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State-specific, racial and ethnic heterogeneity in trends of firearm-related fatality rates in the USA from 2000 to 2010

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ABSTRACT

Objectives: To document overall, racial, ethnic and intent-specific spatiotemporal trends of firearm-related fatality rates (FRF rates) in the USA.

Design: Cross-sectional study per year from 2000 to 2010.

Setting: USA.

Participants: Aggregate count of all people in the USA from 2000 to 2010.

Outcome measures: Data from the Web-based Injury Statistics Query and Reporting System from 2000 to 2010 was used to determine annual FRF rates per 100 000 and by states, race, ethnicity and intent.

Results: The average national 11-year FRF rate was 10.21/100 000, from 3.02 in Hawaii to 18.62 in Louisiana: 60% of states had higher than national rates and 41 states showed no temporal change. The average national FRF rates among African-Americans and Caucasians were 18.51 and 9.05/100 000 and among Hispanics and non-Hispanics were 7.13 and 10.13/100 000; Hispanics had a decreasing change of −0.18, p trend<0.0001. In states with increasing trends (Florida and Massachusetts), Caucasians and non-Hispanics drove the rise; while in states with decreasing trends (California, North Carolina, Arizona, Nevada, New York, Illinois, Maryland), Hispanics and African-Americans drove the fall. The average national FRF rates due to homicides (4.1/100 000) and suicides (5.8/100 000) remained constant, but varied between states.

Conclusions: Endemic national FRF rates mask a wide variation in time trends between states. FRF rates were twice as high in African-Americans than Caucasians but decreased among Hispanics. Efforts to identify state-specific best practices can contribute to changes in national FRF rates that remain high.

Strengths and limitations of this study

- This study uses the best available data reporting system for surveillance of firearm mortality in the USA.
- Brings into light the overall state-specific variability of temporal trends of firearm mortality, which was obscured by the endemic national firearm fatality rates during 2000–2010 and according to race, ethnicity and intent from a seemingly stable national burden of firearm deaths.
- This is the first report that documents firearm fatality trends by ethnicity.
- Our results call for identification of drivers of state-specific temporal trends to introduce tailored programmes targeted to reduce deaths and injury due to firearms.
- Possible under-reporting of firearm fatal events, which cannot be verified.
- Despite the considerable state-specific heterogeneity, the actual variation in firearm mortality may be a feature of cities and counties with varying crime rates, and we do not address the variation existing at such level.
- Finally, comparisons made between other races may not be usefully interpreted due to the heterogeneity and the small frequency of annual events in this subpopulation.

Firearm violence increased during the 1980s and peaked in 1993, with 39 595 firearm deaths in the USA and a firearm-related fatality rate (FRF rate) of 15/100 000.[1] Since the turn of the 21st century, FRF rates in the USA have become endemic around 10.3/100 000 accounting for 17.5% of all injury deaths,[2] while the intent of firearm deaths was mainly suicide and homicide.[3]

The FRF rate in 1993 among African-Americans was three times greater than Caucasians, but similar among Hispanics and non-Hispanics.[1 4] The overall fall in FRF after 2000 corresponded to a related narrowing of the racial gap between African-Americans and Caucasians, where, by 2010, the FRF rates among African-Americans were twice greater than Caucasians.[1] Several factors have been posited that might explain these persistent racial differences, including socioeconomic determinants and increased firearm availability.[5 6]

Although the national temporal trends in FRF have been previously well documented,[3 7 8] there is ample reason to suspect substantial heterogeneity in FRF across states, such as dramatic differences in gun laws controlling access to firearms, variability in enforcement of national standards across states,[8 9] changing demographics and violence.[10] It is likely that some of the state-to-state heterogeneity in the potential determinants of FRF may also contribute to variability in racial and ethnic differences in FRF within states.

With this in mind, this study had two distinct aims. First, we aimed to document national and state-specific trends in FRF rates along with the annual change in FRF rates from 2000 to 2010 and second, to determine the racial, ethnic and intent-specific differences in FRF rates within each state during the same time period.

METHODS

Data source

We accessed the restricted fatal injury data reports from the Web-based Injury Statistics Query and Reporting System (WISQARS), an interactive database system provided by Centers for Disease Control and Prevention's (CDC) Injury Prevention and Control Unit (http://www.cdc.gov/injury/wisqars/).[1] The data in the WISQARS system are derived from CDC annual mortality data from National Vital Statistics System (NVSS), National Center for Health Statistics (NCHS; http://www.cdc.gov/nchs/) and CDC. The NCHS and the National Association of Public Health Statistics and Information Systems restrict reporting NVSS data for cumulative frequencies <10 for subnational geographic areas to prevent unintentional disclosure of cases. International Classification of Disease-10th Revision (ICD-10) was used for coding mortality data including intent of injury.[11]

Study population and variables

Our study population consisted of national and state-specific fatal firearm injuries from 2000 to 2010 obtained from querying the WISQARS data system. Aggregate information such as number of firearm deaths, total population and age-adjusted rates according to race (African-American, Caucasian, other), ethnicity (Hispanic and non-Hispanic) and intent (homicide/legal intervention, suicide, undetermined and unintentional) was obtained.

Statistical analysis

The SEs for national and state-specific age-adjusted FRF rates per 100 000 persons were derived for the overall 11-year period and annually and by race, ethnicity and intent. Age-adjusted rates are obtained by direct standardisation using the 2000 population. The overall 11-year rates were assessed as total firearm deaths over the total population during the 11 years. Since only aggregate data could be obtained from WISQARS without individual patient data, we used random-effects meta-analysis and metaregression.[12] The rates in each category and the SEs were meta-analysed using random-effects meta-analysis. Heterogeneity between states was assessed using I^2 statistic; which ranges from 0% to 100% and denotes the proportion of variation across states other than by chance.[13 14] In order to assess the temporal trends from 2000 to 2010, we assumed linear trends across 11 years and used metaregression to calculate the change in rates (slope) and the SD. The p value from metaregression was used to assess evidence for trend. Standardised mean difference (SMD) was calculated by dividing the annual change in age-adjusted rate by SD.[15 16] We do not present estimates for those states with number of deaths below 10. Lives-lost or lives-saved are estimated by applying annual change to the total 11-year population (2000–2010). The difference between 11-year national and state-specific FRF rates (overall and category-specific) were used to spatially represent the variation between states. STATA V.13.1 (StataCorp LP, College Station, Texas, USA; 2009) was used to analyse the data.

