

Appendix

Contents

1. SUPPLEMENTARY METHODS	3
DATA SOURCES	3
DETAIL OF MODEL EQUATIONS	3
BASE MODELS	4
2. SUPPLEMENTARY RESULTS	5
3. SENSITIVITY ANALYSIS	9

List of tables

Table A: ICD codes used for suicide definition, by year and ICD era	3
Table B: Interpretation of key coefficients	4
Table C: Difference-in-difference analysis of suicide mortality by narrow suicide categories, 1978 – 2015, by sex	6
Table D: Pre-and post-NFA trends in suicide mortality by suicide/assault method and sex	7
Table E: Pre-and post-NFA trends in suicide mortality by narrow suicide method and sex	8
Table F: Difference-in-difference analysis of suicide mortality with 1998 implementation date, 1978 – 2015, by sex	10
Table G: Difference-in-difference analysis of assault mortality with 1998 implementation date, 1978 – 2015, by sex	12

List of figures

Figure A: Trends in age-standardized firearm- and non firearm-related suicides, 1975-2015, by sex	5
Figure B: Impact of changing data series start year on difference-in-difference coefficient, by sex, for broad categories of suicide method	13
Figure C: Impact of changing data series start year on difference-in-difference coefficient, by sex, for homicide	14

1. Supplementary Methods

Data sources

Table A shows the ICD codes used to define suicide categories by ICD era.

Table A: ICD codes used for suicide definition, by year and ICD era

Years	ICD version	ICD code				
		Gun	Drowning	Gas	Hanging	Poisoning
1907 – 1917	1	159	158		157	155
1918 – 1921	2	159	158		157	155
1922 – 1930	3	170	169	167	168	165, 166
1931 – 1939	4	167	166	164	165	163ab
1940 – 1949	5	164c	164b	163b	164	163a
1950 – 1957	6	E976	E975	E972, E973	E974	E970, E971
1958 – 1967	7	E976	E975	E972, E973	E974	E970, E971
1968 – 1978	8	E955	E954	E951, E953	E953	E950
1979 – 1996	9	E955	E954	E951, E952	E953	E950
1997 – present	10	X72-X75	X71	X67	X70	X60-X66, X68-X69

Detail of model equations

The basic data analysis uses a difference-in-difference model structure to assess the effect of the NFA. Data are modeled as Poisson distributed, with population included in the model as an offset to ensure that changes in population structure are accounted for. The model is conducted separately by sex. The model includes a term for a linear time trend, with interaction terms to allow different time trends by homicide or suicide type. A step term (0 before 1997, 1 after) is included to model the impact of the NFA. To account for the possibility of variation in changes in each homicide or suicide category, an interaction between the step term and the suicide/homicide category is also included. To allow for a common effect on the trend, an interaction between time and the step term is included. Finally, to answer the key research question, a three-way interaction between suicide/homicide type, the step term, and time will also be tested. This three way interaction, if significant, indicates that the effect of the NFA on time trends differed between suicide/homicide category.

This can be written in equation form for the simplest case as follows. Suppose that at time i we have data on the number of firearm or non-firearm related suicide deaths y_i , occurring at rate μ_i in population n_i .

Then we can describe the fundamental distribution of the data as

$$y_i \sim \text{Poisson}(\mu_i)$$

where the rate μ_i is related to the covariates through a log-linear expression as follows:

$$\ln(\mu_i) = \alpha + \ln(n_i) + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3} + \beta_4 x_{i1} x_{i2} + \beta_5 x_{i2} x_{i3} + \beta_6 x_{i1} x_{i3} + \beta_7 x_{i1} x_{i2} x_{i3}$$

Where

α is the intercept term

x_{i1} is the year, with the first year in the data series (e.g. 1972) set to be 0

x_{i2} is an indicator variable for whether the death rate is for firearm-related or non firearm-related mortality (0 for non-firearm mortality, 1 for firearm mortality)

x_{i3} is the step function (0 for years <1997, 1 for 1997 and onward)

and coefficients measure the following effects:

