State-Level Estimates of Household Firearm Ownership

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RAND SOCIAL AND ECONOMIC WELL-BEING

Sponsored by Arnold Ventures

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Published by the RAND Corporation, Santa Monica, Calif.

Preface

The RAND Corporation launched the Gun Policy in America initiative in January 2016 with the goal of creating objective, factual resources for policymakers and the public on the effects of gun policies. Researchers studying this topic are often interested in the effect of policies on rates of firearm ownership or how those rates are associated with a range of important outcomes. One particular challenge for researchers in this area is that direct measures of state-level firearm ownership exist for only a few years (2001–2004). Proxy measures of firearm ownership do exist longitudinally but are limited in a variety of ways. Therefore, as part of the Gun Policy in America initiative, RAND researchers developed a longitudinal database of state-level estimates of household firearm ownership that is free to the public. This document describes the methods that the researchers used to construct the estimates and provides technical documentation and other information that will facilitate use of the database.

The RAND State-Level Firearm Ownership Database is one of several research products stemming from the Gun Policy in America initiative. Some other products include a state firearm law database, a systematic literature review and evaluation of scientific studies examining the effects of 18 classes of gun policies on eight outcomes (e.g., rates of violent crime and defensive gun use), a survey of policy experts that identified where access to reliable data would be most useful in resolving policy debates, and an online policy analysis tool that allows users to explore how different combinations of policies are likely to affect a range of outcomes (based on the survey of gun policy experts). These and other resources are publicly available on the project website at www.rand.org/gunpolicy.

The firearm ownership database and this document should be of interest to policymakers, researchers, and other stakeholders looking for information on state firearm ownership in the United States.

Justice Policy Program

RAND Social and Economic Well-Being is a division of the RAND Corporation that seeks to actively improve the health and social and economic well-being of populations and communities throughout the world. This research was conducted in the Justice Policy Program within RAND Social and Economic Well-Being. The program focuses on such topics as access to justice, policing, corrections, drug policy, and court system reform, as well as other policy concerns pertaining to public safety and criminal and civil justice. For more information, email justicepolicy@rand.org.

Funding

Funding for the Gun Policy in America initiative was originally provided through unrestricted gifts from RAND supporters and income from operations. Since June 2018, this initiative has been supported by a grant from Arnold Ventures.

To support RAND's efforts and enable initiatives like the Gun Policy in America project, contact our Office of Development at (310) 393-0411, ext. 6901 or giving@rand.org.

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Summary

The RAND Corporation's Gun Policy in America initiative is an effort to systematically and transparently assess available scientific evidence on the real effects of gun laws and policies. Our goal is to create resources where policymakers and the general public can access unbiased information that enables the development of fair and effective policies. In line with this goal, we sought to improve upon existing measures of firearm ownership.[1]

A key limitation of existing research that attempts to examine the effects of gun policies on firearm ownership or the effects of firearm ownership on other outcomes is that there are problems with the available state-level measures of firearm ownership over time. Briefly, the direct survey measures of firearm ownership correspond exactly to the construct of interest but tend to be sparse, unreliable, and unrepresentative when aggregated to a state-year level; the proxy measures of firearm ownership are often reliable but may have limited validity as measures of firearm ownership. Having accurate estimates of state-level firearm ownership over time is critical for understanding how state policies (e.g., requiring a permit to purchase a firearm) affect rates of household firearm ownership and for understanding how changes in those ownership rates affect key outcomes (e.g., rates of violent crime and defensive gun use). This a descriptive study to develop annual, state-level estimates of firearm ownership by combining a variety of existing measures. The primary goal is to estimate the proportion of adults living in a household with a firearm for each state annually between 1980 and 2016. This document describes the data, methods, and results of our analyses to develop these estimates.

Data

The primary data sources for this study were selected because they provide either direct measures of firearm ownership assessed via survey or proxy measures for firearm ownership (i.e., variables believed to be strongly linked to state-level firearm ownership rates). Specifically, we used four sources of individual-level survey data that directly assess household firearm ownership and the following proxy indicators of such ownership: the proportion of suicides in which a firearm is used (from the Centers for Disease Control and Prevention), the number of hunting licenses per capita (from the U. S. Fish and Wildlife Service), the number of *Guns*

[1] Although not all guns are firearms, in this document, we follow conventional use in U.S. policy discussions and treat the terms *gun* and *firearm* as interchangeable.

& Ammo magazine subscriptions per 100 residents (from the Alliance for Audited Media),[2] and the number of background checks conducted per ten residents (from the National Instant Criminal Background Check System). In addition to these measures, we used a range of state-level demographic information from the U.S. Census Bureau, as well as indicators of universal background check laws and permit-to-purchase laws from the RAND State Firearm Law Database.

Methodology

Even though the surveys directly assessing firearm ownership were designed to be demographically representative of the United States overall, most were not designed to be representative of populations in all states and are not representative of the populations in individual states (with the exception of the surveys conducted as part of the Behavioral Risk Factor Surveillance System). To address these limitations, we derived measures of state-level firearm ownership for each survey ($N = 51$) using multi-level regression with poststratification (MRP). This small-area estimation technique is designed to provide more-accurate estimates for subpopulations, even when the available sample from that subpopulation is not fully representative (Gelman and Little, 1997). Next, we combined the state-level survey estimates derived from MRP with the various proxy indicators of firearm ownership in a structural equation model assessing a latent household firearm ownership rate (HFR) construct. The development process for this structural equation model was focused on addressing three concerns:

- Individual proxy measures may not maintain the same relationship to the HFR over time.
- The error in a measure may not be fully independent from error in other measures (e.g., shared confounds).
- Some measures may be biased for particular state-years.

