Title: Random breath testing in Queensland and Western Australia: Examination of how the random breath testing rate influences alcohol related traffic crash rates

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1 INTRODUCTION

1.1 RANDOM BREATH TESTING IN AUSTRALIA

In a seminal paper on road traffic crashes, the World Health Organization notes: “there is much evidence to indicate that alcohol consumption by a road user is a major factor in road traffic accident causation” (Norman, 1962 p.61). Forty years on, driving whilst under the influence of alcohol remains an ongoing and serious problem throughout the world. In Australia over the period 1981–2006, the percentage of fatally injured motorists with a Blood Alcohol Concentration (BAC) of .05 fell by more than 35% (Faulks, Irwin, Watson, & Sheehan, 2010). Much of this decrease in drink driving fatalities is attributed to the nationwide introduction of random breath testing (RBT) throughout Australia during the late 1970s and 1980s (see Warren Harrison, Newman, Baldock, & McLean, 2003). RBT is the primary drink driving law enforcement tool used throughout Australia. There is strong community support, with nearly universal agreement for the random breath testing of drivers (Freeman & Watson, 2009; Petroulias, 2011).

RBT as a mechanism to reduce alcohol-related traffic crashes (ARTCs) was introduced in Victoria, Australia in 1976 and was adopted by other Australian States from 1980–1988 (Papafotiou-Owens & Boorman, 2011). The key elements of RBT in Australia include legislation to implement, strong enforcement of the program with penalties, public education to raise awareness of the program, and the perception that RBT is truly random and ever-present (Peek-Asa, 1999). Australian RBT operations can be either mobile or stationary. Mobile RBT involves police patrols being “authorised” to pull over any motorist anytime regardless of driver behaviour or whether a crash has occurred. After the motorist has been pulled over, the unit follows the procedure of a stationary RBT operation (Warren Harrison et al., 2003). A stationary operation involves the setting up of checkpoints at locations that are varied and generally not publicly announced. Motorists passing the checkpoint are randomly directed over to the side of the road and breath tested by police, who use a hand held calibration device to test the blood alcohol content of drivers (Warren Harrison et al., 2003). Drivers are required to breathe through a small plastic tube into the device, which returns a blood alcohol concentration within a few seconds. A stationary operation can be undertaken in a variety of ways: 1) an operation involving a large number of police at a fixed location using a drink driving bus (“booze bus”) for testing, 2) large coordinated operations using local resources, often at peak travel/socialising times, and 3) mobile RBT using a single vehicle (Faulks et al., 2010).

1.2 PRINCIPLES OF DETERRENCE

Deterrence theory is frequently applied to explain drink driving behaviour (Bates, Soole, & Watson, 2012; Davey & Freeman, 2011; Freeman & Watson, 2006; Lapham & Todd, 2012). In the academic literature, deterrence refers to one of two types: general deterrence and specific deterrence. General deterrence is defined as an intervention (legislation, policy or practice) that conveys to the general public that actions and behaviours are not acceptable. Thus, general deterrence occurs when the public at large avoids committing an offence because of the perceived risk of detection and the perceived certainty, severity and swiftness of the punishment following detection. Specific deterrence, on the other hand, is defined as the actions taken against an individual that alters his or her future propensity to offend. Specific

deterrence thus occurs when someone who has been detected and punished avoids repeating the behaviour as a consequence.

The distinction between general and specific deterrence in the context of random breath tests (RBTs) refers to the general public's views and attitude changes over time in relation to being caught drink driving versus the change in drink driving attitudes and behaviour of an individual who is pulled over and tested during an RBT intervention (Homel, 1988a; Ross, 1984). Some police jurisdictions in Australia saturate RBTs relative to the numbers of licensed drivers (e.g. Queensland, Kolesnik, 2002), while other jurisdictions, such as Western Australia, place more emphasis on the detection of drink drivers and utilise more target testing RBT operations (Road Safety Council, 2010).

Notionally, both saturation and target testing should act as a means to generally deter people from drink driving (Homel, 1988a). Nonetheless, the risk of being detected by target testing is perceived to be very low, since drink drivers often believe they can hide their impairment from an observer or avoid being observed (Homel, 1988a). This low perceived risk of detection greatly dilutes the general deterrent effect of target testing. Saturated RBT deployments, on the other hand, have a random element because drivers are pulled over indiscriminately, and the sites and times of operation are deliberately varied, which contributes to a perception that anybody could be pulled over and tested anywhere and at any time (Homel, 1988a). We also recognise that the success of general deterrence does not rely solely on perceived risk of detection but also on the perceived severity, certainty and swiftness of punishment (Homel, 1988a). Perceived severity of punishment is a function of public knowledge of legislation and the outcomes of court cases, perceived certainty is a function of police practices (in Australia, very few drink driving offences result in no action) and perceived swiftness is a function of public knowledge about court practices. While policing practices that can alter the perceived risk of detection are readily manipulable, variations in the swiftness and severity of punishment are not.