- β_1 measures the time trend in non firearm-related mortality before the 1996 law
- β_2 measures the rate ratio of mortality in firearm vs. non firearm- mortality at the starting year
- β_3 measures the sudden increase or decrease in non-firearm mortality in 1997 relative to 1996
- β_4 measures the difference in trend for firearms relative to non-firearms in the period before 1996
- β_5 measures the sudden increase or decrease in firearm mortality in 1997 relative to 1996 (the additional impact of the NFA on the level of firearm mortality relative to non firearm- mortality)
- β_6 measures the change in trend in non firearm-mortality in 1997
- β_7 measures the additional change in trend in firearm mortality relative to non firearm-mortality in 1997

That is, β_7 is the specific additional benefit of the NFA on firearm deaths relative to non-firearm deaths. If β_6 is statistically significant and negative it indicates that there was a statistically significant decrease in the trend in non firearm-related mortality occurring contemporaneously with the NFA. In this case β_7 indicates the additional effect of the NFA on firearms mortality relative to non-firearm mortality. If β_6 is negative and β_7 is positive this indicates that non firearm-mortality was affected by the NFA more than firearm mortality. The implication of four possible combinations of values of these two coefficients is summarized in table B.

Table B: Interpretation of key coefficients

Value of β_6	Value of β_7	
	<0	>0
<0	Non-firearm mortality trend decreased after NFA, but firearm mortality trend decreased by a greater amount	Non-firearm mortality trend decreased after NFA, and the firearm mortality trend decreased by less than the non-firearm mortality trend, or even increased
>0	Non-firearm mortality trend increased after the NFA, but firearm mortality trend decreased or increased by less than the non-firearm trend	Both non-firearm and firearm mortality trends increased after the NFA, with firearm trends increasing by more than non-firearm trends

The study estimates these key parameters for suicide and homicide, separately by sex, adjusting for broad age groups and using two definitions of suicide category. One definition categorizes suicides as firearm-related or non firearm-related; the second categorize suicides separately in narrower categories of poisonings, shootings, drownings, gas or hanging. Results for the narrower categories of suicide are presented as supplementary results.

Base models

There are three basic models for this study:

- Suicide mortality by broad category (firearm vs. non-firearm)
- Suicide mortality by narrow category (poisoning, shooting, hanging, gas, drowning)
- Homicide mortality by broad category (firearm vs. non-firearm)

All three analyses are modeled separately by sex, with broad 15-year age categories, for data from 1978 – 2015, with the NFA assumed to start in 1997.

2. Supplementary results

This section shows additional information on mortality by narrow suicide categories. Figure A shows the trends in suicide mortality by broad category of method for men and women. This figure shows that non firearm-related suicides peaked in men at about the time the NFA was introduced, and were approximately broadly static in women before and after the NFA was introduced, though they appear to have been increasing more recently.

