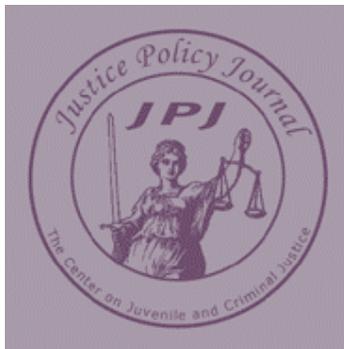


**The impact of Australia's 1996  
firearms legislation:  
a research review with emphasis on  
data selection, methodological issues,  
and statistical outcomes**

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## **Abstract**

*In 1996, Australia introduced firearms legislation that is considered among the strictest in the developed world. The effects of the sweeping reforms remain contentious. An increasing number of publications have specifically set out to evaluate the impacts of the NFA, arriving at seemingly contradictory conclusions as to its success. To date there has been no overview of the existing literature.*

*Consequently, it has been difficult to gain an indicator of whether published research, despite drawing different conclusions, has in fact produced consistent statistical results. This review examined four relevant publications, and found that extant literature is extremely consistent in its statistical findings despite using differing statistical methodology.*

*It appears that disagreement over the impacts of the NFA does not arise from different outcomes of statistical analysis. Reasons for the differing conclusions are discussed. Identification of interpretive confusion surrounding research on the Australian experience, and clarification of the consistency of statistical outcomes, will allow policymakers greater confidence when approaching firearms policy both domestically and internationally.*

### **About the Authors**

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**The impact of Australia's 1996 firearms legislation: a research review with emphasis on data selection, methodological issues, and statistical outcomes.**

**Introduction**

In 1996, Australia introduced firearms legislation that is considered among the strictest in the developed world. The National Firearms Agreement (NFA), ratified by Federal Parliament in 1996 and implemented across all States and Territories by the end of 1997, prohibited certain types of firearms, in particular semi-automatic rifles and semi-automatic and pump action shotguns. The NFA was accompanied by a government funded 'buyback' scheme, costing an estimated half billion dollars, which compensated owners for handing in their firearms. Over 643,000 firearms were subsequently destroyed by police.

The effects of the sweeping reforms remain contentious, especially in regard to the usefulness of the buyback of 'low risk' firearms (Reuter and Mouzos 2003) and in light of historical trends and notable declines in firearm suicide and homicide since the early 1980's (see Figures 1 and 2). In the late 1990's research suggested that the NFA may have been successful in reducing firearm suicides, but ineffective for other firearm-related deaths (Reuter & Mouzos 2003).