Findings and Conclusions

The resulting structural equation model provides information about how closely each of the original measures is associated with the overall construct, and it provides a formal way to investigate possible biases and validity issues with those original measures. Of all the measures of firearm ownership included in the analysis, the state estimates derived from survey data sources were the most closely associated with the underlying construct. In particular, the Behavioral Risk Factor Surveillance System surveys ($N = 3$) showed the strongest association to the latent HFR variable, which is consistent with the field's view of these surveys as the gold standard (e.g., Kleck, 2015). Other direct measures derived from the General Social Survey and from Pew Research Center and Gallup surveys, which have not previously been used to assess state-level firearm ownership, also exhibited strong associations with the latent HFR construct. Unfortunately, these direct survey measures of firearm ownership are miss-

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[2] We use *Guns & Ammo* subscription rates (per 100 residents) instead of subscription rates from other similar magazines (e.g., *Guns*, *Shooting Times*, *Garden & Gun*, *American Handgunner)* because *Guns & Ammo* subscription rates have been identified in other research as being positively associated with crime outcomes (Duggan, 2001) and being an indicator of aggregate gun ownership (Kleck, 2015).

ing for a large number of years and states over the study period. In contrast, the studied proxy measures have considerably better coverage over the period, but they showed a somewhat weaker association with the latent HFR construct. The best of these proxy measures was the proportion of suicides that were firearm suicides in each state-year, computed separately for males and females. However, all proxy measures showed evidence of a variety of measurement problems that needed to be addressed in the final model. These issues included correlations for reasons other than HFR (e.g., confounding) and a lack of time-invariance (e.g., bias in some years). The resulting measure of estimated household firearm ownership rates at the state level uses a structural equation model to combine across all of these survey and proxy measures, while controlling for the identified sources of error, to create a useful measure of the annual proportion of adults living in a household with a firearm for each state between 1980 and 2016.

Acknowledgments

We would like to thank Arnold Ventures, which has sponsored the Gun Policy in America initiative since June 2018. In addition, the RAND State-Level Firearm Ownership Database and this document benefited greatly from insightful quality assurance reviews by Maria Orlando Edelen of RAND and Tom Smith of NORC at the University of Chicago. We would also like to thank Francisco Walter for his assistance in organizing this document.

Abbreviations

BRFSS	Behavioral Risk Factor Surveillance System
CDC	Centers for Disease Control and Prevention
CFI	Comparative Fit Index
CPS	Current Population Survey
FA/A	proportion of aggravated assaults committed with a firearm
FBI	Federal Bureau of Investigation
FH/H	proportion of homicides committed with a firearm
FIPS	Federal Information Processing Standards
FR/R	proportion of robberies committed with a firearm
FS/S	proportion of suicides that are firearm suicides
GSS	General Social Survey
HFR	household firearm ownership rate
MRP	multi-level regression with poststratification
SEM	structural equation modeling
SRMR	standardized root mean squared residual

The RAND Corporation's Gun Policy in America initiative is an effort to systematically and transparently assess available scientific evidence on the real effects of gun laws and policies. Our goal is to create resources where policymakers and the general public can access unbiased information that enables the development of fair and effective policies. In line with this goal, we sought to improve upon existing measures of firearm ownership.[1] In this document, we detail a descriptive study to develop annual, state-level estimates of the proportion of adults living in a household with a firearm. State-level panel estimates of household firearm ownership have long been of interest to researchers seeking to better understand how policies influence firearm prevalence or how variation in firearm ownership relates to important societal outcomes.

Prior research has explored the use of several proxy and direct measures of firearm ownership. For example, some researchers interested in the relationship between firearm ownership rates and crime rates have relied on a variety of proxy measures or combinations of proxy measures to examine these relationships. Such proxy measures include the proportion of suicides in which a firearm was used (Cook and Ludwig, 2002; Cook and Ludwig, 2006; Kleck, 1997; Moody and Marvell, 2005), the proportion of various crime types committed with a firearm (Hemenway and Miller, 2000), gun-related magazine subscriptions (Moody and Marvell, 2002; Duggan, 2001), and the number of hunting licenses per capita (Siegel, Ross, and King, 2014). Much of the work to validate these measures as indicators of firearm ownership involves comparing proxies with survey data, and the proportion of suicides that are firearm suicides emerged as potentially the best available proxy measure (Kleck, 2015). However, a key limitation identified in the existing literature is that the existing indicators of gun ownership may not be valid over time (Kleck, 2004; Kleck, 2015). Additionally, as a matter of validating proxy measures, there are a variety of survey data sources available, but there are differences in trends across survey sources (e.g., the General Social Survey [GSS] and Gallup) over time (Smith, Laken, and Son, 2015).

Although several direct and proxy measures of firearm ownership have been used in prior research, the existing measures that are available at the state level over time are limited in several ways. The existing direct measures of ownership are based on surveys assessing household firearm ownership or possession, but these measures typically have low reliability because of small samples in individual states, have inconsistent reliability across states of different sizes,

1 Although not all guns are firearms, in this report, we follow conventional use in U.S. policy discussions and treat the terms *gun* and *firearm* as interchangeable.

are not designed to be representative of state populations, and are not available in most years. In contrast, the existing proxy measures of firearm ownership derived from administrative data, such as the proportion of suicides that are firearm suicides, are often available at the state level over a long time series, but it is not clear the extent to which variation across states and over time in those proxies should be attributed to differences in firearm ownership or differences in other factors. Essentially, the direct survey measures of firearm ownership correspond exactly to the construct of interest but tend to be sparse, unreliable, and unrepresentative when aggregated to a state-year level; the proxy measures of firearm ownership are often reliable but may have limited validity as measures of firearm ownership. These limitations have led some researchers (e.g., Kleck, 2015) to conclude that we cannot study how policy affects firearm ownership or how firearm ownership affects crime by using the existing state-year measures of firearm ownership. Thus, we sought to combine both direct and proxy measures of firearm ownership into a firearm ownership measure that addresses the problems with each individual measure. The resulting state-level estimates of firearm ownership should be useful to other researchers who wish to test theories about firearm ownership's relationship to crime, injury, and public policy.