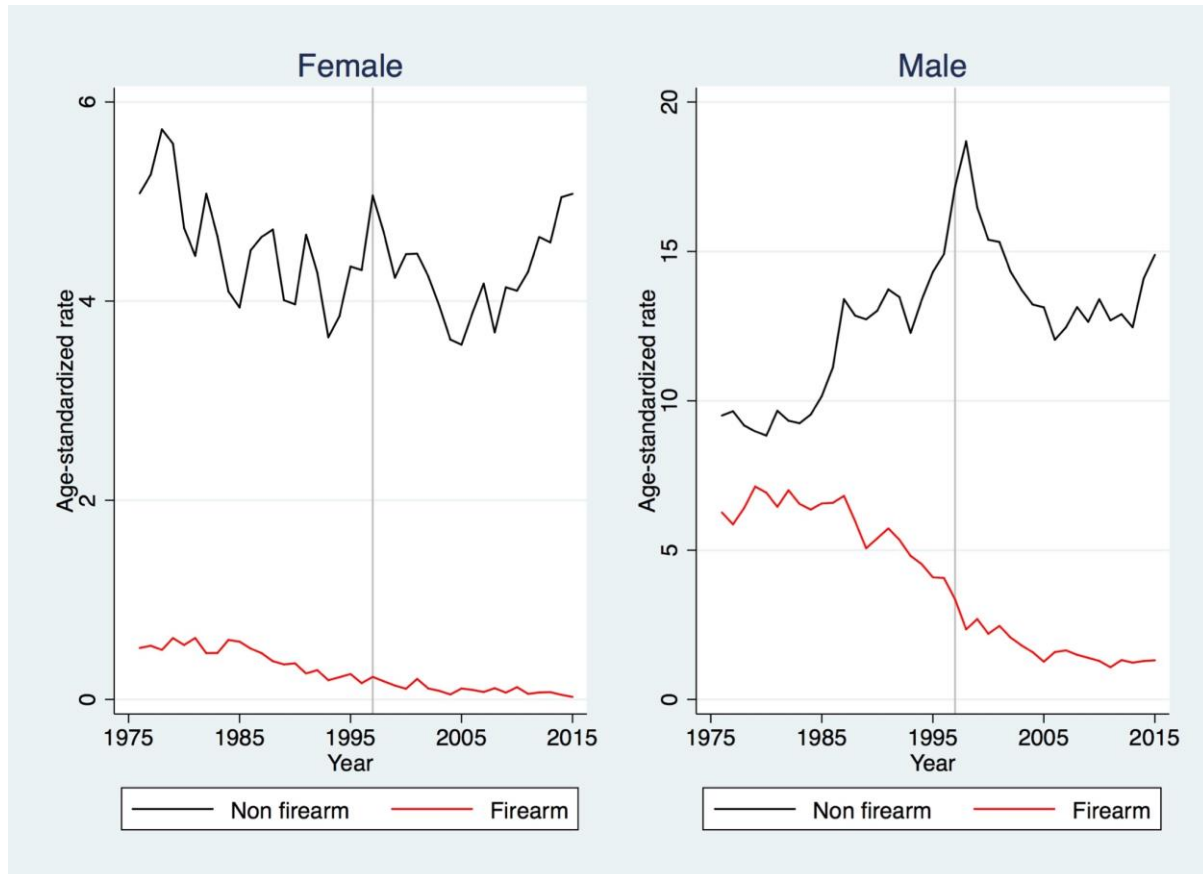


Figure A: Trends in age-standardized firearm- and non firearm-related suicides, 1975-2015, by sex

Table C shows the results of difference-in-difference analysis by narrow categories of suicide method. This is the same basic method as the difference-in-difference analysis of the main text, but with five categories of narrow method interacting with the time trend and the step function, rather than the two used in the main text. For simplicity, all reference categories in the interaction terms are collapsed to a single category (labeled “Reference levels”) to avoid complexity in the table. Firearms were set as the reference category for this analysis, so that a negative, statistically significant interaction coefficient for any other method shows that the NFA had a greater effect on reducing the trend of this method relative to firearms. A positive, statistically significant interaction coefficient for any method indicates that the effect of the NFA on firearm-related suicide was greater than for this method, i.e. that the NFA caused firearm-related suicide mortality to decline at a greater rate than the method for which the positive coefficient is observed. For women, this analysis of narrower categories of suicide method shows that suicides due to gas declined at a faster rate than firearm-related suicides after the NFA was introduced, and the NFA had a similar effect on drowning and hanging trends to firearm-related suicides. In men the NFA was associated with a statistically significantly greater reduction in trend for gas- and hanging-related suicides than for firearm-related suicides. Only poisonings showed a lower effect of the NFA than firearm-related suicides in both sexes.