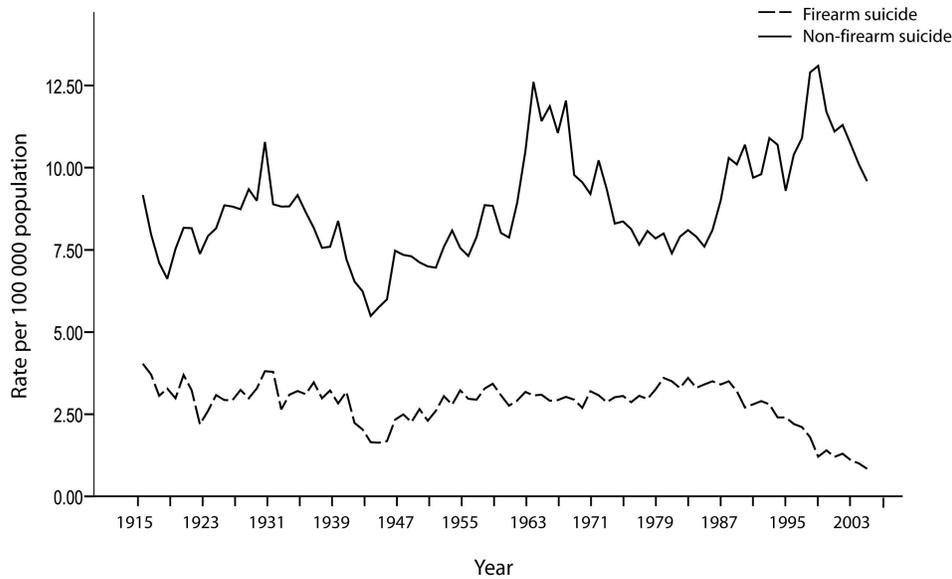


Figure 1: Long term trends for firearm and non-firearm suicide in Australia

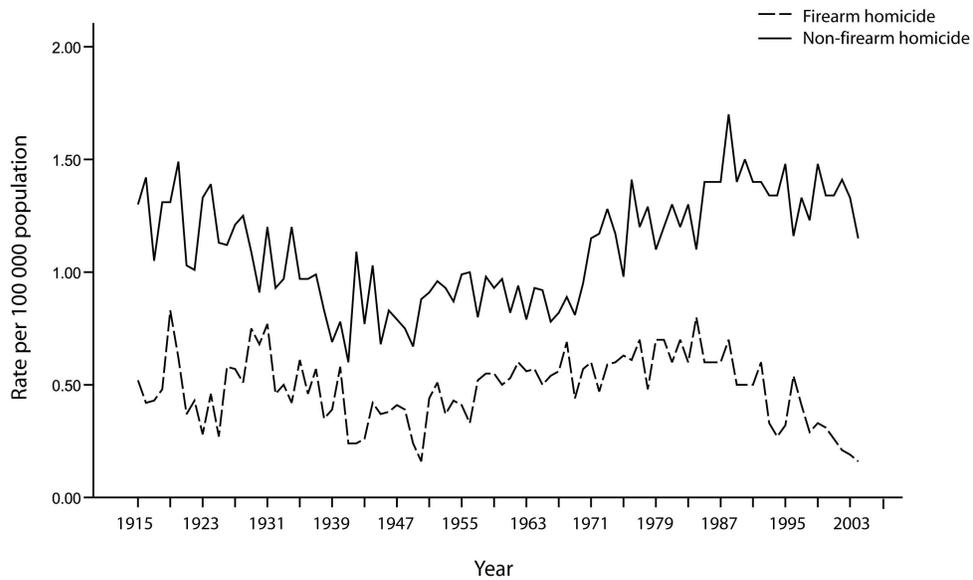


Figure 2: Long term trends for firearm and non-firearm homicide in Australia

Various authors have examined overall trends in firearm related deaths. For example, Mouzos and Rushforth (2003) looked at general trends for firearm deaths over the period 1991-2001, with particular reference to demographic variations within types of firearm related death (such as age and gender trends for firearm suicides). Such papers, while

confirming the presence of ongoing downwards trends in firearm homicide and suicide, do not explicitly address the question of whether the 1996 legislative intervention had a clear impact on the rate of decline.

The 1996 legislative intervention provides a natural experimental design. Using this feature, an increasing number of publications have specifically set out to evaluate the impacts of the NFA, using the hypothesis that an accelerated rate of decline would be observed if the NFA had an effect. Extant studies present differing conclusions about the NFA. Baker and McPhedran (2007: 461) conclude that “[e]xamination of the long-term trends indicated that the only category of sudden death that may have been influenced by the introduction of the NFA was firearm suicide” whereas Chapman et al. (2006: 371) conclude that the legislative reform was followed by “accelerated declines in annual total gun deaths and firearm suicides and a non-significant accelerated decline in firearm homicides,” and Ozanne-Smith et al. (2004: 285) conclude that there were “dramatic declines in rates of firearm related deaths in the state of Victoria, and for the rest of Australia...in the context of strong legislative reform.”

The apparent inconsistency between the conclusions of the studies is undesirable for informing policy decisions – whether domestically or internationally - and merits closer examination with a view to arriving at an integrated overview of research on the impacts of the NFA. To date there has been no comprehensive review of the existing literature. Consequently, it has been difficult to gain an indicator of whether the published research, despite drawing different conclusions, has in fact produced consistent statistical results. The current paper begins to redress that shortcoming by placing particular focus on data selection and statistical methodology, and the outcomes of the statistical analyses.