RESULTS

Between 2000 and 2010, a total of 335 609 firearm-related deaths were recorded and the overall mortality rate was 10.21/100 000. The annual change in FRF rate across 11 years was −0.017 with a 95% CI of −0.044 to 0.010, p trend=0.18, indicating no significant change in national FRF rates. Table 1 presents national FRF rates, for 11 years and annually according to race, ethnicity and intent. Cumulative 11-year FRF rates were disproportionally high among African-Americans (18.51) as compared with Caucasians and other race groups, and lowest among other races (3.38). Among Caucasians, the FRF rates were lower than the overall national 11-year rate while increasing from 8.97 to 9.2 from 2000 to 2010. This annual increase was small (0.006, SMD=0.11) but not significant, p trend=0.71. Even though the FRF rates among African-Americans were consistently higher than national FRF rates, the annual rates reduced from 18.3 to 16.9; and this decline, −0.114, was not significant, SMD=−0.40, p trend=0.22. The decline in FRF rates from 4.76 to 3.25 among other races was significant (change=−0.12, SMD=−1.83, p trend<0.0001). Annual reduction observed among Hispanics showed a significant reduction, −0.179, p trend<0.0001 alongside an already low 11-year FRF rate of 7.13. FRF rates among non-Hispanics remained slightly above the national rates without increase. FRF rate by intent was highest for suicides (5.8), while the annual change was minimal in all four categories with a small significant reduction for unintentional deaths (change=−0.010, SMD=−1.70, p trend<0.0001).

State-specific 11-year FRF rates are represented in figure 1 and online supplementary table S1. Hawaii (HI; 3.02) and Massachusetts (MA; 3.24) had the lowest 11-year FRF rates, while Louisiana had the highest at

Table 1 Trends in firearm deaths in the USA, WISQARS 2000–2010

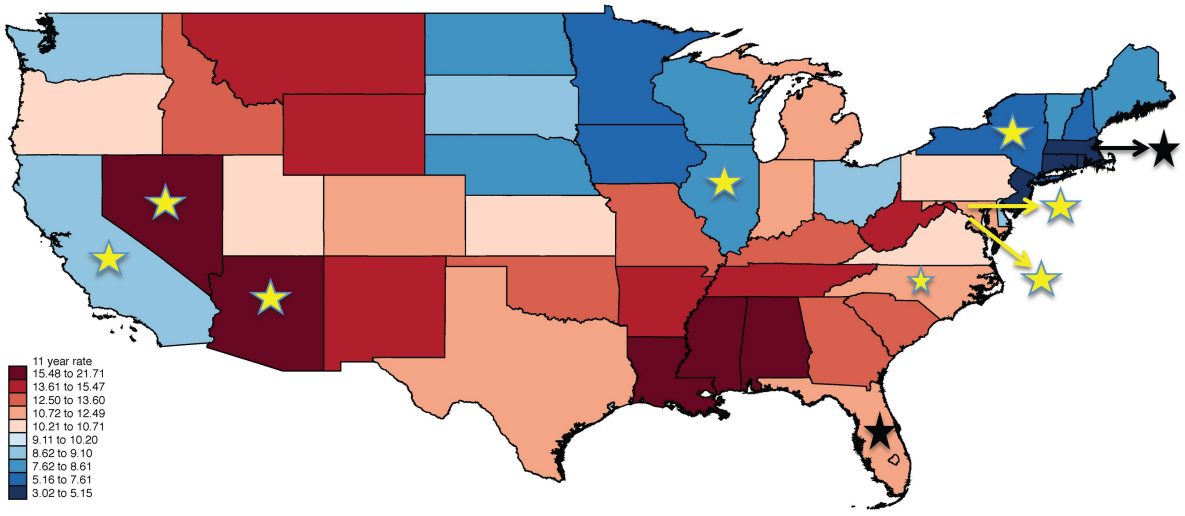
	Age-adjusted firearm deaths per 100 000 population												Change			
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Annual	95% CI	SMD	p Trend
All	10.14	10.31	10.43	10.29	9.99	10.27	10.22	10.24	10.23	10.05	10.07	10.21	−0.017	−0.044 to 0.010	−0.44	0.181
Race																
Caucasian	8.97	9.21	9.19	9.05	8.84	8.98	8.80	8.98	9.18	9.13	9.20	9.05	0.006	−0.027 to 0.039	0.11	0.705
African-American	18.30	18.32	19.22	19.01	18.31	19.34	19.98	19.31	18.19	17.15	16.90	18.51	−0.114	−0.311 to 0.082	−0.40	0.220
Other	4.76	3.89	4.19	4.03	3.70	3.88	3.83	3.38	3.25	3.37	3.25	3.38	−0.121	−0.166 to −0.076	−1.83	<0.0001
Ethnicity																
Hispanic	7.81	7.73	7.63	7.68	7.42	7.51	7.19	7.21	6.60	6.38	5.86	7.13	−0.179	−0.236 to −0.122	−2.13	<0.0001
Non-Hispanic	10.31	10.50	10.67	10.50	10.23	10.53	10.54	10.61	10.74	10.55	10.71	10.54	0.027	−0.002 to 0.056	0.63	0.068
Intent																
Homicide/legal intervention	3.88	4.05	4.17	4.19	4.05	4.28	4.40	4.32	4.14	3.89	3.73	4.10	−0.008	−0.054 to 0.038	−0.12	0.705
Suicide	5.90	5.90	5.92	5.77	5.65	5.66	5.54	5.63	5.82	5.91	6.06	5.80	0.001	−0.035 to 0.038	0.03	0.932
Undetermined	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.09	0.09	0.07	0.08	0.08	−0.0001	−0.002 to 0.002	−0.02	0.944
Unintentional	0.27	0.28	0.26	0.25	0.22	0.27	0.21	0.20	0.19	0.18	0.20	0.23	−0.010	−0.014 to −0.006	−1.70	<0.0001

All values are age-adjusted rates per 100 000 persons. Change denotes annual change in rate per 100 000. Negative value indicates decline in firearm death rates per 100 000 from 2000 to 2010 and positive value indicates increase in firearm death rate per 100 000 from 2000 to 2010. CIs denote the annual change in firearm death rate per 100 000. SMD indicates standardised mean difference; is equal to annual change/SD. p Trend calculated using metaregression indicates the significance of the decline or the increase in firearm-related death rates from 2000 to 2010. Data are from Center for Disease Control and Prevention (CDC)'s National Center for Injury Prevention and Control Web-based Injury Statistics Query and Reporting System (WISQARS).