This study proceeded in two stages: First, we used small-area estimation techniques to mitigate the problems with the reliability and representativeness of state-year measures of firearm ownership derived from survey data. Second, we combined the survey-based and proxy measures of firearm ownership. Specifically, we used multi-level regression with poststratification (MRP) to produce state-level estimates of household firearm ownership from individual surveys. Then, we used structural equation modeling (SEM) to create a latent measure of household firearm ownership from 1980 to 2016.

This document is structured as follows: We begin by describing the data used in these analyses. Next, we explain the MRP process used to produce state estimates from national survey data. Finally, we describe the latent variable model development process, interpret the limitations of the individual measures that were revealed by this model, and provide estimates of the proportion of adults living in a household with a firearm in each state between 1980 and 2016.

Data

The data used in this study include a mixture of administrative and survey data. For the purposes of our model, the ideal data sources

- are theoretically related to rates of firearm ownership
- are empirically associated with direct measures of firearm ownership
- include sufficient coverage to inform estimates across states and years.

Practically, this means that data must include firearm ownership indicators in multiple years for multiple states using a consistent methodology. It is not a requirement, however, that every measure be available in every year, because the models we used produce estimates that are robust to missing data.

To obtain state-level direct measures of household firearm ownership, we used data from four survey sources: the Behavioral Risk Factor Surveillance System (BRFSS), Gallup, the

GSS, and Pew Research Center (see Table 1).[2] Each of the surveys is designed to be a nationally representative sample of individuals, although we use these data to create state-level rather than national-level estimates. We obtained the BRFSS survey data from the Centers for Disease Control and Prevention (CDC)'s website of archived data and documentation (CDC, 2018). We downloaded the available Gallup and Pew Research Center survey data from the Roper Center for Public Opinion Research at Cornell University, and we included all survey years with available data that asked questions about household firearm ownership specifically (i.e.,

Table 1
Data Sources, Years of Availability, and Cumulative Number of State-Year Observations

Data Type	Source	Years	*N*[a]
Direct measures of household firearm ownership	BRFSS	2001, 2002, 2004	148
	Gallup	1980, 1983, 1985, 1986, 1988, 1989, 1990, 1991, 1993, 1996, 1997, 1999, 2000, 2012	636
	GSS	1980, 1982, 1984, 1985, 1987, 1988, 1989, 1990, 1991, 1993, 1994, 1996, 1998, 2000, 2002, 2004, 2006, 2008, 2010, 2012, 2014, 2016	835
	Pew Research Center	1997, 2000, 2003, 2004, 2007, 2009, 2010, 2011, 2012, 2013, 2015, 2016	583
Firearm suicides and total suicides	CDC	1980–2016	1,850
Firearm homicides and total homicides	CDC	1980–2016	1,850
Firearm assaults and total assaults	Uniform Crime Reporting Program	1998–2016	948
Firearm robberies and total robberies	Uniform Crime Reporting Program	1998–2016	948
State resident hunting licenses	U.S. Fish and Wildlife Service	1980–2016	1,849
Guns & Ammo magazine subscriptions	Alliance for Audited Media	1980–2016	1,850
Background checks	National Instant Criminal Background Check System	1999–2016	900
Universal background check law	RAND State Firearm Law Database	1980–2016	1,850
Permit-to-purchase law	RAND State Firearm Law Database	1980–2016	1,850

[a] *N* quantifies the number of state-years of data for each data source. A measure that is available in all 50 states for the full 37-year period would have *N* = 1,850. A nationally representative survey may still contain no data from a given state; in such cases, that state-year is missing for that survey source. For that reason, *N* is sometimes less than 50 times the number of years that a given data source is available.

[2] We used data from 51 total survey-years: three from the BRFSS, 14 from Gallup, 22 from the GSS, and 12 from Pew Research Center. Some of the data used in this analysis are derived from Sensitive Data Files of the GSS, obtained under special contractual arrangements designed to protect the anonymity of respondents. These data are not available from the authors. Persons interested in obtaining GSS Sensitive Data Files should contact the GSS at GSS@NORC.org.

we did not use questions about personal firearm ownership because this is a separate construct, albeit related) and that contained a state indicator. We obtained the restricted state-level indicators for the GSS through a request to NORC at the University of Chicago (2016). When a survey source had more than one survey in a year, we treated them as a single survey.[3]

The survey sources varied in frequency, and not all sources spanned the time period of interest (see Table 1). Survey sources ranged from three years of data (BRFSS) to 22 years of data spread across the full period (GSS), together yielding 51 survey-years of data. The total number of state-year observations from each survey source is noted in the last column of Table 1; the numbers vary, in part, because some states had no respondents in a given survey.

The data for our proxy measures include the number of

- firearm suicides, total suicides, firearm homicides, and total homicides from the CDC (undated-a, undated-b)
- firearm assaults, total assaults, firearm robberies, and total robberies from the Federal Bureau of Investigation (FBI)'s Uniform Crime Reports (FBI, undated)
- state resident hunting licenses from the U.S. Fish and Wildlife Service (2019)
- *Guns & Ammo* magazine subscriptions from the Alliance for Audited Media (1979–2014)[4]
- background checks from the FBI's National Instant Criminal Background Check System (FBI, 2019).

In the data analysis, we also used some measures that are neither direct nor proxy measures of firearm ownership but were important for ensuring that estimates were representative of state populations or were unbiased with respect to potential confounds. These additional measures were demographic variables for each state-year from the U.S. Census Bureau (2019), an indicator for whether a state had a law requiring a universal background check for handgun purchases, and an indicator for whether a state had a law requiring a permit to purchase a handgun; we drew the state law information from the RAND State Firearm Law Database (Cherney et al., 2019). Combined, our data set for this study includes data for 50 states across 37 years, 1980–2016.

Preprocessing Survey Data Using MRP

The surveys we used were originally collected to be nationally representative samples and were not intended to provide accurate estimates at the state level (except for the BRFSS surveys, for which sampling was stratified by state). To leverage these data sets and estimate state-level rates of household firearm ownership, we used MRP—a small-area estimation technique commonly used for producing subnational estimates from nationally representative surveys (Gelman and

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[3] We did not include several years of Gallup surveys between 2000 to 2016 that were not available through the Roper Center or that contained a question about only personal firearm ownership. The 1993 Gallup survey included an oversample of gun owners by design, and we removed this survey from our state estimates.