Table C: Difference-in-difference analysis of suicide mortality by narrow suicide categories, 1978 – 2015, by sex

Female			
Variable	Rate ratio	95% CI	P value
Age group			<0.001
15-29 years	Ref.	-	
30-44 years	1.33	1.27 – 1.38	
45-59 years	1.42	1.36 – 1.49	
60 years and over	1.15	1.10 – 1.20	
Method			<0.001
Firearm	Ref		
Poisoning	4.16	3.28 – 5.27	
Drowning	0.75	0.54 – 1.02	
Gas	0.37	0.28 – 0.50	
Hanging	0.64	0.49 – 0.84	
Year	0.940	0.927 – 0.954	<0.001
NFA time period			
Before NFA	Ref		
After NFA	1.12	0.46 – 2.70	0.8
Method / year interaction			<0.001
Firearm	Ref		
Poisoning	1.023	1.007 – 1.040	
Drowning	1.016	0.995 – 1.038	
Gas	1.102	1.081 – 1.123	
Hanging	1.094	1.075 – 1.114	
NFA / year interaction			
Before NFA	Ref		
After NFA	0.989	0.960 – 1.019	0.5
NFA / Method interaction			<0.001
Reference levels	Ref		
After NFA / Poisoning	0.22	0.09 – 0.56	
After NFA / Drowning	0.77	0.26 – 2.35	
After NFA / Gas	30.63	11.54 – 81.30	
After NFA / Hanging	1.18	0.47 – 2.95	
NFA / Method / year interaction (DiD term)			<0.001
Reference levels	Ref		
After NFA / Poisoning	1.061	1.029 – 1.095	
After NFA / Drowning	1.019	0.980 – 1.059	
After NFA / Gas	0.886	0.856 – 0.917	
After NFA / Hanging	1.009	0.977 – 1.041	
Male			
Variable	Rate ratio	95% CI	P value
Age group			<0.001
15-29 years	Ref		
30-44 years	1.19	1.16 – 1.21	
45-59 years	1.06	1.03 – 1.08	
60 years and over	1.02	0.99 – 1.04	
Method			<0.001
Firearm	Ref		
Poisoning	0.38	0.34 – 0.43	
Drowning	0.05	0.04 – 0.07	
Gas	0.26	0.23 – 0.28	
Hanging	0.19	0.17 – 0.21	
Year	0.973	0.969 – 0.976	<0.001
NFA time period			
Before NFA	Ref		

After NFA	0.97	0.78 – 1.19	0.8
Firearm / year interaction			<0.001
Firearm	Ref		
Poisoning	1.011	1.004 – 1.018	
Drowning	1.025	1.010 – 1.039	
Gas	1.065	1.059 – 1.072	
Hanging	1.093	1.086 – 1.099	
NFA / year interaction			
Before NFA	Ref		
After NFA	0.982	0.975 – 0.989	<0.001
NFA / Method interaction			<0.001
Reference levels	Ref		
After NFA / Poisoning	0.54	0.40 – 0.74	
After NFA / Drowning	0.73	0.40 – 1.34	
After NFA / Gas	29.79	22.51 – 39.43	
After NFA / Hanging	4.38	3.43 – 5.59	
NFA / Method / year interaction (DiD term)			<0.001
Reference levels	Ref		
After NFA / Poisoning	1.034	1.023 – 1.046	
After NFA / Drowning	1.017	0.995 – 1.039	
After NFA / Gas	0.893	0.884 – 0.902	
After NFA / Hanging	0.965	0.956 – 0.974	

Table D combines all the main effect, two- and three-way interaction terms to produce estimates of the annual rate ratio for both suicide methods, for women and men separately. For example, this can be interpreted as finding that non firearm-related suicides were increasing by 3.3% per year in males before the NFA, and then began to decline at a rate of 1.4% per year after the NFA; compared to firearm-related suicides, which were declining at 3.0% per year before the NFA, and 4.5% per year after. This table shows clearly the extreme magnitude of the decline in non firearm-related suicides in men in the immediate aftermath of the NFA, which is inconsistent with the conclusion that the NFA was responsible for the change in firearm-related suicides.

