WA and Queensland, estimating a total reduction of 2,583 fatal accidents over a ten year period (1982-1992). We extend this work by examining a longer time-series (albeit based on annual data) and by using age-specific mortality data to ascertain how the effects of RBT were distributed across age groups. Specific research questions addressed by the study were:

1. What are the long-term effects of the introduction of RBT on traffic accident mortality in four Australian states?
2. How do these effects vary across age groups?

Methods

Prior to 1989, data on age-specific traffic fatalities were compiled from historical statistical publications (e.g. NSW Department of Motor Transport (1960) and Commonwealth Bureau of Census and Statistics (1958)). For the years from 1989 onwards, data were available in the Australian Road Deaths Database (2013). Due to vagaries in reporting standards between states and over time, pre-1989 data were not available for consistently defined age groups. In particular, estimates for fatalities among 17-20 year olds in Western Australia (between 1950 and 1959), New South Wales (between 1950 and 1952) and Victoria (between 1950 and 1954) and Queensland (1950-1985) were not available and had to be derived by estimating proportionally from other age groups. For example, the Queensland data generally provided deaths for 15-19 year olds and for 20-24 year olds. Using years where more detailed breakdowns were available, we estimated the proportion of 15-19 year old deaths likely to involve 17-19 year olds and the proportion of 20-24 year old deaths involving 20 year olds to produce an estimate for 17-20 year old deaths, which allowed for consistent analyses with the remaining states.

The autoregressive moving average model (ARIMA) with an intervention dummy was employed to analysis the long-term effect of RBT on the traffic accidents in this study (1970). This approach includes moving average (MA) or autoregressive (AR) terms in the statistical model and enables modelling of any systematic impact of measurement errors and factors not included in the model on the independent variable (Ramstedt 2008). The prior condition for the time series analysis is that all the series are required to be stationary, with time trends removed to avoid the risk of obtaining a spurious estimation (George 1994). In most cases, a differencing of the time series is sufficient to eliminate non-stationarily (Norström 2001). An ARIMA (1,1,1) model with dummy variables can be written as follow:

$$\Delta Y_t = \alpha + \beta \Delta Y_{t-1} + \sum_i \gamma_i D_{i,t} + \delta \Delta E_{t-1}$$

Where Δ is the differencing operator, Y_t represents the dependent variable at time *t* (age-specific traffic accident death in four states), α is constant (which marks average annual changes due to other causes), β is the coefficient value of AR(1) term, δ is the coefficient value of the MA(1) term (ΔE_{t-1}), $D_{i,t}$ is the one-off event dummy variables and $\gamma_i$is the estimates of the effect of the events or interventions. The one-off event dummy variables have been widely applied in many studies to analysis effect of seasonality, major changes in policy and financial crises (Mann *et al.* 2000; Norström 2000; Jiang and Liu 2011). Prior to the event the dummy variable is coded as 0. At the onset of the event the intervention dummy is coded as 1 and it remains at 1 for the duration of the presence of the event.

In this study, the introduction of RBT in NSW was on December 1982; VIC (July 1976); QLD (December 1988) and WA (October 1988). Thus, based on the length of the time series in this study, the intervention period of RBT on these four states can be defined as 1983-2010 in NSW; 1977-2010 in VIC; 1989-2010 in QLD and 1989-2010 in WA. Time series data from 1951 to 2010 were used, ensuring that sufficient data pre- and post- the intervention were available. The models estimate the change in mortality due to the intervention based on the assumption that traffic accident deaths would otherwise have followed the trend from the pre-RBT period. This allows us to estimate the total effect of RBT on traffic accident deaths in the four states.

Results

Results of the analyses are presented in Table 1 for all four states. The estimated effects are presented for the age groups 17-20, 21-29 and 30-39 years. The results suggest that RBT has prevented large numbers of accident deaths in NSW, particularly for young adults 1132 and 1267 lives saved among 17-20 and 21-29 year olds respectively. The total net effects of RBT on traffic accident deaths in NSW were 41%, 31% and 8% for 17-20, 21-29 and 30-39 year olds from 1983 to 2010. The model specification for each ARIMA model is reported in the tables and model fit was evaluated by Box-Ljung portmanteau test for uncorrelated residuals in each model (at 10 lag). The effect of RBT in Victoria is similar to NSW, with 37% and 17% reductions in traffic accident deaths for 17-20 and 21-29 year olds respectively. The prevention effect of RBT on traffic accident deaths for the 30-39 year olds was 2% between 1977 and 2010.