Four studies were considered. These were: Baker and McPhedran (2007), Carcach, Mouzos, and Grabosky (2002), Chapman et al. (2006), and Ozanne-Smith et al. (2004). It

should be noted that Ozanne-Smith and colleagues' (2004) study compared one state (Victoria) with the rest of Australia, whereas other studies looked at nationwide data. Similarly, AIC publications (Carcach et al. 2002) tend to focus on firearm homicide rather than suicide, whereas other studies have examined both suicides and homicides. Although a greater number of studies would have been conducive to a thorough review process, at the time of writing only the above studies explicitly dealt with the impacts of the 1996 legislation as an intervention point.

### **Data selection**

Baker and McPhedran (2007), Chapman et al. (2006), and Ozanne-Smith et al. (2004) all use time series data from 1979 onwards, and base their analyses on data sourced primarily from the Australian Bureau of Statistics (ABS). The late 1970's represented a period where firearm deaths were at a peak (although not the highest on record - see Figures 1 and 2). While it could be argued that the use of a relatively high point in the time series as a starting point 'biases' predictions towards finding a continuation of the downwards trend post-1996, this is an a priori argument based on the untestable assumption that the pre-existing trend should not have continued post-1996. There is no empirical support for this claim. However, it is appropriate to note that time series analyses may be sensitive to data selection.

Importantly, the common purpose of the three studies mentioned above was not to compare recent trends against long term historical trends (which fluctuate substantially over time, a consideration discussed in greater detail under 'recommendations'). Rather, the stated intent of extant studies has been to assess whether the pre-existing downwards trend in firearm homicides and suicides continued post-1996 and, if so, whether it accelerated post-1996 relative to its earlier rate (or, in the case of Ozanne-Smith et al. 2004, pre- and post-1988 as well as 1996), or relative to predictions based on that earlier rate.

Baker and McPhedran's (2007) data series ended at 2004, Chapman et al. (2006) at 2003, and Ozanne-Smith et al. (2004) examine data to the year 2000. Carcach et al. (2002) looked at data from 1989 to 1999, a far shorter time series based upon information held in the National Homicide Monitoring Program (NHMP) database. On the surface, the variable time periods preclude direct comparison between the studies. However, in terms of review, the difference proves useful by enabling evaluation of whether the results differ depending on the post-1996 time series used. Consequently the different studies neatly elucidate the potential role of time series selection on statistical evaluation of the impact of an intervention (firearms legislation). They also provide an indicator of whether the results differ as a function of time, or whether consistent outcomes are found at each of the different cut-off points selected.

### **Methodology**

Each study employed a different data analysis method. Baker and McPhedran (2007) standardized the number of deaths against population, generating a rate expressed per 100 000 population. They applied ARIMA (AutoRegressive Integrated Moving Average) models to the time series, using the period 1979-1996 to predict death rates out to 2004. The predicted and observed rates were then compared using t-tests. In contrast, Chapman et al (2006) applied a negative binomial model, to compare rate ratios for 1979-1996 with 1997-2003. Although this model treats deaths as count data, in practical terms it expresses deaths as rates, by using population as an offset.

Ozanne-Smith et al. (2004) used a slightly different modeling approach to Baker and McPhedran (2007) and Chapman et al. (2006). Namely, they compared three epochs: 1979-1988, 1989-1996, and 1997-2000. Those periods were selected because Victoria changed its firearm laws in 1988, then again in 1996. Ozanne-Smith et al. (2004) used a Poisson regression model that incorporated a fixed offset. They treated death counts as the dependent

variable in the model, while the offset (population counts by region and year) enabled their analysis to focus on rates rather than absolute death counts.

Carcach et al. (2002) adopted a different experimental focus; they set April 1996 (in which the Port Arthur killings occurred) as a 'pivot point' in the data series, and looked at whether there were any transitory or sustained changes in homicide in Australia. They used intervention analysis (Moving Average process, a variation of the ARIMA technique) to compare the time series of daily homicides before and after April 1996, with the number of incidents as the variable of interest.