[4] We collected June publisher's statements and geographic analysis reports from the Alliance for Audited Media for 1980–2016. We use *Guns & Ammo* subscription rates (per 100 residents) instead of subscription rates from other similar magazines (e.g., *Guns*, *Shooting Times*, *Garden & Gun*, *American Handgunner)* because *Guns & Ammo* subscription rates have been identified in other research as being positively associated with crime outcomes (Duggan, 2001) and being an indicator of aggregate gun ownership (Kleck, 2015).

Little, 1997; Kastellec, Lax, and Phillips, 2010; Park, Gelman, and Bafumi, 2004). A brief overview of the two-step process for the model is as follows (based on a description in Park, Gelman, and Bafumi, 2004):

1. Fit a multi-level model of the survey response with the following classes of predictors:
   a. the individual characteristics of survey respondents that are both included in the survey and available for the entire population of the state in that year (e.g., characteristics assessed on the census, such as gender and race)
   b. state characteristics (e.g., population density, percentage of residents who are foreign born)
   c. random intercepts for each state and census region.

   The model then can be used to create an estimate, π_j, that represents the expectation of the survey response within category *j*, defined by the cross-classification of all demographic information and the state identifier. For example, if two demographic variables are available, *age* (binned into five categories) and *gender* (two categories), one would use the model to get predicted mean values of firearm ownership across 500 categories (5 ages × 2 genders × 50 states).
2. Poststratify the estimates π_j into a state-level estimate that is representative of the state according to the demographic and state information used in step 1. To do this, first calculate N_j, the total number of individuals in the population within each category *j*, using data on the characteristics of each state (e.g., the number of women aged 25–44 in a given state). Then, for each state *s*, the average estimated response in state *s*, θ_s, is calculated as

$$\theta s = \frac{\sum_{j \in s} N_j \pi_j}{\sum_{j \in s} N_j} .$$

   Thus, the overall estimate for a given state is a simple weighted average of the model-predicted values for each demographic category in that state, weighted by the number of individuals in each category.

To maximize the accuracy of the state-level estimates, it is important that the MRP models include as predictors the individual-level and state-level characteristics associated with firearm ownership and that the model is parsimonious enough to be well estimated in a sample with as few as 1,000 respondents across 50 states. To try to ensure these characteristics, we conducted our MRP model development using the 2001 BRFSS data set. This data set was ideal for our model development because it was near the middle of the period over which we were estimating rates of household firearm ownership; it was very large in size, with nearly 220,000 respondents, which avoids concerns about exploratory overfitting; and it was designed to be representative of state populations, allowing us to compare MRP estimates with more-conventional survey-weighted estimates. We can then generate estimates from this parsimonious model for each survey-year of data, even for much smaller surveys.

We first identified the available individual-level characteristics that are associated with living in a household with a firearm, and we then identified the state-level characteristics associated with firearm ownership, conditioned on these individual characteristics. For candidate state-level characteristics, we tested all of the state-level covariates considered in Schell, Griffin, and Morral (2018); population per square mile; and the log and square root transformations of those covariates. Because there are only 50 states and the final model would include both state- and region-level random effects, we restricted the number of state characteristics included in the final model to three to avoid overfitting. These were selected through a stepwise procedure, using the model Akaike information criterion as the selection criterion. This procedure resulted in a multi-level logistic regression model of the following form, where π_j represents the expectation for each survey response for a given individual *i* in a given state *s* with a single survey:

$$\pi_i = logit^{-1}(\eta_s + \beta_0 + \beta_1^T AGEGROUP_i + \beta_2 female_i + \beta_3 Hispanic_i + \beta_4 married_i$$
$$+\beta_5^T EDUCATION_i + \beta_6^T RACE_i + \beta_7 oldermale_i) \ ,$$

$$\text{where } \eta_s = b_0^T STATE_s + b_1^T CENSUSREGION_s + \gamma_2 \sqrt{PopulationDensity_s}$$
$$+\gamma_3 \sqrt{IncarcerationRate_s} + \gamma_4 \sqrt{PercentForeignBorn_s} \ .$$

In the formula for η_s, the terms b_0 and b_1 represent state-level random effects, and the γ terms represent state-level fixed effects. The multinomial predictors in the model were defined as follows:

- AGEGROUP
  – 18 ≤ age < 25
  – 25 ≤ age < 35
  – 35 ≤ age < 45
  – 45 ≤ age < 55
  – 55 ≤ age < 65
  – 65 ≤ age < 75
  – 75 ≤ age < 100
- EDUCATION
  – less than high school
  – high school or some college
  – college graduate or higher
- RACE
  – white
  – Asian or Pacific Islander
  – black
  – multi-racial
- OLDERMALE
  – age > 65 and male
- *STATE*
  – indicator of state
- CENSUSREGION
  – Northeast
  – Midwest
  – South
  – West.

The full results for the multi-level regression model using data from the 2001 BRFSS survey are presented in Appendix A. For example, the results in Appendix A indicate that being nonwhite, female, or Hispanic is associated with a lower likelihood of household firearm ownership, whereas being married or being an older male is associated with a higher likelihood of household firearm ownership. Differences in gender and marital status are commonly found in the literature on household gun ownership surveys (Coyne-Beasley et al., 2005; Ludwig, Cook, and Smith, 1998).

The models were fit using the glmer function from the lme4 package in R. The model was fit separately for each survey in each year so that measurement errors are independent across surveys and years.[5]

We used the described model to produce the strata estimates, π_j, which are the predicted firearm ownership rates for each combination of covariates *j*. We used the Current Population Survey (CPS) to estimate the number of people in each of the strata, and we used that estimate to create a weighted average of the π_j values that is representative of each state.