Table 1 Effect of RBT on traffic accident deaths in NSW, Vic, Qld and WA

Period	17-20 years			21-29 years			30-39 years		
	Actual accidents	Estimated accidents	Effect	Actual accidents	Estimated accidents	Effect	Actual accidents	Estimated accidents	Effect
NSW		*(0,1,1)*			*(0,1,0)*			*(1,1,2)*	
1983	194	230	-36	229	309	-80	102	140	-38
.	.	.	.	.	.	.	.	.	.
1997	73	137	-64	122	187	-65	95	100	-5
.	.	.	.	.	.	.	.	.	.
2010	53	50	3	73	73	0	58	64	-6
Total net effects =			-1132			-1267			-198
Total net effects in percentage =			41%			31%			8%
VIC		*(0,1,0)*			*(1,1,0)*			*(0,1,1)*	
1977	170	178	-8	218	220	-2	109	112	-3
.	.	.	.	.	.	.	.	.	.
1997	61	106	-45	82	128	-46	48	65	-17
.	.	.	.	.	.	.	.	.	.
2010	40	59	-19	66	75	-9	34	47	-13
Total net effects =			-1099			-696			-51
Total net effects in percentage =			37%			17%			2%
QLD		*(0,1,1)*			*(0,1,1)*			*(1,1,2)*	
1989	82	78	-4	96	121	-25	67	70	-3
.	.	.	.	.	.	.	.	.	.
1997	67	62	-5	81	104	-23	47	60	-13
.	.	.	.	.	.	.	.	.	.

2010	33	35	-2	47	69	-22	38	53	-15
Total net effects =			-74			-479			-6
Total net effects in percentage =			6%			29%			0.5%
WA		*(1,1,0)*			*(1,1,0)*			*(1,1,2)*	
1989	52	53	-1	70	63	7	29	30	-1
.	.	.	.	.	.	.	.	.	.
1997	34	41	-7	37	59	-22	34	32	2
.	.	.	.	.	.	.	.	.	.
2010	19	17	2	48	51	-3	32	37	-5
Total net effects =			-84			-188			-35
Total net effects in percentage =			12%			17%			5%

Note: ARIMA model specification is represented as (a, b, c). Box-Ljung portmanteau tests (Q-statistic) suggest that there was no systematic variation in the residuals of models.

The estimated effects in QLD and WA suggest that the implementation of RBT was effective for all age groups with 559 lives saved in QLD and 307 in WA between 1989 and 2010. The effects of RBT on traffic accident deaths in these states were strongest for 21-29 year olds, with smaller and inconsistent effects found in the younger and older age groups. The variation in effects seen over time in these two states is in part due to the smaller numbers being modelled, but may also relate to variations in both enforcement and public campaigns raising awareness of RBT, both of which have been shown to be important in maintaining RBT effectiveness (Henstridge *et al.* 1997).

Conclusion

This study has presented a time series analysis of the effect of RBT on traffic accident death in Australian four states. The results suggest that the implementation of RBT has produced a sufficient prevention effect on traffic accident mortality in Australia. In NSW, VIC, QLD and WA, the impacts of RBT on traffic accident death were overall 27%, 20%, 12% and 14% respectively among 17-39 year olds. There was clear evidence from across the four states that RBT had a greater impact on younger drivers, with the 30-39 year old age group having only modest mortality reductions due to RBT.

Due to data limitations, this study has not specifically estimated the impact of the amount of actual RBT enforcement on traffic mortality, a key factor in some earlier analyses (REF to H & H 1997 again). Despite this, the study produced similar aggregate results to these previous analyses, while providing the first clear evidence of the age distribution of the effects of RBT in Australia. It is possible that the effects presented here overestimate the impact of RBT by not considering a range of other polices (e.g. compulsory seatbelt laws) that may have reduced road deaths. In contrast, the effects in Queensland and Western Australia may be underestimated due to the impacts of the lowering of the drinking age in those states during the 1970s. Further research will expand this work to address the potential confounding effects of these policy changes. In spite of these limitations, our study adds to the robust international literature showing that, controlling for the declining trend in traffic accidents, the implementation of RBT greatly reduce fatal road accidents in Australia, preventing an estimated 5309 traffic accident deaths in Australian four states.

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