18.62. The District of Columbia (DC) and seven states showed a significant declining trend in FRF rate, while MA and Florida (FL) documented a significant increase. DC had the largest significant annual reduction at −1.067 (6.2 lives-saved per year, p trend=0.002) though it had the highest rate of 21.71. Although MA had a low FRF rate, a significant increase was observed, change=0.074, p trend=0.008. FL also showed an increase, change=0.160, 28.2 lives-lost per year, p trend=0.016. FRF rates for Delaware (DL) and Ohio (OH) were 8.89 and 9.1, with a near significant increasing trend, changes of 0.2 and 0.12. FRF rate in New York (NY) was 5.15 with a change=−0.064, 12.3 lives-saved per year, p trend=0.006. Illinois (IL) had a significant reduction, change=−0.155, 19.6 lives-saved per year, p trend=0.025). FRF rates in California (CA) was −0.166 (59.3 lives-saved per year, p trend=0.001), Arizona (AZ) at −0.230 (13.4 lives-saved per year, p trend=0.025) and Nevada (NV) at −0.264 (6.4 lives-saved per year, p trend=0.008). Maryland (MD) and North Carolina (NC) had a significant decline: change=−0.169, 9.4 lives-saved per year, p trend=0.048 and −0.174, 15.3 lives-saved per year, p trend=0.001).

The 11-year FRF rates for each state by race are presented in figure 2A–C and online supplementary figure S1A–C. Among Caucasians, the lowest rate was in MA with a significant increase from 2000 to 2010 (change=0.05, p trend=0.037). FL also recorded a significant increase (change=0.12, p trend=0.045) but had high 11-year FRF rate, 10.02. NV recorded the highest and unchanging FRF rate at 16.3. The four states that showed a significant declining trend from 2000 to 2010 were NY (change=−0.05, p trend=0.015), IL (change=−0.12, p trend=0.028), NC (change=−0.1, p trend=0.032) and CA (change=−0.12, p trend=0.001). Among African-Americans, HI had the lowest 11-year FRF rates at 2.93 while Missouri had the highest at 30.12 and DC was at 40.95. Oklahoma (OK), OH and DL had high 11-year rates at 20.04, 20.19 and 13.61, respectively, with significant increasing changes of 0.93, 0.51 and 0.79, p trends of 0.008, 0.027 and 0.028, respectively. A declining trend was observed among African-Americans in CA (change=−0.58, p trend=0.042), AZ (change=−0.83, p trend=0.019), NV (change=−1.53, p trend=0.005), NC (change=−0.38, p trend=0.024), Indiana (IN; change=−0.66, p trend=0.012), Kansas (change=−1.07, p trend=0.021), Minnesota (MN; change=−0.61, p trend=0.038) and DC (change=−1.58, p trend=0.017), even though their 11-year FRF rates were high. Among other races, Texas (TX; change=−0.19, p trend=0.033) and CA (change=−0.1, p trend=0.009) showed a significant decline.

Figure 3A, B and online supplementary figure S2A,B present the 11-year FRF rates for each state by ethnicity. Georgia (change=−0.54, p trend=0.012), CA (change=−0.18, p trend=0.009), Utah (change=−0.79, p trend=0.030), AZ (change=−0.56, p trend=0.016) and NV (change=−0.48, p trend=0.007) were five high-FRF-rate



		AZ	CA	DC	IL	MD	NV	NY	NC	FL	MA
Overall	FRF rate	15.47	9.01	21.71	8.61	11.39	16.07	5.15	12.49	11.12	3.24
	Change, P-trend	**-0.23, 0.025**	**-0.17, 0.001**	**-1.07, 0.002**	**-0.16, 0.025**	**-0.17, 0.048**	**-0.26, 0.008**	**-0.06, 0.006**	**-0.17, 0.001**	**0.16, 0.016**	**0.07, 0.008**
Caucasian	FRF rate	15.73	8.73	3.03	5.80	6.81	16.30	4.05	11.61	10.02	2.57
	Change, P-trend	-0.19, 0.081	**-0.12, 0.001**	-0.03, 0.89	**-0.12, 0.028**	-0.05, 0.29	-0.08, 0.38	**-0.05, 0.015**	**-0.10, 0.032**	**0.12, 0.045**	**0.05, 0.037**
African-American	FRF rate	18.97	23.43	40.95	24.48	21.18	22.36	10.73	14.77	15.16	10.65
	Change, P-trend	**-0.83, 0.019**	**-0.58, 0.042**	**-1.58, 0.017**	-0.32, 0.14	**-0.42, 0.067**	**-1.53, 0.005**	-0.06, 0.27	**-0.38, 0.024**	**0.29, 0.056**	0.25, 0.097
Other	FRF rate	7.83	2.88	2.78	0.90	2.17	4.93	0.82	7.73	3.07	0.97
	Change, P-trend	**-0.43, 0.053**	**-0.10, 0.009**	ne, ne	ne, ne	-0.12, 0.60	-0.48, 0.19	-0.05, 0.20	-0.30, 0.11	-0.08, 0.49	-1.08, 0.26
Hispanic	FRF rate	14.73	7.42	4.71	6.65	3.96	10.05	3.63	8.12	6.24	4.00
	Change, P-trend	**-0.56, 0.016**	**-0.18, 0.009**	ne, ne	**-0.40, 0.001**	-0.25, 0.10	**-0.48, 0.007**	**-0.17, 0.001**	-0.24, 0.20	0.09, 0.34	0.09, 0.34
Non-Hispanic	FRF rate	14.58	9.19	23.45	8.60	11.95	16.93	5.36	12.62	12.31	3.08
	Change, P-trend	-0.05, 0.57	**-0.15, 0.001**	**-1.20, 0.003**	-0.06, 0.28	**-0.16, 0.068**	-0.11, 0.27	-0.04, 0.094	**-0.14, 0.004**	**0.23, 0.002**	**0.07, 0.033**
Intent	Homicide	↓	↔	↓	↓	↔	↓	↓	↓	↑	↑
	Suicides	↔	↓	↔	↔	↔	↔	↔	↓	↔	↔
	Undetermined	↔	↔	ne	↔	ne	ne	ne	ne	↔	↔
	Unintentional	ne	↔	ne	↔	ne	ne	ne	↔	↔	↔