Table D: Pre-and post-NFA trends in suicide mortality by suicide/assault method and sex

Sex and mortality type	Before NFA	After NFA
Suicide		
Female		
Non-firearm	0.987 (0.983 – 0.992)	1.003 (0.999 – 1.007)
Firearm	0.940 (0.927 – 0.954)	0.930 (0.906 – 0.954)
Male		
Non-firearm	1.032 (1.029 – 1.035)	0.986 (0.984 – 0.989)
Firearm	0.973 (0.969 – 0.976)	0.955 (0.949 – 0.961)
Assault		
Female		
Non-firearm	0.992 (0.984 – 1.000)	0.973 (0.964 – 0.982)
Firearm	0.970 (0.956 – 0.985)	0.920 (0.896 – 0.945)
Male		
Non-firearm	1.003 (0.997 – 1.009)	0.974 (0.968 – 0.980)
Firearm	0.979 (0.968 – 0.990)	0.948 (0.934 – 0.963)

Table E shows the impact of the NFA on the trends in suicide mortality by sex, comparing the trend before the NFA with the trend after the NFA. These trends are expressed as annual multiples, so can be converted into percentage declines by subtracting 1 from the value and multiplying by 100. It is clear from Table E that amongst men the trend in deaths due to gas and hanging both reduced by more than the trend for firearm-related suicides after the NFA was introduced, while amongst women the trend in firearm-related mortality did not change at the time of the NFA, while that for gas reduced significantly.

Table E: Pre-and post-NFA trends in suicide mortality by narrow suicide method and sex

Sex and method	Before NFA	After NFA
Female		
Firearm	0.940 (0.927 – 0.954)	0.930 (0.906 – 0.954)
Poisoning	0.962 (0.956 – 0.968)	1.009 (1.003 – 1.016)
Drowning	0.956 (0.941 – 0.970)	0.962 (0.945 – 0.981)
Gas	1.037 (1.025 – 1.049)	0.908 (0.897 – 0.918)
Hanging	1.029 (1.019 – 1.039)	1.026 (1.021 – 1.032)
Male		
Firearm	0.973 (0.969 – 0.976)	0.955 (0.949 – 0.961)
Poisoning	0.983 (0.978 – 0.989)	0.999 (0.993 – 1.005)
Drowning	0.996 (0.983 – 1.010)	0.995 (0.980 – 1.010)
Gas	1.036 (1.031 – 1.041)	0.908 (0.903 – 0.913)
Hanging	1.063 (1.058 – 1.068)	1.007 (1.005 – 1.010)

3. Sensitivity Analysis

Table F shows the difference-in-difference analysis of the effect of the NFA on trends in suicide mortality if the implementation start date is changed to 1998, for broad categories of method and separately by sex. For women the NFA had no significant impact on firearm-related suicides above the effect observed in non firearm-related suicides, while for men it was associated with a statistically significantly lower effect on the trend – that is, the NFA caused a larger decline in the trend for non firearm-related suicides than for firearm-related suicides. These results are similar to those obtained with an implementation date of 1997, indicating that the change in implementation date to 1998 made little difference to the overall conclusions of the study.

Table F: Difference-in-difference analysis of suicide mortality with 1998 implementation date, 1978 – 2015, by sex

Female			
Variable	Rate ratio	95% CI	P value
Age group			<0.001
15-29 years	Ref		
30-44 years	1.33	1.27 – 1.38	
45-59 years	1.42	1.36 – 1.49	
60 years and over	1.15	1.10 – 1.20	
Method			
Non firearm	Ref		
Firearm	0.20	0.16 – 0.24	<0.001
Year	0.991	0.987 – 0.995	<0.001
NFA time period			
Before NFA	Ref		
After NFA	0.67	0.57 – 0.78	<0.001
Firearm / year interaction			
Non firearm	Ref		
Firearm	0.949	0.935 – 0.963	<0.001
NFA / year interaction			
Before NFA	Ref		
After NFA	1.015	1.009 – 1.021	<0.001
NFA / Method interaction			
Before NFA / non firearm	Ref		
Before NFA / firearm	Ref		
After NFA / non firearm	Ref		
After NFA / firearm	1.30	0.48 – 3.54	0.6
NFA / Method / year interaction (DiD term)			
Before NFA / non firearm	Ref		
Before NFA / firearm	Ref		
After NFA / non firearm	Ref		
After NFA / firearm	0.981	0.949 – 1.013	0.2
Male			
Variable	Rate ratio	95% CI	P value
Age group			<0.001
15-29 years	Ref.		
30-44 years	1.19	1.16 – 1.21	
45-59 years	1.06	1.03 – 1.08	
60 years and over	1.02	0.99 – 1.04	
Method			
Non firearm	Ref		
Firearm	1.33	1.24 – 1.43	<0.001
Year	1.034	1.032 – 1.037	<0.001
NFA time period			
Before NFA	Ref		
After NFA	3.04	2.77 – 3.34	<0.001
Firearm / year interaction			
Non firearm	Ref		
Firearm	0.938	0.933 – 0.942	<0.001
NFA / year interaction			
Before NFA	Ref		
After NFA	0.955	0.952 – 0.959	<0.001
NFA / Method interaction			
Before NFA / non firearm	Ref		
Before NFA / firearm	Ref		
After NFA / non firearm	Ref		
After NFA / firearm	0.25	0.19 – 0.32	<0.001