The three BRFSS surveys are the only direct measures of household firearm ownership that are reliable and valid for state-level estimates using the existing survey weights. Thus, we compared the MRP estimates with the standard state-level estimates included in each BRFSS survey to document the extent to which our MRP estimates differ from state-representative surveys in which measurement error is minimal. The correlations between MRP estimates and standard survey-weighted estimates are shown in Table 2. These showed extremely high associations across states, both in the year used for model development (2001) and for the two other BRFSS years.

The model that we developed for predicting state-level household firearm ownership in the BRFSS guided our modeling decisions when estimating state-level household firearm ownership in the other surveys from Gallup, the GSS, and Pew Research Center. However, changes to the MRP model were needed when surveys coded their race variable differently or in years in which the CPS (used to determine the characteristics of the states for poststratification) assessed race using different categories. These changes to model specification generally required coding individual race as white or non-white, in which case we added information about the state racial characteristics into the state portion of the model. For example, we added a variable in the η_s equation assessing the proportion of individuals in state *s* who were black or the proportion of individuals in state *s* who were Asian. Other surveys did not always include

Table 2
Correlation Between MRP Estimates of Household Firearm Ownership by State and Estimates Using the Original BRFSS Weights

Year	Correlation
2001	0.989
2002	0.991
2004	0.979

[5] Because each survey-year was analyzed separately, differences in question wording across surveys, as well as question wording changes within surveys over time, were not addressed at this stage; they were addressed later in the structural equation model.

questions regarding marital status or Hispanic status. A summary of departures from the core model are documented in Table 3.

In each case, we made corresponding changes to the construction of the poststratification categories to ensure that they aligned correctly with the predictors in the model. These models provided state-level estimates of household firearm ownership across the desired period that appear to be consistent across surveys. This consistency in trends can be seen in the figures in Appendix C for each state. The result was a data set containing 50 state-level estimates of household firearm ownership corresponding to each survey and year (for a total of 51 total survey-years), which could then be combined with the state-level proxy data.

Estimating a Latent Variable of Household Firearm Ownership

In the second step for the model, we took the survey-based measures and combined them with the broader set of proxy measures to develop a more accurate measure of household firearm ownership for each state over time. Specifically, we used Mplus version 7.3 to develop a structural equation model of household firearm ownership rates (HFRs) that incorporates the state-level survey estimates from MRP and the other data listed in Table 1 (Muthén and Muthén, 2017). This model represents each observed direct or proxy indicator of firearm ownership as being partially caused by the underlying construct of interest, the HFR, and partially caused by other observed or unobserved confounds. This common cause results in covariation among the observed indicators of the HFR, while the other causes of each variable are (1) captured in a random "uniqueness" term (also called error or residual) for confounds that are unique to each indicator; (2) modeled through correlated errors when two indicators are thought to share a common source of variability other than the HFR (e.g., *Guns & Ammo* subscriptions and hunting licenses partially reflect interest in hunting rather than gun ownership); or (3) modeled through the effect of *exogenous* variables, which are potential confounds that are allowed to directly affect both the latent HFR variable and individual indicators of

Table 3
MRP Modeling Differences Across Survey-Years

Survey Model	Difference
BRFSS	• Models are described in the text and were consistent for all survey-years. • Race was coded as described in the text, but multi-racial was available only in 2004.
Gallup	• Hispanic was available: 1988, 1989, 1996, 1997, 1999, 2000, 2012. • Marital status was available: 1980, 1983, 1985, 1986, 1990, 1991, 1996, 2012. • Race was coded as white or non-white for all years; proportion black was included at the state level for all years; and proportion Asian was included for years that it was available in the CPS: 1988, 1989, 1990, 1991, 1993, 1996, 1997, 1999, 2000, 2012.
GSS	• Hispanic (orthogonal to race) was available: 2000, 2002, 2004, 2006, 2008, 2010, 2012, 2014, 2016. • Race was coded as white, black, or other to align with the CPS until 2004, when multi-racial was included.
Pew Research Center	• Race was coded as white or non-white until 2008. • Race was coded as white, black, Asian or Pacific Islander, or multi-racial after 2008. • Information on state proportion Asian and state proportion black was available: 1997, 2000, 2003, 2004, 2007. • Marital status was available: 1997, 2000, 2003, 2004, 2007, 2009, 2010, 2013.

the HFR (e.g., universal background check laws may increase the number of background checks and decrease the HFR by making it harder to obtain a gun). The resulting model identifies a latent measure of the HFR (see Figure B.1 in Appendix B) that combines the various indictors of the HFR while explicitly accounting for several types of error within those indicators (Little, 2013; Muthén, 1997).

The model was developed to represent our theoretical understanding of the relationships between firearm ownership rates and the various indicators of ownership across states and time. Model development was an exploratory process that incorporated both theoretical considerations and measures of model fit (e.g., model modification indices and global model fit indices, such as the Comparative Fit Index [CFI] or the standardized root mean squared residual [SRMR]; see Hu and Bentler, 1999). In addition, the structural equation model was estimated using the expectation-maximization algorithm to handle incomplete data (i.e., a given measure that is not available in every state-year; see Dempster, Laird, and Rubin, 1977). We primarily focused the development process on three concerns:

- Certain measures may not maintain the same relationship with the HFR over time (e.g., magazine subscriptions have declined over time, so change in this measure may not be due to changes in firearm ownership).
- The error in particular measures may not be fully independent (e.g., shared confounds).
- Some measures may be biased for particular state-years.

For example, we closely tracked survey item wording over time to look for changes in the household firearm ownership questions that might change the relationship in particular years. These three concerns are particularly relevant for survey question wording changes that can result in bias. Table 4 presents the question wording changes and year of change for each of the survey data sources. We present all the observed changes in the table, but in both our judgment and in the empirical findings, the most substantial question wording change occurred in the Pew Research Center surveys after 2013: In that case, the relevant question added "or does anyone in your household," which may have prompted the respondent to think more about nonpersonal ownership. This change was associated with a significant increase in the proportion of respondents reporting a firearm in their household, and we accounted for this biasing effect in our final structural equation model.