Figure 1 FRF rates from 2000 to 2010. FRF rates are 11-year cumulative age-adjusted rates per 100 000 persons from 2000 to 2010 for each of the 50 states and District of Columbia (DC) ranging from 3.02 (Hawaii, HI) to 21.71 (DC) per 100 000. The colours represent increasing rates from blue to red. Significant decline in seven states (Arizona (AZ), California (CA), Illinois (IL), Maryland (MD), Nevada (NV), New York (NY) and North Carolina (NC) and DC) are represented as gold stars and significant increase in FL and Massachusetts (MA) as black stars within the map and in the table. The table summarises the rates per 100 000, annual change in rate and p trend for those states that show significant increase or decrease. 'FRF' denotes firearm-related fatality. 'Change' indicates the annual change in rates from 2000 to 2010. 'p Trend' indicates the significance of the decline or the increase in FRF rates from 2000 to 2010 and was calculated using metaregression. Negative values for change indicate a decrease while positive values indicate increase in rates across the years. The intent-specific rates of FRF is denoted with arrows in the table below: downward arrow denotes reduction in rates, upward arrows indicate an increase and two-way arrows indicate no change. 'ne' represents data which cannot be estimated due to frequency <10. HI (11-year=3.02, change=−0.057, p trend=0.36) and Alaska (11-year=18.09, change=0.10, p trend=0.64) are not represented in the map.

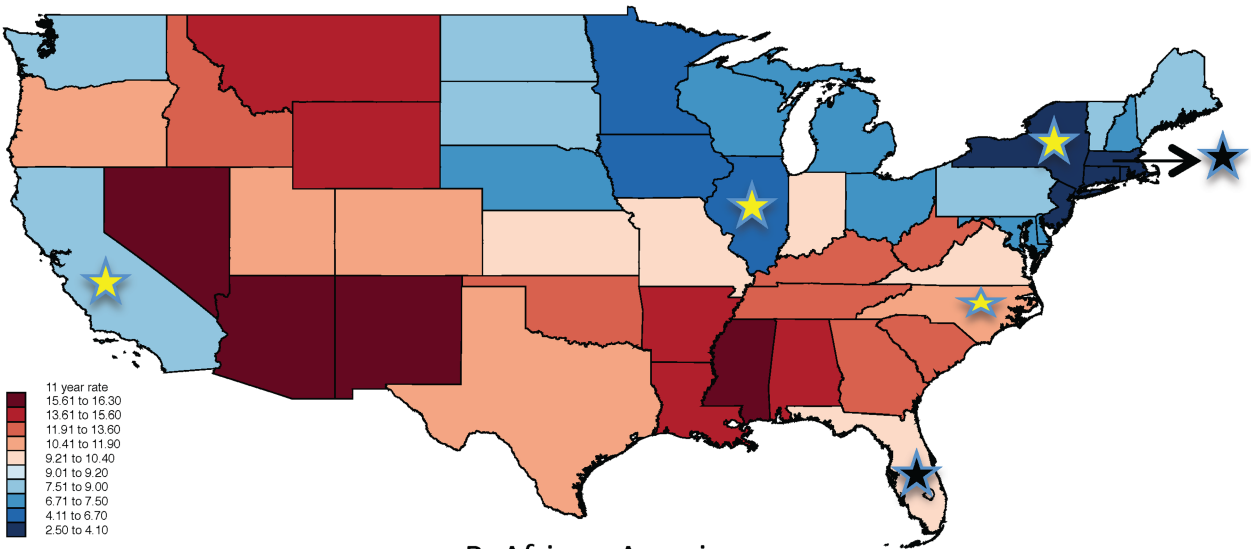
states (>7.13) while NY (change=−0.17, p trend=0.001), IL (change=−0.4, p trend=0.001), TX (change=−0.21, p trend=0.004) and Oregon (change=−0.33, p trend=0.037) were the four low-FRF-rate states with a significant declining trend among Hispanics. No states demonstrated an increase among Hispanics, while non-Hispanics showed a significant increasing trend in MA (change=0.07, p trend=0.033), Pennsylvania (change=0.08, p trend=0.039), OH (change=0.13, p trend=0.048), DL (change=0.25, p trend=0.036), TX (change=0.14, p trend=0.022), FL (change=0.23, p trend=0.002) and OK (change=0.15, p trend=0.045). A declining trend in non-Hispanics was observed in MD (change=−0.16, p trend=0.068), NC (change=−0.14, p trend=0.004) and CA (change=−0.15, p trend=0.001). In TX, the FRF rates among Hispanics (change=−0.21, p trend=0.004) demonstrated a significant decline and a significant increase among non-Hispanics (change=0.14, p trend=0.022; see online supplementary table S2).

FRF rates from 2000 to 2010 and by intent is provided in figure 4A–D and online supplementary figure S3A–D. Most of the northern states had low (<3.73) homicide FRF while southern states had high FRF. NY (change=−0.05, p trend=0.004), IL (change=−0.1, p trend=0.027), NC (change=−0.1, p trend=0.023), NV (change=−0.15, p trend=0.031) and DC (change=−1, p trend=0.002) had significant declining trends, while MA (change=0.08, p trend=0.001), Connecticut (change=0.08, p trend=0.023), OH (change=0.12, p trend=0.006), DL (change=0.37, p trend<0.0001) and FL (change=0.15, p trend=0.007) had increasing homicide FRF. A majority of the states had suicide FRF rates >5.8; CA (change=−0.07, p trend=0.009) and NC (change=−0.07, p-trend=0.037) had declining trends. Unintentional FRF rates showed a significant decreasing trend in three states, OH (change=−0.01, p trend=0.022), Kentucky (change=−0.06, p trend=0.009) and Tennessee (change=−0.05, p trend=0.002).