### **Analyzing trends over time: general considerations**

Given that each study examined trends over time, a brief note about general differences in analysis methods is helpful. While there is no 'one size fits all' approach to time series analysis, considerations such as the form of the data and general assumptions of the models used should be taken into account. Of particular relevance in the current context is the presence of nonstationary data (i.e., data that changes over time/contains a trend, such as the incidence of firearm deaths), which has different implications for each model. In Poisson models, it may be appropriate to perform an inverse transformation of the data to accommodate nonstationarity, whereas an assumption of negative binomial models is that the data are stationary (means and variances are constant over time). In contrast, ARIMA approaches nonstationarity by incorporating differencing equations into a model, to make the series stationary.

For example, a model with one order of differencing assumes the presence of a constant trend, whereas a model with two orders assumes the series has a time-varying trend. Related considerations about time series modeling, particularly when forecasting methods such as ARIMA are used, include the number of past observations used to predict each future value and the value assigned to the moving average (the number of past error terms to be

used in determining the weighted average of the present observation). These parameters are generally set based on the characteristics of the data, and may in turn influence the results obtained.

The minimum period required for meaningful analysis of trends over time is a subject of ongoing debate, and there is no broad consensus in this regard. Some argue that the minimum number of data points should simply exceed the number of parameters contained within the model used (e.g., Hyndman & Kostenko 2007) whereas others adopt general rules of thumb such as 'six or more years' (e.g., Murdoch, Wilcox, Kuzmicich, & Krsinich 2000). In the current context, two studies (Baker & McPhedran 2007 and Chapman et al. 2006) used post-intervention time series of seven or more years. Ozanne-Smith et al. (2004), however, had only four years of post-1996 data available at the time of their study. In contrast, Carcach et al. (2002) assessed relatively few years of data, but increased the number of data points available through looking at daily data.

## **Results**

Despite the disparate statistical approaches, each study has produced remarkably consistent results. Chapman et al. (2006) found no significant difference in the rate ratios for firearm homicide pre- and post-1996. Ozanne-Smith et al. (2004) found no significant differences in trends for firearm homicides across different periods of firearm legislative reform. Baker and McPhedran (2007) found no significant difference in the predicted and observed rates of firearm homicide post-1996 (that is, the pre-existing trend in firearm homicides did not accelerate post-1996). Carcach et al. (2002), using the shortest time series, found no evidence that the incidence of firearm homicide changed after April 1996.

Of the three studies examining firearm suicide, all found significant differences in the pre- and post-1996 trends. It should be noted that firearm suicides account for the vast majority of firearm related deaths in Australia (around 80%). This in turn impacts upon the

findings for overall firearm related deaths. Baker and McPhedran (2007) did not combine and analyze all deaths, instead keeping each type of death in a separate category. They noted a downward acceleration in suicides post-1996. Chapman et al. (2006) and Ozanne-Smith et al. (2004) examined total firearm deaths pre- and post-1996. The latter two studies found a significant acceleration in the downwards trend in total firearm deaths, which reflects a statistical byproduct of the large number of suicides and the acceleration in the decline in firearm suicides post-1996.

Baker and McPhedran (2007) and Chapman et al. (2006) both examined trends for non-firearm homicides and suicides. Chapman et al. (2006) found a significant difference pre- and post-1996 for non-firearm suicides, with faster declines post-1996. They also found a faster decline in non-firearm homicides post-1996, although the acceleration barely reached levels of statistical significance. Baker and McPhedran's (2007) analysis of non-firearm deaths did not find significant differences pre- and post-1996, although they do acknowledge that non-firearm suicides began declining after many years of increases. Ozanne-Smith et al. (2004) did not include non-firearm deaths in their analyses, but mention that in Victoria overall suicide and homicide levels did not decline following legislative change.