In Australia the penalties for drink driving vary across jurisdictions (for a review of each state and territory see Palk, Sheehan, & Davey). The level of penalty for most jurisdictions is dependent on licence type, the level of blood alcohol concentration and/or whether it is a first or repeat offence (Peek-Asa, 1999). Penalties can involve a fine, demerit points, licence disqualification and imprisonment (or a combination of these). Given the variations in punishment by state, it is likely that there are differing perceptions across the states of the legal consequences related to drink driving. The actual penalty applied to an offender may affect the likelihood that a drink driver will reoffend. Research using participants from the Australian state of New South Wales identified that, all other things being equal, higher fines did not act as a specific deterrent against drink driving (Weatherburn & Moffatt, 2011).

This *perception of detection* (or what is known as "RBT exposure") is not simply determined by the volume of RBT conducted in Australia. Recent research by Petroulias (2011) reported that in 2010, 80% of the surveyed population saw police conducting random breath tests in the six months prior to the survey (higher than the 2008 and 2009 result of 75%). In addition, in 2010, 37% of the community reported having been breath tested in the previous six months, which is a marked increase on results from previous years. The perceived omnipresence of RBTs is thus important to why people alter their behaviour in the context of RBT in Australia.

1.3 EFFECTIVENESS OF RBT IN AUSTRALIA

International comparative research considers Australia to have the most successful RBT program, compared to other countries, in terms of crash reductions (Erke, Goldenbeld, & Vaa, 2009). This success is attributed to the program's high intensity (Erke et al., 2009). Erke et al. (2009) conclude from their meta-analysis that testing all drivers under road block, saturation conditions is more effective than only testing those that arouse suspicion. Australian RBT programs tend to have higher intensity enforcement than other countries. For example, Australia uses "booze buses" in high visibility locations, state governments spend large amounts on publicity, and the total number of drivers tested in Australia is higher than in other countries (Erke et al., 2009). Nevertheless, within Australia there is considerable diversity in RBT program implementation both, in how RBT was introduced and how it is implemented today (see Warren Harrison et al., 2003; Homel, 1988a; Papafotiou-Owens & Boorman, 2011).

Evaluations conducted after the introduction of RBT in Australia suggest that RBT produced long term reductions in ARTCs (Baldock & White, 1997; Henstridge, Homel, & Mackay, 1997; Homel, Carseldine, & Kearns, 1988). Henstridge et al. (1997) found results were most clear for New South Wales, where RBT reduced fatal accidents initially by 48%. The initial impact of RBT ranges from 48% for fatal accidents in New South Wales to 13% for all serious accidents in Western Australia, and the degree of effectiveness appears to be linked to the type of program implemented (Faulks et al., 2010). For RBT programs to deter motorists from drink driving it is paramount that there is a perception by motorists that offenders will most likely be caught for the offence (Homel, 1988a, 1990). As such, initial success is linked to "boots and all" approaches featuring high levels of testing, sustained operations supported by media campaigns, with long term success linked to sustained testing levels and innovation (Faulks et al., 2010).

1.4 RBT RATES IN AUSTRALIA

Australia does not have a regulatory policy that dictates how many RBTs should be conducted annually. Each state has targets that vary in their degree of formality. Most Australian states and territories loosely adopt an annual RBT target equivalent to one-third of the number of licensed drivers within their jurisdiction, which is largely based on the reviews of Homel and others (Henstridge et al., 1997; Homel, 1988b; Homel et al., 1988). Keeping police enforcement operating at high levels of visibility requires high levels of police resourcing, sustained over time (Warren Harrison et al., 2003).

In this paper we explore the relationship between monthly RBT rates (per 1,000 licensed drivers) and ARTC rates over time, across two Australian states: Queensland and Western Australia. We analyse the RBT, ARTC and licensed driver rates across 12 years, between January 2001 and August 2012; however, due to administrative restrictions, we model ARTC rates against RBT rates for the period July 2004 to June 2009.