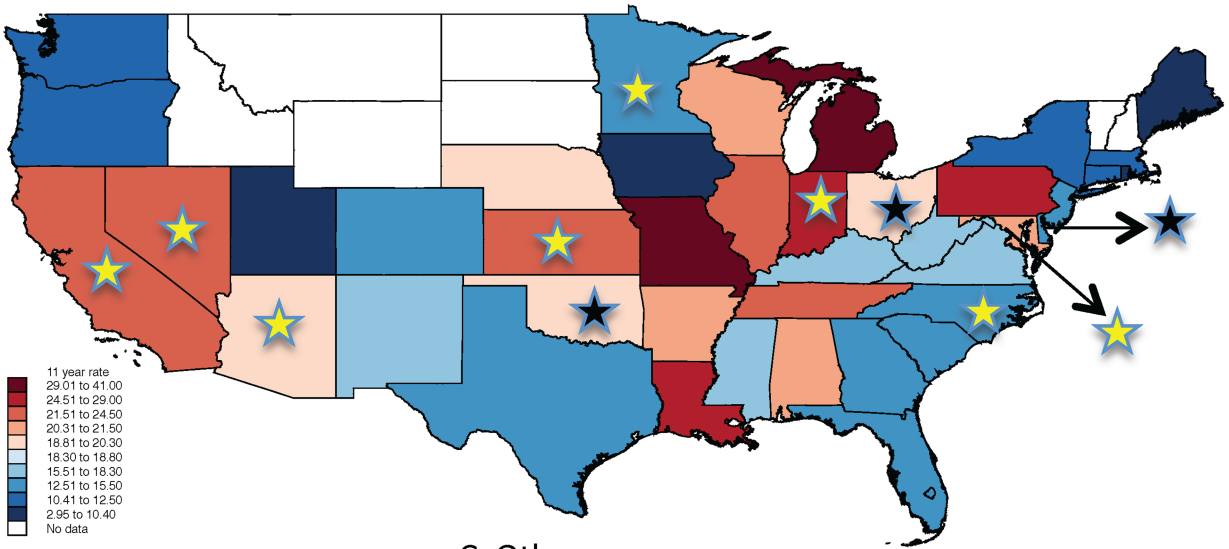
DISCUSSION

The national 11-year FRF rate from 2000 to 2010 was 10.21, and was almost three times higher than Switzerland

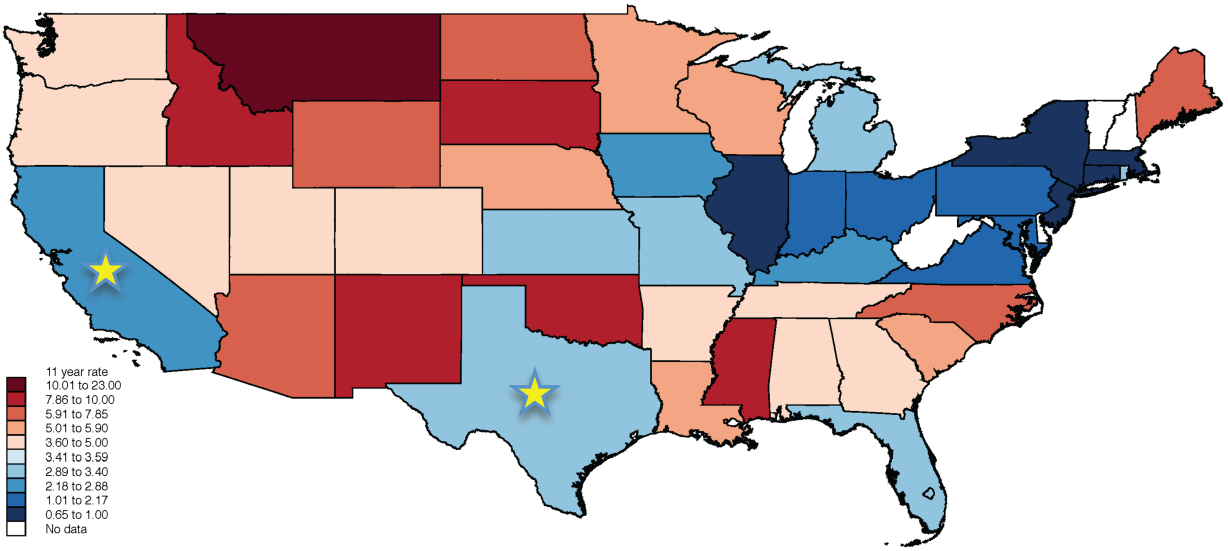
A. Caucasian



B. African-American



C. Other



and Finland.[17] There were four main observations that emerge from this analysis. First, while overall, African-Americans had higher national rates than Caucasians and Hispanics had lower national rates than non-Hispanics, the 11-year FRF rates declined among Hispanics and non-white non-black races with no significant change observed among Caucasians, African-Americans or non-Hispanics. Second, a substantial interstate heterogeneity was evidenced by 11-year state-specific FRF rates being as low as 3.02 in HI to as high as 21.71 in DC. FL and MA recorded an upward FRF trend while AZ, CA, IL, MD, NV, NY, NC and DC had declining FRF rates during the study period. Third, racial and ethnic variation was shown to drive many of the state-specific variations. Fourth, changes in different FRF-intent also drove many of the state-specific differences.

Firearm deaths increased from 28 663 in 2000 to 31 672 in 2010, about 30 509 deaths per year and no change in rate. These findings are similar to a report by the Bureau of Justice of a rapid decline in firearm homicides from 1993 to 1999 followed by a levelling of rates from 2000 to 2011.[18] It is important to bear in mind that these endemic conditions are associated with substantial, long-term cumulative health burden associated with firearm death throughout the USA.[19] During 2000–2011, there were 306 946 firearm-related deaths. With the endemic annual FRF rate of 10.3, US population at 338 million by 2020[20] and 10% decadal population increase, we estimate 336 778 firearm-related deaths to occur between 2011 and 2020.