We designed the overall model to provide independent estimates of the HFR in each state-year. That is, the estimate for a given state-year was based exclusively on the variables that were available in that state-year. For example, the estimated HFR for California in 2000 was based on the surveys and on proxy measures available in that state-year, without incorporating California data from 1999 or 2001. However, the data were not independent across state-years, so the final model adjusts the standard errors and model fit statistics for clustering of data within states. An alternative to this approach would have been to explicitly model this dependency within states; however, that approach results in HFR estimates that share information over time. Although this would undoubtedly result in smoother and more-accurate measures, it may cause problems for researchers wanting to use our firearm ownership estimates to investigate, for instance, the effect of a new gun policy on ownership, because the temporal variation in firearm ownership within states would be altered in a way that could obscure any abrupt shifts.

Table 4
Wording over Time of Survey Questions on Household Firearm Ownership

Survey Source	Years	Question
BRFSS	2001	The next question is about firearms, including weapons such as pistols, shotguns, and rifles; but not BB guns, starter pistols, or guns that cannot fire. Are any firearms now kept in or around your home? Include those kept in a garage, outdoor storage area, car, truck, or other motor vehicle.
	2002, 2004	The next questions are about firearms. We are asking these in a health survey because of our interest in firearm-related injuries. Please include weapons such as pistols, shotguns, and rifles; but not BB guns, starter pistols, or guns that cannot fire. Include those kept in a garage, outdoor storage area, or motor vehicle. Are any firearms now kept in or around your home?
Gallup	1980	Do you happen to have any guns in your home?
	1983, 1988, 1989	Do you have any guns in the house?
	1985, 1986	Do you happen to have any guns in the house?
	1990, 1991a, 1991b, 1993a	Do you have a gun in the house?
	1993c, 1997, 1999b	Do you have a gun in your home?
	1993b, 1996a, 1996b, 1999a, 2000, 2012	Do you have a gun in your home? Do you have a gun anywhere else on your property such as in your garage, barn, shed or in your car or truck?
GSS	1980–2016	Do you happen to have in your home (IF HOUSE: or garage) any guns or revolvers?
Pew Research Center	1997, 2000, 2003	Do you happen to have any guns or revolvers in your home?
	2004, 2007, 2009, 2010a, 2011, 2012, 2013a	Do you happen to have any guns, rifles or pistols in your home?
	2010b	Do you happen to have any guns, rifles or pistols in your home, or not?
	2013b, 2013c, 2015, 2016	Do you, or does anyone in your household, own a gun, rifle or pistol?

NOTE: The Gallup and Pew Research Center surveys and polls are listed in the references at the end of this document. Some of the Gallup polls are listed as being authored by CNN and USA Today. As noted earlier, the BRFSS surveys were obtained from the CDC (2018), and those from the GSS were obtained from NORC at the University of Chicago (2016).

We used a multi-step procedure to develop the latent variable model (see Kline, 2016; Newsom, 2015). We offer an overview of this process here and discuss it in more detail in the next section. First, we identified which variables appeared to be good candidates for inclusion in the latent variable model of the HFR. Using an initial model that assumed stationarity (constant model coefficients) over time, we identified and removed variables with low standardized factor loadings. Specifically, we dropped variables with standardized loadings below 0.20, which corresponds to dropping variables that had less than 4 percent of their variance attributable to the latent HFR construct. Including such poor proxies of firearm ownership in the model would provide little information about the true HFR. As part of this phase, we also investigated the most-appropriate functional forms for our proxy variables (e.g., nonlinear transformations for proxy measures with substantial skew) with the goal of maximizing the standardized factor loading of each proxy before selecting our final set of indicator variables.

In the second phase, we investigated the possibility of correlated errors among the indicators of HFRs. These associations occur when two of the indictors share a common source of error—that is, they are correlated for some reason other than the household firearm ownership rate. This investigation was guided primarily by substantive theory (e.g., the firearm suicide rate for males and females over state-years may be correlated for methodological reasons other than firearm ownership). Our final model also included some correlations based on empirical evidence of such an association, which we discuss in the next section.

In a third phase, we investigated time-invariance by modeling variation in the model intercepts and loadings over time (Little, 2013; Widaman, Ferrer, and Conger, 2010). When such variability over time was identified (via improvements in the fit statistics), the model or the measures were modified to relax assumptions about time invariance and avoid the potential biasing effects of such assumptions. As part of this process, we explored potential breaks in the series resulting from survey design changes (wording or sampling) or other known factors that may change how proxies related to the HFR over time (e.g., changes in laws affecting background checks). When investigating time-invariance, we used three blended linear splines of time over the period, with evenly spaced knots at 1992 and 2004. The coefficient of time spline 1 represents the linear effect of time before 1986, spline 2 represents the linear slope between 1997 and 1999, and spline 3 represents the linear slope after 2009. The slope between those periods (around each knot) transitions smoothly between the slopes of the adjacent splines. If the model coefficients on the three splines were equal, it would imply a constant linear trend over the entire period.

Table 5 summarizes the different variables that we created from the original survey and administrative data sources listed in Table 1 and indicates which form of the variable was included in the final model (in bold). We assumed that the proxy measures may be sensitive to constructs other than household firearm ownership. This could include simple administrative practices (e.g., changes in background check laws that have nothing to do with firearm ownership) or more-complex factors underlying the phenomenon being measured (e.g., the availability of alternatives to firearms as a means for attempting suicide). Thus, we wanted to explore different methods for normalizing or scaling those variables to maximize their relationship to firearm ownership. Additionally, we investigated a square root transformation of the hunting license and *Guns & Ammo* subscription variables because of their strong positive skew. Finally, we standardized rates of *Guns & Ammo* subscriptions and background checks within year. As we discuss later, we did this because the relationship between these proxy measures and the HFR changes substantially over time, with each proxy measure showing dramatic changes in its mean and variance over time, despite the evidence from all other indicators that there were relatively modest changes in the HFR over the same period.