NFA / Method / year interaction (DiD term)			
Before NFA / non firearm	Ref		
Before NFA / firearm	Ref		
After NFA / non firearm	Ref		
After NFA / firearm	1.037	1.029 – 1.046	<0.001

Table G shows the same difference-in-difference analysis for assault, with the NFA implementation date set to 1998. For both sexes the NFA had no significant impact on firearm-related assault deaths above the effect observed in non firearm-related assaults at this time. For both women and men the NFA was associated with a statistically significant reduction in the trend of non firearm-related deaths, indicating that the change in implementation date to 1998 made little difference to the overall conclusions of the study.

Table G: Difference-in-difference analysis of assault mortality with 1998 implementation date, 1978 – 2015, by sex

Female			
Variable	Rate ratio	95% CI	P value
Age group			<0.001
15-29 years	Ref		
30-44 years	1.03	0.96 – 1.11	
45-59 years	0.72	0.66 – 0.78	
60 years and over	0.48	0.44 – 0.53	
Method			
Non firearm	Ref		
Firearm	0.40	0.31 – 0.52	<0.001
Year	0.991	0.984 – 0.999	0.02
NFA time period			
Before NFA	Ref		
After NFA	1.23	0.85 – 1.77	0.3
Firearm / year interaction			
Non firearm	Ref		
Firearm	0.979	0.963 – 0.994	0.007
NFA / year interaction			
Before NFA	Ref		
After NFA	0.984	0.972 – 0.996	0.01
NFA / Method interaction			
Before NFA / non firearm	Ref		
Before NFA / firearm	Ref		
After NFA / non firearm	Ref		
After NFA / firearm	1.43	0.49 – 4.16	0.7
NFA / Method / year interaction (DiD term)			
Before NFA / non firearm	Ref		
Before NFA / firearm	Ref		
After NFA / non firearm	Ref		
After NFA / firearm	0.975	0.942 – 1.010	0.2
Male			
Variable	Rate ratio	95% CI	P value
Age group			<0.001
15-29 years	Ref.	-	
30-44 years	1.16	1.10 – 1.22	
45-59 years	0.84	0.79 – 0.90	
60 years and over	0.49	0.46 – 0.53	
Method			
Non firearm	Ref		
Firearm	0.44	0.36 – 0.53	<0.001
Year	1.002	0.996 – 1.008	0.5
NFA time period			
Before NFA	Ref		
After NFA	1.62	1.25 – 2.11	<0.001
Firearm / year interaction			
Non firearm	Ref		
Firearm	0.978	0.965 – 0.983	<0.001
NFA / year interaction			
Before NFA	Ref		
After NFA	0.974	0.965 – 0.983	<0.001
NFA / Method interaction			
Before NFA / non firearm	Ref		
Before NFA / firearm	Ref		
After NFA / non firearm	Ref		
After NFA / firearm	0.85	0.44 – 1.63	0.6

NFA / Method / year interaction (DiD term)			
Before NFA / non firearm	Ref		
Before NFA / firearm	Ref		
After NFA / non firearm	Ref		
After NFA / firearm	1.001	0.979 – 1.023	0.9

Figure B shows the trend in the difference-in-difference coefficient for women and men as the starting year of the data used for analysis is moved backwards in one year increments from 1978 to 1961. This figure shows the changing coefficient for broad categories of suicide only. It indicates that the finding for female suicide rates is quite dependent on start year, with the impact of the NFA becoming statistically significant if data from before 1976 is included in the sample. For men the lack of impact of the NFA is a more robust finding, but this finding also reverses if data from before 1968 is included in the sample.