The 11-year FRF rates we report among African-Americans were twice greater than that of Caucasians and six times greater than that of other races is in line with reports showing disproportionately larger firearm fatality and injury rates than Caucasians and other races.[3 21 22] Although there was a plateau of the national FRF rates, rates among Hispanics and non-white non-black races declined and may be explained by the lack of access to firearms or low firearm ownership among Hispanics and other races.[23] Our results explain the report where Hispanics were least likely to use firearms for suicides albeit being more likely to self-injury than any other race groups.[24] Data from 1981 to 2010 found that among youths a decline in homicide rates for African-Americans between was significantly slower than the declines for Hispanics and other racial and ethnic groups,[25] suggestive of lower crime.

We found 41 states with no FRF-rate change, while 7 states and DC demonstrated either a significant decline or increase. MA and FL recorded a significant increase, MA with smallest and FL with largest annual increase while MA had the lowest 11-year FRF rate. The Brady Center to Prevent Gun Violence[9] firearm legislative strength score for 2011 has MA to be third with a score of 65 among all states in restrictive firearm legislation, while FL has a score of 3. After MA passed the toughest firearm control legislation in 1998, firearm ownership rates plummeted but violent crimes (476.1–468.9) and homicides (2.2–3.3) rose.[26] The significant FRF-rate increase in MA may be explained by the influx of firearms from the two neighbouring states (Maine and New Hampshire) with weak firearm control legislation.[27] FL is a 'shall-issue', weak legislature state with just two laws to prevent illegal gun trafficking.[27] 'Shall-issue' jurisdiction requires a licence to carry a concealed firearm, where the licence must be issued if the subject meets determinate criteria in the law and the issuing authority has no discretion to reject.[28] In contrast to the increasing FRF rates, the aggregate violent crimes in FL declined from 801.1 to 542.9,[29] emphasising a particularly concerning public health problem of increasing gun violence even in a climate of reducing violence.

CA, NY, IL, AZ, NV, MD, NC and DC had declining trends but the most marked reduction was observed in CA and may be directly linked to strength of firearm legislature, a score of 81.[9] CA has eight state laws to prevent illegal gun trafficking[27] and a reduction in homicide crime rate in CA by 25.4% from 2001 to 2010.[30] An emergency department study from 2004 to 2008 reporting reduction of firearm death rate in CA

Figure 2 Firearm-related fatality rates from 2000 to 2010 according to race. Caucasians: firearm-related fatality rates are 11-year cumulative age-adjusted rates per 100 000 persons from 2000 to 2010 for each of the 50 states and District of Columbia (DC); ranging from 2.57 (Massachusetts, MA) to 16.30 (Nevada, NV) per 100 000. The colours represent increasing rates from blue to red. White represents no data or states where the frequency was <10 among Caucasians. Significant decline in 4 states (California (CA), New York (NY), Illinois and North Carolina (NC)) are represented as gold stars and significant increase in MA and Florida as black stars. Hawaii (HI; 11-year=4.29, change=0.03, p trend=0.84) and Alaska (AK; 11-year=15.77, change=0.15, p trend=0.56) are not represented in the map. African-Americans: firearm-related fatality rates are 11-year cumulative age-adjusted rates per 100 000 persons from 2000 to 2010 for each of the 50 states and DC; ranging from 2.93 (HI) to 40.95 (DC) per 100 000. The colours represent increasing rates from blue to red. White represents no data or states where the frequency was <10 among African-Americans. Significant decline in eight states (CA, NV, Arizona, Kansas, Minnesota, Indiana, NC and DC) are represented as gold stars and significant increase in Oklahoma, Ohio and Delaware as black stars. HI (11-year=2.93) and AK (11-year=12.36) are not represented in the map. Other race: firearm-related fatality rates are 11-year cumulative age-adjusted rates per 100 000 persons from 2000 to 2010 for each of the 50 states and DC; ranging from 0.82 (NY) to 22.54 (AK) per 100 000. The colours represent increasing rates from blue to red. White represents no data or states where the frequency was <10 among other race. Significant decline in two states (CA and Texas) are represented as gold stars and there were no states with significant increase. HI (11-year=2.18, change=−0.04, p trend=0.50) and AK (11-year=22.54, change=−0.15, p trend=0.75) are not represented in the map.