Table 5
Candidate Measures and Specifications Considered in the SEM Analyses

Variable Name	Variable Specifications Considered (Specification Used in the Final Model in Bold)	Variable Type of Specification Used in the Model
Household firearm ownership	• **Proportion of respondents who reported living in a household with a firearm (BRFSS, Gallup, GSS, Pew Research Center)**	Proportion
Proportion of suicides that are firearm suicides (FS/S)	• **Separate measures for male and female FS/S** • Total FS/S • Weighted FS/S that accounts for differences in the gender ratio of suicide	Proportion
Proportion of homicides committed with a firearm (FH/H)	• FH/H • Homicide with a firearm rate	Proportion
Proportion of aggravated assaults committed with a firearm (FA/A)	• FA/A • Aggravated assault with a firearm rate	Proportion
Proportion of robberies committed with a firearm (FR/R)	• FR/R • Robbery with a firearm rate	Proportion
State resident hunting licenses, permits, and tags	• **Hunting license rate (square root)** • Hunting license rate	Rate (per capita)
Guns & Ammo subscriptions	• ***Guns & Ammo* subscription rate (square root, standardized within year)** • *Guns & Ammo* subscription rate (square root) • *Guns & Ammo* subscription rate	Rate (per 100 residents)
Background checks	• **Background check rate, excluding checks for issuing a permit to purchase a firearm or to carry a concealed weapon or rechecks for existing permits, standardized within year** • Background check rate, excluding checks for issuing a permit to purchase a firearm or to carry a concealed weapon or rechecks for existing permits • Background check rate, including checks for issuing a permit to purchase a firearm and rechecks for existing permits • Background check rate, including checks for issuing a permit to purchase a firearm or to carry a concealed weapon and rechecks for existing permits • Background check rate, including checks for purchases of long guns only	Rate (per 10 residents)

Results

Table 6 presents the parameter estimates for the final model (model fit: chi-squared = 0.000, degrees of freedom = 63; CFI = 1.000; SRMR = 0.078).[6] For a more complete description of this model and its estimation, see the Mplus code in Appendix B, along with a description of this model as a system of simultaneous regression equations. This model sets the scale of the latent HFR measure by defining a factor loading of BRFSS to 1 and the intercept of BRFSS to 0. It also includes several exogenous variables used to help identify and remove sources of error or bias: three blended linear splines of time to identify time invariance, a flag for state-years with universal background checks, and a flag for states that require a permit to purchase a firearm (we exclude checks for issuing a permit from the background check data because most permit checks are not for purchases). All exogenous variables were allowed to affect the HFR directly and were allowed to affect the proxy measures as needed. When these exogenous variables are associated with an individual measure conditioned on the mediated effect of the variable through HFR, that indicates a type of bias with that measure.

Specifically, it implies that the mean of that measure varies as a function of the exogenous variable in a manner that cannot be explained by changes in the mean of the HFR. For example, the mean of the rate of *Guns & Ammo* subscriptions per 100 residents changes over time in a manner not explained by changes in the HFR, resulting in an association between the *Guns & Ammo* variable and time conditioned on the HFR. This helps address the first of our three concerns—that certain measures may not maintain the same relationship with household firearm ownership over time. Specifically, we found that rates for *Guns & Ammo* subscriptions, background checks, and hunting licenses had trends that differed from rates of household firearm ownership over time. We did not find evidence that the factor loadings for any of our measures changed over time, however. Additionally, several of the measures indicated correlated error as a result of common method variance (e.g., male and female FS/S) or as indicated by the model (e.g., *Guns & Ammo* subscription and hunting license rates). Finally, we accounted for a question wording change that biased the Pew Research Center estimates in several years of data. Next, we explain how we constructed each measure used in this model and provide information that explains our decisions to include correlated errors or exogenous effects for certain variables in our final model.

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[6] The primary model adjusts standard errors and fit statistics for clustering by state. This was done using the Type = Random, Complex commands in Mplus. When using this method, Mplus applies a sandwich estimator (Hardin, 2003) for the standard errors of individual parameters to adjust for clustering within state. It also modifies the model log-likelihood so that the common likelihood ratio test with the corrected likelihood more closely approximates a Wald test using those corrected standard errors (see Muthén,1993; Satorra and Bentler, 1988). These modified likelihoods are also used for likelihood-based fit statistics (chi-squared and CFI, in our case) and generally show better fit when errors are positively associated within clusters. Although these adjustments to model likelihood have good asymptotic properties, such corrections may not always result in an accurate model likelihood in small sample cases (Savalei, 2014). However, it is worth noting that our model fit indices are acceptable even without an adjustment for clustering: chi-squared = 537.61, degrees of freedom = 62; CFI = 0.953; SRMR = 0.073. In addition, the estimated value of the HFR for any given state-year is essentially identical across models that do and do not adjust for clustering.

Table 6
Final Structural Equation Model for the Household Firearm Ownership Rate

Model Parameter	Estimate (1)	Standard Error (2)	z-Score (Estimate/ Standard Error) (3)	Standardized Estimate (4)
HFR factor loadings				
BRFSS	1.000	NA	NA	0.987
Gallup	0.996	0.048	20.703	0.920
GSS	0.835	0.031	27.046	0.936
Pew Research Center	0.922	0.031	30.021	0.962
Male FS/S	0.752	0.074	10.114	0.868
Female FS/S	0.819	0.078	10.557	0.725
Hunting licenses	0.817	0.120	6.784	0.692
Guns & Ammo subscriptions	4.916	0.683	7.199	0.749
Background checks	5.125	0.760	6.745	0.782
Exogenous effects on HFRs				
Time spline 1	0.001	0.001	1.257	0.027
Time spline 2	–0.011	0.001	–7.970	–0.361
Time spline 3	0.002	0.001	2.352	0.046
Universal background check	–0.029	0.053	–0.543	–0.073
Permit to purchase	–0.202	0.050	–4.007	–0.562
Exogenous effects on hunting licenses				
Time spline 1	0.000	0.001	–0.401	–0.009
Time spline 2	0.009	0.002	4.627	0.246
Time spline 3	–0.003	0.001	–2.542	–0.061
Exogenous effects on *Guns & Ammo* subscriptions				
Time spline 1	–0.006	0.004	–1.311	–0.021
Time spline 2	0.055	0.011	5.204	0.282
Time spline 3	–0.010	0.005	–2.141	–0.036
Exogenous effects on background checks				
Time spline 2	0.052	0.011	4.915	0.271
Time spline 3	–0.009	0.004	–2.171	–0.034
Universal background check	0.106	0.212	0.500	0.041
Permit to purchase	–0.427	0.253	–1.687	–0.181
Exogenous effects on Pew Research Center				
Pew question change	0.068	0.005	14.583	0.148