2 METHODS

In 1988, Queensland and Western Australia were the last two Australian states to introduce RBT, after a long period during which the police had the discretion to choose whether to test drivers pulled over at road blocks. The Queensland Police Service uses an "in-house" agreement for their annual number of RBTs (this being a 1:1 ratio of RBTs to licensed drivers; Queensland Travelsafe Committee, 1996; Watson & Freeman, 2007). Western Australia (Stockwell, Maisey,

& Smith, 1991), by contrast, adopted Homel's (1989) original suggestion of a 1:3 ratio (1 RBT per 3 licensed drivers) and more recently have been reducing this ratio in favour of more targeted and selected testing methods (Harvey L, 2012; Road Safety Council, 2010).

Of all Australian States and Territories, on a number of characteristics, Western Australia is most similar to Queensland (see Table 1). While the two states contrast in terms of their RBT policies, they are the first and second largest states, geographically, and the third and fourth most populated. In Queensland, only 46% of the population live in the capital city compared to 75% of the population in Western Australia; however, the differences in the population living in urban areas, within the two states, is less varied. There is little difference between the proportion of registered licensed drivers or current drinkers; however, according to the 2010 National Drug Strategy Household Survey (Australian Institute of Health and Welfare, 2011), 15% of the Western Australian population have "driven a motor vehicle while under the influence of or affected by alcohol" compared to only 10% of the Queensland population (odds ratio 1.57, 95% confidence interval 1.35–1.84; $p < 0.001$)

Table 1. Geographical*, licensed drivers and drinking characteristics† of Queensland and Western Australia

	Queensland	Western Australia
Original ratio of RBTs to licensed drivers	1:1	1:3
Population*	4.5m	2.4m
State (population) *	3rd	4th
Capital city (population) *	46%	75%
Geographical size*	1.8mil km ²	2.5mil km ²
Proportion urban*	60%	71%
Licensed drivers	71%	69%
Current drinkers†	83%	84%
Drink-driving last 12 months†	10.3%	15.5%
Odds Ratio: Drink-driving last 12 months	1	1.56

*State data drawn from the (Australian Bureau of Statistics, 2012); †Drinking data drawn from the National Drug Strategy Household Survey (Australian Institute of Health and Welfare, 2011).

2.1 ADMINISTRATIVE DATA SOURCES

Our research draws on three administrative data sources to assess the relationship between RBT rates and ARTC rates per licensed drivers. Where possible, data collected spans January 1 2000 to September 30 2012.

2.1.1 RANDOM BREATH TESTING (RBT)

The RBT administrative dataset includes the number of breath tests conducted per month. The requested Queensland RBT data were provided by the Traffic Analysis Unit within the Queensland Police Service (QPS), and span January 2000 to December 2011. The data capture

all road side breath testing but does not include evidentiary breath testing (EBT). The Western Australian data were provided by the Traffic Policy Unit within Western Australia Police (WAP) and span January 2001 to August 2012. The data specifically denote “target breath tests” (that is “breath testing that is the result of separate event” Temby, 2013), “non-booze bus RBT” and “booze bus RBT”. To align with the Queensland data only the data for non-booze bus RBT and booze bus RBT were combined and, for the purpose of this paper, all breath testing data are referred to as RBT.

2.1.2 ALCOHOL-RELATED TRAFFIC CRASHES

The ARTC administrative dataset contains a monthly count of the number of traffic crashes for Queensland and Western Australia where an individual's recorded BAC reaches or exceeds 0.05g/ml of alcohol in blood. In Western Australia the data provided by Main Roads Western Australia consists of all police attended crashes, with only the highest breath alcohol concentration (BAC) reading of all drivers (or motorbike riders) reported. The crash data from Western Australia span January 2001 to December 2010 and were aggregated to monthly counts. The data also contains a series of summary fields relating to the severity outcome of the most severe casualty: these fields include property damage (with a field for both major and minor), medical attention, hospitalisation and fatality.

The Queensland crash data consists of all police attended crashes and are maintained and provided by the Department of Transport and Main Roads. Due to administrative processes the Queensland ARTC data are only available for the period July 2004 to June 2009. Three databases were provided: one reflects the unit record of the crash incident, another provides information about ‘controllers’ (or drivers of the vehicles) and the third provides information on casualty cases from the incident. Within the crash database a field exists indicating the severity of the most severe outcome of the crash. The categories consist of property damage (unspecified), minor injury, medical treatment, hospitalisation and fatality.