Unintentional (i.e., accidental) firearm deaths were falling prior to the change in legislation but then increased post-1996, which is noted by all authors. This was an unexpected observation, given that it would be reasonable to expect a continuation of the pre-existing decline in unintentional firearm deaths following legislative intervention. However, it is possible that the reported incidence of unintentional deaths may not reflect the actual incidence of such deaths. Specifically, current data coding practices may be 'over-counting' unintentional firearm deaths (McPhedran & Baker 2008). Until this question is satisfactorily resolved it remains premature to draw any firm conclusions about unintentional firearm

deaths, and therefore the current review focuses on consistency between studies with regard to homicide and suicide findings.

### **Method substitution**

There has been considerable debate within criminological and psychological literature about whether restricting legal access to certain methods is associated with displacement or substitution. Much of this debate is set against a background of rational choice theory. Rational choice theory rests on the premise that individuals contemplating suicide or a criminal act will respond to situations by evaluating opportunities, as well as costs and benefits (not necessarily financial), before deciding whether they will engage in method substitution or refrain from criminal or suicidal action (e.g. Cornish & Clarke 1986, 1987; Guerette, Stenius, & McGloin 2005; Hayward 2007).

It has been noted in relation to suicide that although method restriction may be associated with decreases in deaths using that particular method, overall declines do not necessarily occur (Beautrais 2007). For example, De Leo, Evans, and Neulinger (2002) observed that in one Australian state, Queensland, declines in male firearm suicide were offset by increases in suicides via hanging. It has also been suggested that declines in suicide may arise from external factors such as greater public awareness of mental health issues, and the increased use of antidepressants (Goldney 2006), rather than representing an influence of method restriction.

Similarly, the efficacy of method restriction as a form of situational crime prevention, and enacted through firearms legislation, remains equivocal. The results of such interventions vary between and within countries (Cook, Moore, & Braga 2001; Killias, van Kesteren and Rindlisbacher 2001). Furthermore, consideration should be given to the prospect of divergence between short-term and long-term outcomes; for instance, whether evidence for or

against method substitution is transitory or sustained. There is no consensus as to the time frame within which method substitution would be expected to occur.

There are difficulties in directly testing for the presence of method substitution, primarily because a rigorous experimental approach is not usually possible. For example, a suitable control group may not be available, and the role of external factors in influencing trends may not be readily quantifiable. Consequently, displacement is generally assessed by proxy, through comparing observed trends in the use of different methods. In the context of changes to firearms legislation it would be expected that if method substitution occurred, it would manifest as an “increasing downward trend in firearm deaths after the introduction of gun control laws but a compensatory lesser downward or even upward trend in non-firearm-related deaths over the same period” (Chapman et al. 2006: 366).

Baker and McPhedran (2007) and Chapman et al. (2006) discuss method substitution in relation to firearms legislation, and include non-firearm homicides and suicides in their analyses. Both studies agree that there is little evidence of method substitution post-1996. This is particularly applicable to firearm suicides, given the accompanying declines in non-firearm suicides. However, the decline in non-firearm suicides is noted by Baker and McPhedran (2007) as a confound when attempting to draw conclusions about the accelerated decline in firearm suicides post-1996. The authors suggest that any effects of firearms legislation on firearm suicides cannot be adequately differentiated from the likely impacts of wider social changes (for example, improved funding for mental healthcare) on all suicides, regardless of method. There is a clear need for more comprehensive investigation of this question.

Ozanne-Smith et al’s (2004) observation that overall suicide and homicide rates did not change in Victoria highlights a question that has not been adequately addressed to date. Specifically, regional variations in firearm and non-firearm homicide and suicide trends have

not been well examined. This may be a difficult task for firearm homicides given the relatively low sample size nationally. However, it appears prudent to give greater consideration to regional variation as it applies to firearm and non-firearm suicides, and to continue to exercise caution regarding the impacts of firearm legislation on firearm suicides until this type of analysis can be undertaken.