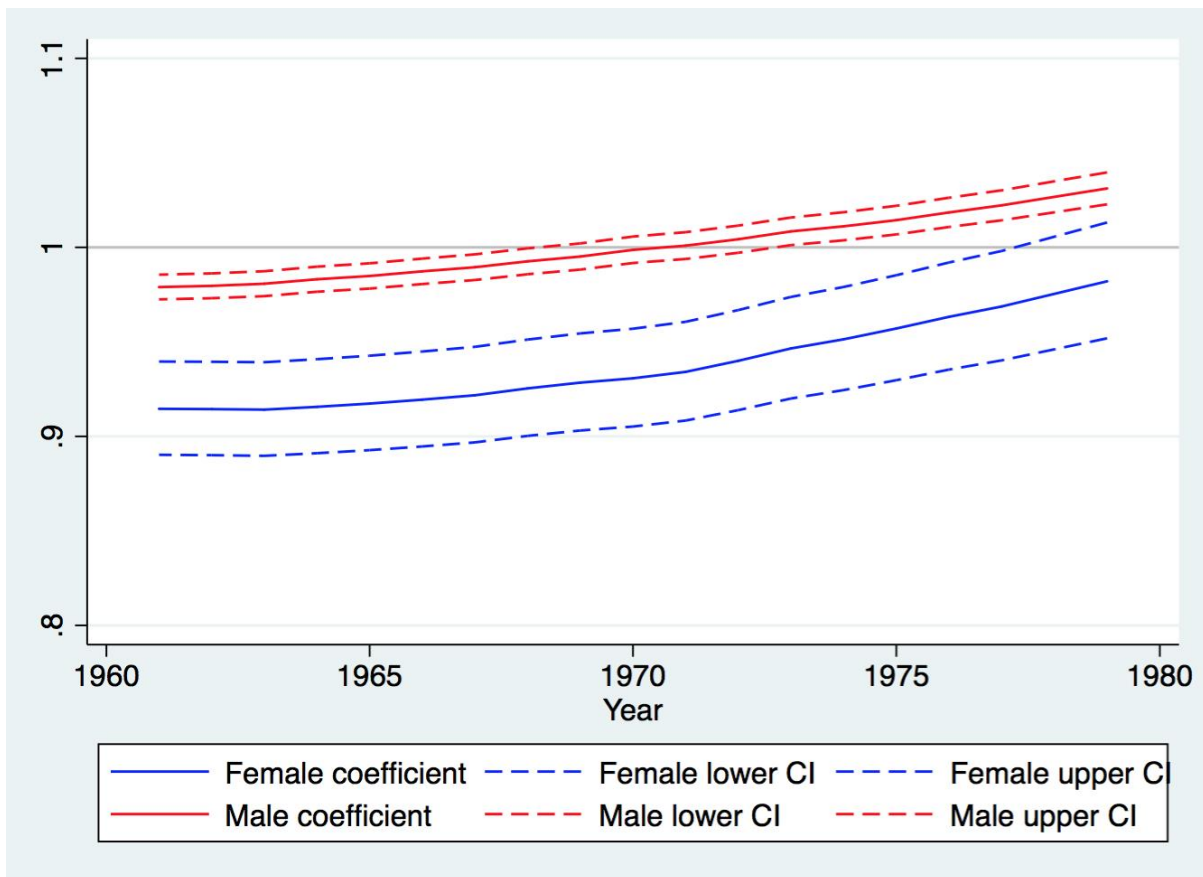


Figure B: Impact of changing data series start year on difference-in-difference coefficient, by sex, for broad categories of suicide method

Figure C shows the same sensitivity analysis for homicide deaths, by sex. This figure shows that the effectiveness of the NFA becomes statistically significant for women if data from before 1975 is included in the analysis, but that there is no change in the finding of non-significance for men even if the data series is extended as far back as 1961.