Each entry of the ARTC data provided for Western Australia reflects a single crash incident. In multiple vehicle accidents, if more than one driver was detected with a BAC of 0.05g/ml or greater, that incident was coded as an ARTC. Because of this, the number of drivers with a BAC of 0.05g/ml or greater is not reported, only that at least one driver had a BAC of 0.05 g/ml or greater. The Queensland ARTC data were recoded to reflect the Western Australian data. In cases where the accident was a multiple vehicle incident the highest BAC of all drivers was determined and a single record was constructed. A binary variable was coded 1/0 to indicate if the BAC of any driver was 0.05 g/ml or greater. The Queensland ARTC data were aggregated to monthly counts. Finally, for the purposes of this study we do not differentiate the severity of the crash (i.e., property damage, hospitalisation or fatality) but look at all crashes where alcohol was reported and exceeded the legal limit of 0.05 g/ml.

2.1.3 REGISTERED LICENSED DRIVERS

The Western Australian licensed driver administrative data were provided by the Department of Transport, Western Australia. The data provided were annual numbers of registered licensed drivers for the years 2000 to 2011. As monthly data were required for analysis the monthly count of registered licensed drivers was extrapolated by interpolating monthly numbers between consecutive pairs of annual numbers. As data for 1999 were not available to interpolate 12 month change for the period 2000, we used licensed driver data between January

2001 and December 2011. The licensed driver data from Queensland were monthly numbers of registered licensed drivers spanning January 2000 to December 2011.

2.2 STATISTICAL ANALYSIS

We use a two-step process to analyse the data. First, we explore individual state ARTC and RBT trends over time. Further, using Joinpoint (detailed below) we model these data to confirm we have enough variation to examine the relationship between ARTC rates at different RBT ratios. Second, using OLS regression we model ARTC and RBT rates for the two states.

Prior to analysis all administrative data were aggregated to monthly counts. Due to the high volume of RBTs conducted we present RBTs either as a factor of 1,000 (e.g., 310,298 would be presented as 310). The estimated annual number of RBTs is based on a percentage (or ratio) of the annual count of licensed drivers. To calculate monthly ratios of RBTs to licensed drivers we divided the monthly number of licensed drivers by 12 to get a monthly ratio estimate for the number of RBTs to licensed drivers.

We first used Joinpoint Regression software (Statistical Research and Applications Branch, 2013) to quantify any significant deviations in trends over time for each of the administrative datasets. This software is data driven and uses joinpoint (or piecewise) regression as a statistical method to identify significant variations in trends within epochs (Yu, Barrett, Kim, & Feuer, 2007). Using this approach avoids the need to arbitrarily select a base for estimating the direction and magnitude of slopes within a data series. The software uses statistical criteria and joined log-linear segments to determine when and how often the monthly percent change (MPC) varies across a data series. We specified the model to test with the maximum number of three join points within the series and optioned the Joinpoint software to fit an adjusted autocorrelated errors model. Based on the number estimated line segments drawn from the analysis, each segment of the series is characterized by an MPC (Kim, Fay, Feuer, & Midthune, 2000) and the associated 95% confidence interval is indicative of the adequacy of the final model and the degree of random variation inherent in the underlying rates. In text, we have used an asterisk (*) to indicate if the MPC segment is significantly different from zero. The model uses a Monte Carlo Permutation method to test if an apparent change in trend is statistically significant by taking a sample of all possible $N!$ permutations. A re-sampling method of 5000 iterations is specified. For further information the reader is encouraged to visit the Joinpoint website (surveillance.cancer.gov/joinpoint).

All descriptive analysis and the linear-log OLS regression analysis (and associated diagnostics) estimates were undertaken using Stata (StataCorp, 2011).

3 RESULTS

3.1 ALCOHOL RELATED TRAFFIC CRASHES WA AND QLD

Our results show different patterns for the monthly number of RBTs, registered licensed drivers and ARTCs for Queensland and Western Australia (see Figure 1). In Figure 1 we present patterns of the three administrative datasets for all available data. Following this descriptive examination of the data, successive analysis is based only on data from July 2004 to June 2009 (the solid vertical lines in Figure 1), as this was the only available ARTC data for Queensland.

For Queensland (see Figure 1a), as the number of licensed drivers increases with the increase in population (see long-dash line), the monthly rate of RBTs (see short-dash line) steadily increases in order to maintain the 1:1 RBT to licensed driver ratio.