### **Future directions**

None of the above papers attempt to analyze the post-1996 trends against historical epochs using a longer time series. However, there are a number of considerations that should be addressed if longer time series were to be used. The long term data contain a number of fluctuations. For example, firearm suicide rates peaked in the 1930's, then declined, then began to rise again from the 1970's onward. Consequently, any conclusions about post-1996 trends, based on long term data, would need to be contextualized against the possibility that the declines represent firearm homicides and suicides falling to 'historically average' levels rather than any influence of legislative change. This possibility places a clear caveat upon assessments of the impacts of the NFA.

Applying any of the models mentioned above to such variable long term data containing trends in both directions would not be statistically sound unless a series of precise 'intervention' points were included or evidence of a regular cyclic trend could be demonstrated. Even then, the application of the models used in current studies to long term time series would produce questionable results. It is possible that different approaches (for example, Bayesian/neural network modeling, nonlinear techniques) may prove informative in this regard.

Additionally, it is not particularly meaningful to compare the relatively short post-1996 period with a period of over 80 years (represented by the 1915-1996 series). Longer term time series encompass a range of prominent external events that could foreseeably affect

the incidence of firearm and non-firearm homicide and suicide (for example, two World Wars). Consequently, if comparisons of the post-1996 trends with historical trends were undertaken, it would be necessary to try to take into account external factors and the underlying shape of the data.

The studies under review took a univariate approach. Time was the only independent variable included in the various models used. However, relevant covariates merit inclusion in future studies. These may include economic indicators like employment levels and/or home loan interest rates, which have both been associated with the incidence of male suicide in particular (Berk, Dodd, and Henry 2006). Also, the inclusion of broad socioeconomic covariates may generate helpful insights.

### **Conclusions**

Review of existing literature shows that disagreement about the impacts of the NFA cannot be attributed to different statistical outcomes. The extant literature is extremely consistent in its findings – namely, that there was no significant change in the rate of decline in firearm homicides following the legislative intervention, and that there was a significant acceleration in the rate of decline in firearm suicides. Therefore, it appears that any disagreement over the NFA arises from the different conclusions presented in the various studies rather than from the outcomes of the statistical analyses. This in turn appears to relate to a handful of common interpretive misunderstandings.

One example of interpretive confusion is a failure to recognize that accelerated declines in overall firearm related deaths are a byproduct of the high proportion of firearm suicides included in the overall figures. Another common example is overlooking the implications of the decline in non-firearm suicides when interpreting analysis of firearm suicides. Since the likely influence of social and other change on suicides across the board cannot be readily disaggregated from possible influences of gun laws on firearm suicides, it

remains unwise to draw firm conclusions about the NFA and firearm suicide. This also relates to interpretations of method substitution; if the declines in non-firearm suicide are taken as evidence against method substitution, then the declines in non-firearm suicide must also be acknowledged as evidence of additional factors unrelated to firearm legislation contributing to declines overall.

A caution is necessary concerning arguments that a certain outcome ‘could not’ or ‘would not’ have happened had the legislation not been introduced. An example of such reasoning would be a statement that the downward trends would not have continued post-1996, had the laws not been implemented, and inferring that the laws therefore had an impact because the downwards trend did continue post-1996. Such assertions are based upon a framework which seeks to draw conclusions from a priori and untestable premises. While playing a role within theoretical discussion, a priori arguments should not take precedence over empirical evidence. In the current context (evaluating evidence for the impacts of an intervention) it is necessary to adhere to an experimental approach that sets out testable hypotheses and uses empirical methods.

Studies on Australia’s firearms legislation, using different time series and different statistical methodologies, have produced consistent results. In light of this, it appears reasonable to conclude that on the basis of available research there is no evidence for an impact of the NFA on firearm homicides and that the evidence for an impact on firearm suicides must be contextualized against the declines in non-firearm suicide that became evident from 1997 onwards. It is hoped that the overall consistencies revealed by review of existing studies, as well as the identification of common interpretive misunderstandings that have created the appearance of incongruent findings, will provide a guide for future research efforts and allow policymakers greater confidence when approaching domestic and international firearms policy.

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