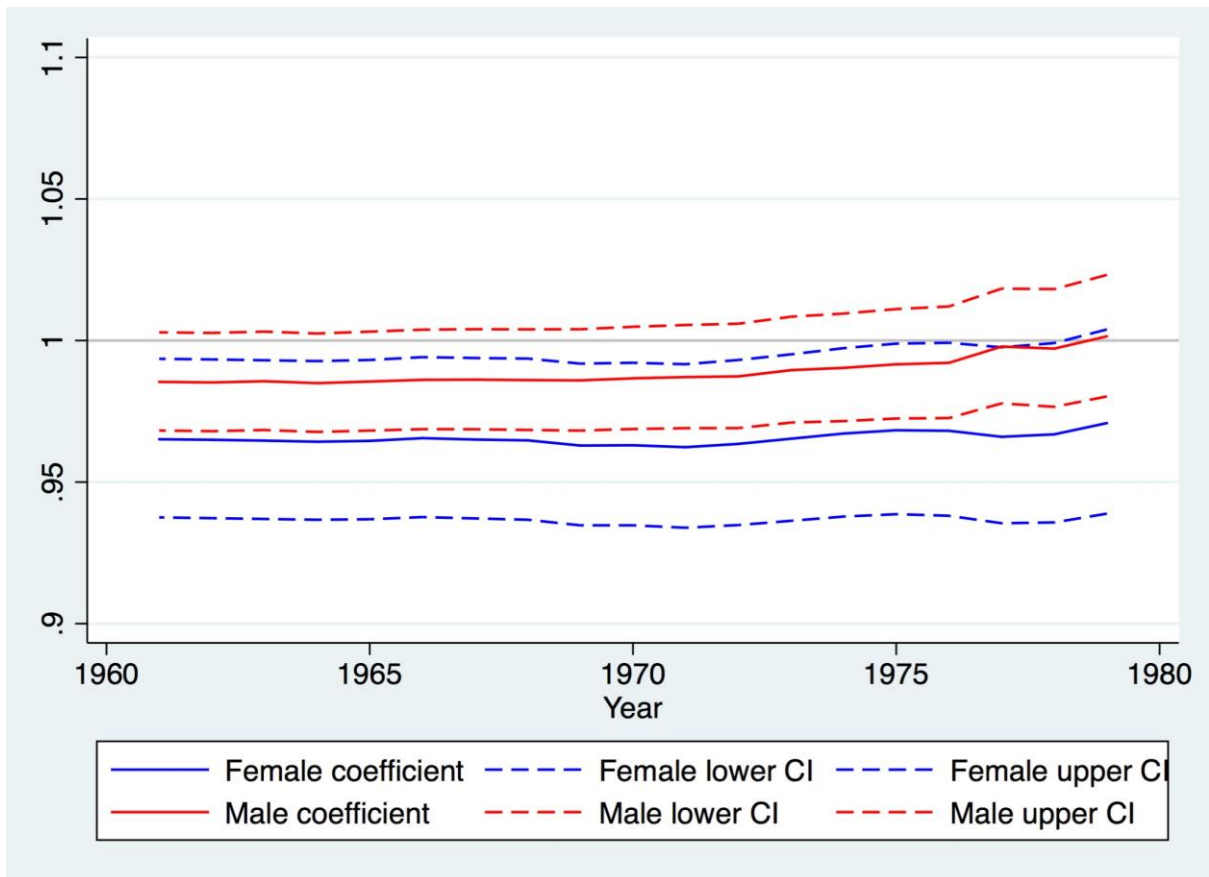


Figure C: Impact of changing data series start year on difference-in-difference coefficient, by sex, for homicide