The joinpoint analysis suggests that there was no significant deviation across the series in the monthly RBT rates. The estimated overall MPC for the series was 0.16 (95% confidence interval (CI) 0.10 to 0.22*); as the confidence interval does not contain zero, the slope of the MPC is considered significantly different from zero ($p < 0.001$). For the first 6 months of the series the average monthly number of RBTs conducted in Queensland was 217 (in 1000s; CI: 188 to 247); this increased to 285 (in 1000s; CI: 238 to 333) for the last 6 month period. Across the same period, the results from the joinpoint analysis suggest three significant joins in the licensed driver data. Between January 2000 and November 2006 the estimated MPC was 0.20 (CI: 0.20 to 0.21*); the MPC after this period increased to 0.44 (CI: 0.39 to 0.46*) until July 2007. For the following period (until August 2011) the MPC returned to 0.28 (CI: 0.27 to 0.28*). After this point the estimated MPC was -0.02 (CI: -0.13 to 0.08). For the series, the number of registered licensed drivers in Queensland started at more than 2.3 million drivers and increased to 3.25 million.

Finally, the results of the joinpoint analysis suggest that there was no significant variation in the MPC for the ARTC series. The estimated MPC for this series was 0.30 (CI: 0.12 to 0.47*). The average number of ARTCs for the first six months of the series (July 2004 to December 2004) was 145 (CI: 133 to 157), increasing to 159 (CI: 135 to 182) for the last six months of the series (January 2009 to June 2009).

For Western Australia (see Figure 1b), the monthly rate of RBTs conducted decreases over an eight year period until July 2008, where there is a substantial acute decline in the RBT rate, followed by a monotonic upturn. Joinpoint analysis suggests that the MPC between January 2000 and July 2008 was -0.41 (CI: -0.52 to -0.31*), at which point the MPC is -10.63 (CI: -43.13 to 40.44) for a three month period. Following this, the MPC is significantly positive 0.65 (CI: 0.29 to 1.01*) until the end of the series. For the first 6 months of the series the average monthly number of RBTs conducted in Western Australia was 92 (in 1000s; CI: 83 to 102); this decreased to 58 (in 1000s; CI: 45 to 70) for the last 6 month period prior to the MPC change in July 2008. After the acute decline in the RBT rate, the average monthly numbers of RBTs for the first 6 months of the last line segment was 42 (in 1000s; CI: 31 to 54). By the end of the series the average monthly number of RBTs was 75 (in 1000s; CI: 65 to 85). Across the same period, the results from the joinpoint analysis suggest one significant join in the licensed driver data. Between January 2001 and September 2004 the estimated MPC was 0.35 (CI: 0.35 to 0.36*). After this the gradient of the MPC was not as steep (0.11; CI: 0.10 to 0.11*). It is noted that the tight confidence intervals for the licensed driver data from Western Australia are due to the interpolation from the supplied annual data. For the series, the number of registered licensed drivers in Western Australia started at more than 1.12 million drivers and increased to 1.45 million by the end of the series.

Finally, the results of the joinpoint analysis suggest that there were three significant joins in the ARTC series. Between January 2001 and March 2001 the estimated MPC was 29.98 (CI: -18.42 to 106.77) and from March 2001 to January 2003 the MPC was -0.58 (CI: -1.49 to 0.35); neither of these MPCs differed significantly from zero. Between January 2003 and November 2008 the MPC significantly increased to 0.62 (CI: 0.48 to 0.76*); after that the MPC remained at -1.72 (CI:

-2.36 to -1.07*) until the end of the series. For the first 12 months of the series the (January 2001 to January 2002) the average number of ARTCs was 76 (CI: 69 to 82); for the 6 months prior to November 2008 the average number of ARTCs had increased to 110 (CI: 100 to 120). After this, reflecting the downturn of the MPC, the average number of ARTCs in the last 6 months of the series was 76 (CI: 64 to 89).

It is likely that a contributing factor to the increase in the absolute number of crashes seen in both Queensland and Western Australia is the result of population growth. According to the Australian Bureau of Statistics (Australian Bureau of Statistics, 2012) both states had a somewhat equivalent population growth during the study period, with the rate for Queensland being around 2.4% and the rate for Western Australia being approximately 2.2%. This suggests it is unlikely that the notable differences between the two states for RBTs and ARTCs are due to differences in population growth.

Insert Figure 1 here

Fig 1. Absolute number of monthly alcohol related traffic crashes and monthly RBTs by state

While the absolute number of ARTCs in Queensland is roughly twice that observed in Western Australia (see Fig 1 above), the total number of licensed drivers in Queensland is more than double that of Western Australia. We adjusted for this difference by modelling both the number of RBTs and the number of ARTCs, accounting for the number of licensed drivers (see Fig 2 below).