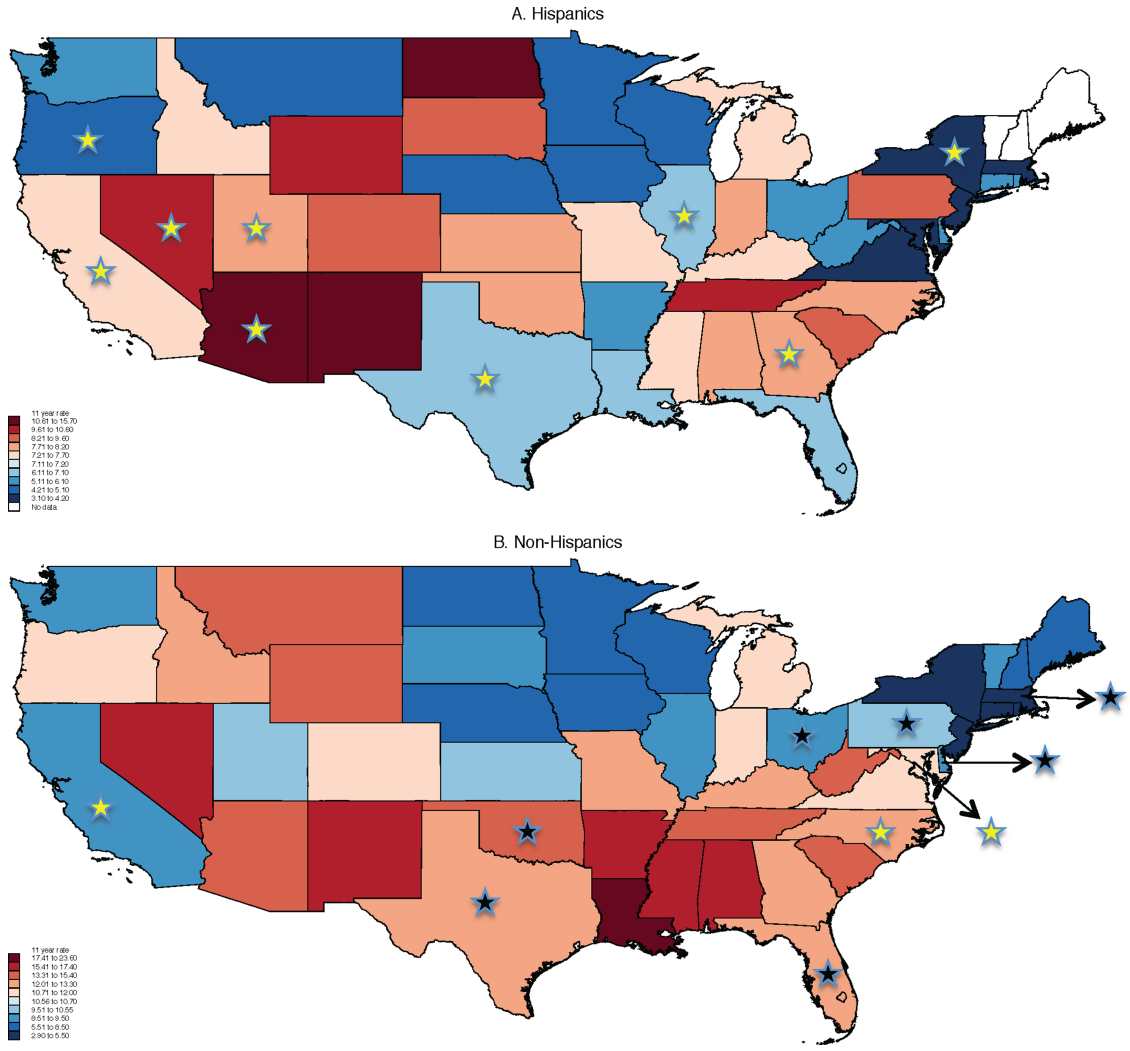


Figure 3 Firearm-related fatality rates from 2000 to 2010 according to ethnicity. Hispanic: firearm-related fatality rates are 11-year cumulative age-adjusted rates per 100 000 persons from 2000 to 2010 for each of the 50 states and District of Columbia (DC); ranging from 3.13 (New Jersey) to 15.63 (North Dakota) per 100 000. The colours represent increasing rates from blue to red. White represents no data or states where the frequency was <10 among Hispanics. Significant decline in nine states (California (CA), Arizona, Nevada, Oregon, Utah, Texas (TX), Illinois, Georgia and New York) are represented as gold stars and there were no states with significant increase. Hawaii (HI; 11-year=3.84) and Alaska (AK; 11-year=8.95) are not represented in the map. Non-Hispanic: firearm-related fatality rates are 11-year cumulative age-adjusted rates per 100 000 persons from 2000 to 2010 for each of the 50 states and DC; ranging from 2.95 (HI) to 23.45 (DC) per 100 000. The colours represent increasing rates from blue to red. White represents no data or states where the frequency was <10 among non-Hispanics. Significant decline in three states (CA, North Calorina and DC) are represented as gold stars and significant increase in seven states (TX, Oklahoma, Florida, Ohio, Pennsylvania, Delaware and Massachusetts) as black stars. HI (11-year=2.95, change=−0.05, p trend=0.50) and AK (11-year=18.44, change=0.13, p trend=0.57) are not represented in the map.

echoing the results of our study.[31] NY and IL had similar trend profiles and an overall decline in FRF rates, but the Brady scores were 62 and 35[9] with 10 and 8 policies preventing illegal firearm trafficking, respectively.[27] FRF-rate reduction in AZ and NV is in contrast to CA and NY, having no laws preventing illegal gun trafficking,[27] with Brady scores 0 and 5, respectively.[9] In AZ violent crime rate dropped from 544.5 offences in 2002 to 372.2 in 2010,[32 33] and NV had reductions in index crimes.[34] This reduction and our results may be attributed to policing strategies.[35] Our reported reduction in firearm death rates in DC may be attributed to nine laws preventing illegal gun trafficking.[27] Firearm policies are not stringent in NC, strength of firearm legislature being 16[9] with only five illegal gun trafficking laws.[27] However, the violent crime rate in NC dropped from 493 to 363 from 2000 to 2010,[36] suggesting that the factors that led to reduction in crime rates may have also driven FRF-rate reduction.

We found that the state-specific increasing trend in FL was driven by an increase among Caucasians, African-Americans and non-Hispanics and can be explained by violent crime rates in FL which ranks fourth in violent crime.[37] The racial gap in arrests for major