Insert Figure 2 here

Fig 2. Monthly rate of ARTCs per 100,000 licensed drivers (bottom lines) and monthly number of RBTs per 1,000 licensed drivers between July 2004 and June 2009, including estimated MPC line segments.

After adjusting for the rate of licensed drivers in each state Fig 2 provides a comparison of the monthly rate of ARTCs and monthly rate of RBTs. In Queensland the monthly rate of ARTCs is virtually flat (although slightly increasing). The results of the joinpoint analysis suggest the MPC is 0.014 (CI: -0.164 to 0.193) and not significantly different to zero. On average, roughly six ARTCs per 100,000 licensed drivers are observed across the period (5.5; CI: 5.4 to 5.7). For the same period, the monthly rate of RBTs per 1,000 licensed drivers can be observed to be decreasing. The joinpoint analysis reveals no detectable variations in the data. The overall MPC for RBTs per 1000 licensed drivers for the period is -0.31 (CI: -0.54 to -0.08*); falling from 94 (CI: 50 to 138) per month for the first 6 months to 82 (CI: 71 to 92) for the last 6 months.

In Western Australia the monthly rate of ARTCs, after adjusting for the rate of licensed drivers, significantly increased over the five-year period. The results of the joinpoint analysis indicate that the MPC is 0.47 (CI: -0.31 to 0.62*). Over the period the rate of ARTCs increased from 6.3 (CI: 5.5 to 7.1) per month for the first 6 months to 7.4 (CI: 6.8 to 8.0) for the last 6 months. For the same period, the monthly rate of RBTs per 1,000 licensed drivers can be observed to be decreasing with no detectable variation in the data series. The overall MPC for RBTs per 1000 licensed drivers for the period is -0.72 (CI: -0.81 to -0.62*). The average rate of RBTs per 1,000 licensed drivers in Western Australia for the first 6 months of the series was 49 (CI: 42 to 55) falling to 29 (CI: 25 to 32) for the last 6 months.

The joinpoint analysis (long-dashed lines) presented in Figure 2 demonstrates the flat ARTC rates relative to the RBT rates in Queensland and the increasing ARTC rates relative to the RBT rates in Western Australia. We use the variation of ARTC rates to RBT rates between the two states to model the relationship between the ARTC rates per 100,000 licensed drivers against the RBT rates. A scatterplot of this data is presented in Fig 3.

Fig 3 depicts an inverse relationship between the monthly rate of ARTCs against the rate of RBTs conducted after taking into account the rate of licensed drivers within each state. The yearly average (estimated from the monthly data) for the two states are also plotted. These yearly data show that over the past six years the rate of ARTCs per 100,000 licensed drivers in Western Australia typically increases whilst the rate of RBTs conducted relative to the population of licensed drivers decreases. The averaged-annual rate of ARTCs per 100,000 licensed drivers was 6.84 (ranging from 5.96 in 2005 to 7.44 in 2007). In Queensland, on average, from 2007 to 2009, the ratio was close to 1 (or 100%; ranging from 98% coverage to 113% coverage of registered licensed drivers) while the averaged-annual rate of ARTCs per 100,000 licensed drivers was maintained at 5.5 (ranging from 5.44 in 2006 to 5.69 in 2005). Note we exclude 2004 and 2009 as these averaged-annual data are based on 6 months.

As observed in Fig 3, the data appear to follow an exponentially decreasing curve such that as the percentage of RBTs conducted to licensed drivers approaches 100% (i.e., a ratio of 1:1), there is a decrease in the monthly rate of ARTCs observed per 100,000 licensed drivers. However, as the percentage exceeds 100% the gradient of the slope reduces. To best account for the form of this curve we modelled the data using a linear-log OLS regression. We took the natural log of the ratio of RBTs to licensed drivers (see equation 1):

Insert Equation 1 here

Equation 1: Fitted linear-log OLS regression model for ARTCs against the natural log transformation of RBTs after accounting for number of licensed drivers

Insert Equation 2 here

Equation 2: Coefficients of the fitted model in Equation 1

These results suggest that for every 10% increase in the percentage of RBTs to licensed drivers there is a 0.15 (CI: 0.11 to 0.19) decrease in the difference in the number of ARTCs per 100,000 licensed drivers. The adjusted R^2 of the linear-log model is 0.36 ($F_{(1,118)}=67.33$; $p<0.001$), suggesting that 36% of the variance in the monthly number of ARTCs per 100,000 licensed drivers is accounted for by the ratio of RBTs to licensed drivers. The results of a specification link test and Cameron & Trivedi's decomposition test (StataCorp, 2009) both indicate that the model is well specified and that while the linear-log model still has some, although marginal, evidence of heteroskedasticity ($\chi^2_2=7.41$, $p=0.025$), there is no evidence of skewness ($\chi^2_1=3.27$, $p=0.071$) nor Kurtosis ($\chi^2_1=0.77$, $p=0.380$).

Table 2 presents the estimated difference of monthly alcohol related traffic crashes per 100,000 licensed drivers for varying percentage increases in RBTs to licensed drivers. For example, based on the data shown in Fig 3 and the estimated ratio changes seen in Table 1, if the ratio of RBTs to licensed drivers is increased from 1:3 to 1:1 (or 33% to 100%; see italicised row) the

estimated percentage decrease in ARTCs per 100,000 licensed drivers would be 1.76; or just under 2 ARTCs per month per 100,000 licensed drivers.

Table 2. Expected decrease in the number of ARTCs per 100,000 licensed drivers given a particular percentage increase in the number of RBTs per licensed drivers

Percentage increase in RBTs to licensed drivers From X to Y	Expected (decrease) difference in ARTCs per 100,000 Licensed drivers per month		
	Estimate	LCI	UCI
33% increase (e.g., 75 to 100%)	0.45	0.34	0.56
50% increase (e.g., 50 to 75%)	0.64	0.49	0.80
100% increase (e.g., 50 to 100%)	1.10	0.83	1.37
200% increase (e.g., 25 to 75%)	1.74	1.32	2.17
203% increase (33 to 100%)	1.76	1.34	2.18
300% increase (e.g., 25 to 100%)	2.20	1.67	2.73

Insert Figure 3 here

Fig 3. Monthly number of ARTCs per 100,000 licensed drivers relative to the percentage of RBTs to licensed drivers with the fitted linear-log curve from Equation 1.

4 DISCUSSION

The introduction and use of RBT in Australia is a central and important law enforcement initiative, embraced by all states and territories since the 1980s. As both a general and specific deterrent measure against drinking and driving, international comparative research considers Australia to have the most successful RBT program, compared to other countries, in terms of crash reductions (Erke et al., 2009). RBT success in Australia, compared to other countries, is often attributed to its high intensity enforcement, high visibility to all drivers, and extensive publicity (Erke et al., 2009).

Nevertheless, within Australian jurisdictions RBT program implementation and effectiveness varies considerably (Homel, 1990). This study examines the relationship between monthly RBT rates and ARTC rates over time, across two Australian states: Queensland and Western Australia. The two states have different RBT policies, yet are similar demographically, geographically and with respect to current drinker and drink driving statistics. We analyse the RBT, ARTC and licensed driver rates across 12 years, between January 2001 to August 2012; however, due to administrative restrictions, we model monthly ARTC rates against RBT rates for the period July 2004 to June 2009.

Our analysis reveals an inverse relationship between the ARTC rates against the RBT rates. The Queensland data presented in Figure 2 illustrate that the monthly ARTC rate is almost flat over the five year period. The results of the joinpoint analysis suggest the estimated MPC is 0.014, which translates to an average of 5.5 ARTCs per 100,000 licensed drivers across the study period. For the same period, the monthly rate of RBTs per 1,000 licensed drivers is observed to be decreasing across the study with the results of the joinpoint analysis revealing no significant variations in the data. The MPC for RBTs per 1000 licensed drivers across the period is -0.31.

The rate of RBTs fell from an average of 94 per month for the first 6 months to 82 for the last 6 months.

By comparison, the Western Australian monthly ARTC rate per 100,000 licensed drivers significantly increased over the five-year period from an average of 6.3 per month for the first 6 months to 7.4 for the last 6 months (see Figure 2). For the same period, the monthly rate of RBTs per 1,000 licensed drivers can be observed to be relatively flat until January 2008, when the rate decreased significantly. The average rate of RBTs fell from 49 per month for the first 6 months to 29 for the last 6 months.

The joinpoint analysis presented in Figure 2 demonstrates the flat ARTC rates relative to the RBT rates in Queensland and the increasing ARTC rates relative to the RBT rates in Western Australia. Given these rate differences between the two states, as well as the substantial variation in the ratio of RBTs per licenced drivers, we combine these data to model ARTC rates against RBT rates.