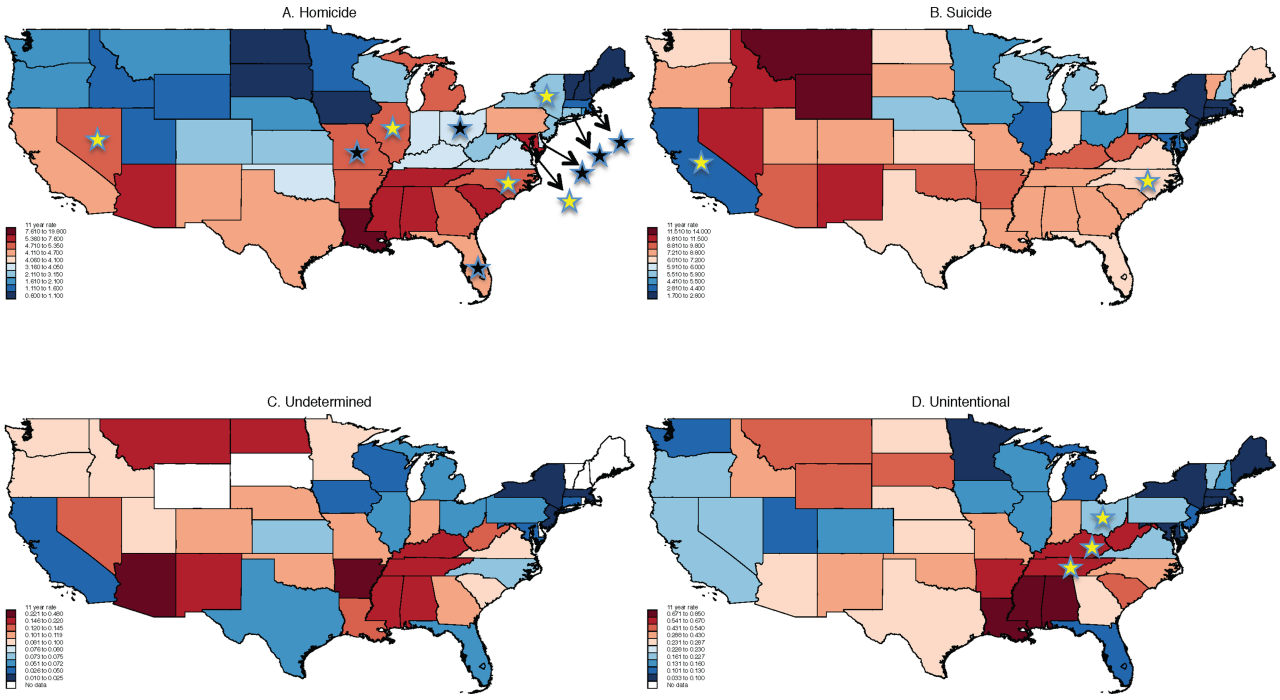


Figure 4 Firearm-related fatality rates from 2000 to 2010 according to intent. Homicide: firearm-related fatality rates are 11-year cumulative age-adjusted rates per 100 000 persons from 2000 to 2010 for each of the 50 states and District of Columbia (DC); ranging from 0.65 (New Hampshire) to 19.75 (DC) per 100 000. The colours represent increasing rates from blue to red. White represents no data or states where the frequency was <10. Significant decline in five states (Nevada, Illinois, North Carolina (NC), New York and DC) are represented as gold stars and significant increase in Missouri (MO), Florida, Ohio (OH), Massachusetts (MA), Connecticut and Delaware as black stars. Hawaii (HI; 11-year=0.79, change=−0.01, p trend=0.68) and Alaska (AK; 11-year=3.54, change=0.001, p trend=0.95) are not represented in the map. Suicide: firearm-related fatality rates are 11-year cumulative age-adjusted rates per 100 000 persons from 2000 to 2010 for each of the 50 states and DC; ranging from 1.61 (MA) to 13.79 (AK) per 100 000. The colours represent increasing rates from blue to red. White represents no data or states where the frequency was <10. Significant decline in two states (California and NC) are represented as gold stars and there were no states with significant increase. HI (11-year=2.10, change=−0.001, p trend=0.95) and AK (11-year=13.79, change=0.11, p trend=0.61) are not represented in the map. Undetermined: firearm-related fatality rates are 11-year cumulative age-adjusted rates per 100 000 persons from 2000 to 2010 for each of the 50 states and DC; ranging from 0.01 (New Jersey) to 0.47 (AK) per 100 000. The colours represent increasing rates from blue to red. White represents no data or states where the frequency was <10. There was no significant decline or increasing state-specific trends. HI (11-year=ne) and AK (11-year=0.47) are not represented in the map. Unintentional: firearm-related fatality rates are 11-year cumulative age-adjusted rates per 100 000 persons from 2000 to 2010 for each of the 50 states and DC; ranging from 0.04 (MA) to 0.83 (Louisiana) per 100 000. The colours represent increasing rates from blue to red. White represents no data or states where the frequency was <10. Significant decline in three states (OH, Kentucky and Tennessee) are represented as gold stars and there were no states with significant increase. HI (11-year=0.08) and AK (11-year=0.29) are not represented in the map.

crimes widened in FL from 2000 to 2010: 6175 African-Americans and 6071 Caucasians were arrested in 2000 to 2398 and 3192 in 2010.[38] The increase in FRF rates in MA driven by Caucasians and non-Hispanics is in contrast to the racial differences observed in violent deaths with non-Hispanic African-Americans having the highest rate of 21.6 as compared with 4.9 among Caucasians.[39] MA has relatively low violent crime rate (ranks 20th in the USA),[37] and stringent firearm control.[9] Even though nationally no significant reduction in FRF rates among African-Americans were observed in our study, FRF rates among African-Americans drove the state-specific declines in AZ, NV, CA, NC and DC. Declining trends among Hispanics in AZ, NV, CA, NY and IL contributing to state-specific declines may be due to a combination of low firearm ownership[23] and racially targeted crime-control activities.[40] In IN, KS, MN and OK, with no statewide reduction, the FRF rates fell solely among African-Americans, with no change among Caucasians. These states have very few laws to prevent firearm violence and trafficking[27] and rank among the highest 20 states in crime rates except MN.[37]

The increasing trend in FL and MA in our study was due to increase in firearm homicides. According to data from CDC, rates of suicides in FL remained constant from 2000 to 2010, while in MA these rates doubled from 1.92 to 3.15.[1] In 2010, 71% of homicides in FL were by firearms,[29] and in MA, 22% of the homicides were by firearm.[39] In CA, where all racial and ethnic groups revealing declining trends, was driven by reduction in suicide FRF and is

associated with the states' increased effort in implementing 'The Mental Health Services Act' to reduce suicide rates.[41] In our study, reduction in homicides was caused by declines in AZ, IL, NV, NY, NC and DC. These declining patterns are similar to the reduction in all-cause homicide rates from 2000 to 2010 that occurred in a smaller magnitude among AZ, IL, NV, NY, NC and in a much larger magnitude in DC.[1]

There are several limitations in our study. Under-reporting of firearm fatal events is a known phenomenon and a limitation of this study, which cannot be verified. There is, however, no reason to suspect that African-Americans and Hispanics are more likely than Caucasians and non-Hispanic individuals to have a fatal firearm injury misclassified on the death certificate, so this under-reporting should not have biased our findings. Another limitation is that, despite the considerable state-specific heterogeneity, the actual variation in firearm mortality may be a feature of cities and counties with varying crime rates, and we do not address the variation existing at such level. Finally, comparisons made between other races may not be usefully interpreted due to the heterogeneity and the small frequency of events in this sub-population. However, as other race makes up about 10% of the US population, the results are discussed in relation to African-Americans and Hispanics.

In summary, we showed no change in national firearm mortality rates during 2000–2010, but showed distinct state-specific patterns with racial and ethnic variation and by intent. The distinctive state-specific firearm fatality profiles vary by race, ethnicity and intent adding another layer of complexity to the FRF trends. This calls for specific studies to identify the drivers of the state-specific temporal trends followed by introducing tailored programmes that target specific racial and ethnic groups in specific states.

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