The fitted linear-log OLS regression modelled in figure 3 shows that when the RBT ratio is low (for example, 1:3) the associated monthly rate of ARTCs per 100,000 licensed drivers is relatively high, estimated to be around 7.5 per 100,000 licensed drivers. For Western Australia over the past six years, the number of ARTCs per 100,000 licensed drivers has increased, while the number of RBTs conducted relative to the population of licensed drivers has decreased. In Queensland, on average, from 2007 to 2009, the ratio was close to 1:1, while the average number of ARTCs per 100,000 licensed drivers has been relatively stable at 5.5.

The comparison between Western Australia and Queensland shows that Queensland's ARTC MPC is 0.014 compared to the MPC of 0.47 for Western Australia. While Queensland maintains a relatively flat ARTC rate, the ARTC rate in Western Australia is increasing. Our findings highlight that for every 10 percent increase in the percentage of RBTs to licensed driver there is a 0.15 decrease in the rate of ARTCs per 100,000 licenced drivers. Moreover, in Western Australia, if the 2011 ratio of 1:2 were to double to a ratio of 1:1, based on the fitted model (see Equation 2) the estimated rate of monthly ARTCs per 100,000 licensed drivers could decrease by 1.10 (CI: 0.83 to 1.37), which is approximately 15 crashes per month (ranging between 12 and 19 crashes).

4.1 LIMITATIONS

The fitted model (see Equation 1) has not been modelled to account for any auto-correlation associated with time or any clustering effects by state. However, the purpose of this paper is to demonstrate the links between ARTCs per 100,000 licensed drivers against the ratio of RBTs conducted to the number of licensed drivers, and from this aim we simply demonstrate the modelling structure of the data. If we were to stratify the data by state – for example only presenting data on Queensland – we would not be able to demonstrate as effectively changes in the number of ARTCs per 100,000 licensed drivers against the ratio of RBTs to licensed drivers for low and high ratios, as the differential in Queensland is so small.

While there are no caveats provided by either data custodian it is important to acknowledge that it is well established in the literature that there is an under-reporting of breath testing by police at road crashes (Chikritzhs, Stockwell, Heale, Dietze, & Webb; Stevenson et al.). The researchers acknowledge that the under-reporting of BACs may occur and at different rates

between the two states which could bias the numbers of ARTC. Researchers have utilised surrogate measures such as high alcohol hours to overcome the limitation of missing data (see, Chikritzhs, Stockwell, Heale, Dietze, & Webb, 2000b; W. Harrison, 1990); however a comparison of high alcohol hours and recorded BACs is beyond the scope of this paper.

The researchers also acknowledge that differences in operational crash-reporting and policies for taking blood and breath alcohol tests from drivers could produce ARTC numbers that are not directly comparable between the two states, and thus potentially bias the results. Queensland has attempted to maintain a relatively stable 1:1 RBT ratio with an associated ARTC rate. The researchers demonstrate this association using the Joinpoint analysis (Figures 1 and 2). In order to examine the relationship between RBT and ARTC rates it was necessary to include another Australian state with RBT rates that were significantly different to Queensland. Nevertheless we caution the reader of the potential limitation on these data due to possible differences in operational crash-reporting procedures between states.

4.2 FUTURE RESEARCH

We intend to undertake the analysis outlined in our paper for all Australian states to explore the relationship between RBT rates and ARTCs over time. We will also extend the analysis to determine the optimum level of RBT enforcement – defined as the level where the marginal benefit equals the marginal cost – needed to have an impact ARTC rates. The benefits-cost ratio in this analysis would include the social costs of ARTCs saved compared with the costs of providing increased RBTs. For example, to double the ratio in Western Australia from 1:2 (observed during 2011) to 1:1 would mean doing an additional 50,000 RBTs per month. Counter to this increased RBT rate though is a saving of 1.5 ARTCs per month. Full treatment of this issue, including costing, is critical to further discussions of optimum levels of RBT in the future.

5 CONCLUSION

Motor vehicle traffic crashes are a significant cost to society, both socially due to loss of life or serious injury, and financially, through economic costs, the associated burden on health systems and human capital. Our research demonstrates a strong relationship between the number of RBTs conducted annually and the number of ARTCs that occur where a driver's BAC reached or exceeded 0.05g/dL of alcohol in the blood.

As asserted by Homel (1988b), the effectiveness of RBTs lies in deterrence. Our research shows that as the number of RBTs conducted increases the number of drivers willing to risk being detected for drinking driving decreases, because the perceived risk of being detected is considered greater. This in turn results in the number of ARTCs diminishing. The results of this study provide an important evidence base for policy decisions for RBT operations.

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