Table 6—Continued

Model Parameter	Estimate (1)	Standard Error (2)	z-Score (Estimate/ Standard Error) (3)	Standardized Estimate (4)
Correlated errors: Male FS/S with…				
Female FS/S	0.004	0.001	5.250	0.601
Correlated errors: Hunting licenses with…				
Female FS/S	−0.008	0.002	−4.258	−0.531
Male FS/S	−0.003	0.001	−3.366	−0.379
Correlated errors: *Guns & Ammo* subscriptions with…				
Female FS/S	−0.030	0.009	−3.408	−0.370
Male FS/S	−0.013	0.004	−3.425	−0.297
Hunting licenses	0.037	0.012	3.225	0.392
Background checks	0.106	0.048	2.201	0.282
Intercepts				
BRFSS	0.000	NA	NA	
Gallup	0.030	0.020	1.490	
GSS	0.039	0.012	3.243	
Pew Research Center	0.060	0.013	4.582	
Male FS/S	0.285	0.032	8.974	
Female FS/S	0.009	0.026	0.354	
Hunting licenses	−0.025	0.052	−0.481	
Guns & Ammo subscriptions	−2.417	0.291	−8.320	
Background checks	−2.445	0.359	−6.813	
HFR	0.540	0.022	24.813	

NOTES: Model coefficients with a z-score between −1.96 and 1.96 are not statistically significant at the $p < 0.05$ level. The BRFSS loadings and intercept were assigned to 1 and 0, respectively, to set the scale of the HFR, so the standard errors for these are not applicable (NA). Because of rounding, values in column 3 may not exactly equal column 1 divided by column 2.

Direct Measures of the Household Firearm Ownership Rate

BRFSS surveys. The BRFSS survey is the only national survey with information on firearm ownership that uses a sampling procedure intended to be representative at the state level, and it is thus considered the best measure of state household firearm ownership (see, for example, Kleck, 2015). As a result, we used the BRFSS estimate to set the scale (mean and variance) of the latent factor, so the loading and intercept were not estimated for this factor indicator and instead were set to 1 and 0, respectively. As shown in Table 6, the standardized loading for the BRFSS indicator was high (0.987); that is, for a 1.000-standard-deviation increase in the HFR, one would expect a 0.987-standard-deviation increase in the BRFSS estimate. This implies an almost perfect correlation between the two measures in the three years in which the BRFSS survey was available (R-squared = 0.975). There were no exogenous effects (indicating biases in the measure) or correlated errors for the BRFSS estimates in the final model.

Gallup surveys. We used 14 years of Gallup surveys in uneven intervals between 1980 and 2012, with a large gap from 2000 to 2012 (see Table 1). Gallup had the fourth-highest standardized loading and the lowest of the surveys at 0.920 (see Table 6). There were no exogenous effects or correlated errors for the Gallup estimates in the model.

GSS. The GSS had the most complete series of surveys available during our study period, with 22 survey-years spanning 1980 to 2016 and occurring biennially beginning in 1994 (see Table 1). As shown in Table 6, the GSS had the third-highest standardized loading on the latent HFR variable at 0.936, and the HFR accounted for 88 percent of the variance in GSS estimates. There were no exogenous effects or correlated errors for the GSS estimates in the model.

Pew Research Center surveys. We used 12 years of Pew Research Center surveys in uneven intervals between 1997 and 2016 (see Table 1). Pew Research Center had the second-highest standardized loading at 0.962 (see Table 6). The only change we made to improve the Pew Research Center measure was to include a dichotomous indicator identifying the year that Pew changed wording for the household firearm question. In 2013, the question wording changed from “Do you happen to have any guns, rifles or pistols in your home?” to “Do you, or does anyone in your household, own a gun, rifle or pistol?” We estimate that, after Pew added a direct reference to “anyone in the household,” the percentage of individuals responding in the affirmative increased by 7 percentage points, suggesting an effect caused by the wording of the question. Without controlling for this item bias, overall model fit would be reduced and Pew’s standardized loading would be reduced to 0.940. There were no correlated errors for the Pew Research Center estimates in the model.

Proxy Measures

Proportion of suicides that are firearm suicides—male and female (male FS/S and female FS/S). The proportion of suicides in which a firearm is used for males and the proportion for females were included as separate HFR indicators in the model. The theoretical rationale for splitting male and female FS/S is that there is a large difference in the FS/S rate across male and female victims, so differences in overall FS/S across states and years may be driven by differences in the gender distribution of suicide rather than by changes in firearm ownership. We also examined the common measure of all FS/S, as well as a weighted version of FS/S that accounts for yearly differences in female FS/S. Both tended to have smaller factor loadings and contributed to worse model fit, although the difference was not large. For instance, the overall FS/S measure had a slightly lower loading (0.865) than the male FS/S measure in this model, and it decreased nonclustered model fit. In addition to allowing for a better model fit, having separate measures for FS/S for gender also takes advantage of the information provided by female FS/S (see Table 6). Removing female FS/S from the model reduced model fit and increased the standardized loading (0.870) for male FS/S slightly. The final model in Table 6 contains a correlation between male FS/S and female FS/S. The inclusion of this correlation was specified *a priori* due to the two measures sharing method variance. In addition, both of these measures had errors that were negatively associated with rates of hunting licenses and *Guns & Ammo* subscriptions. We included estimates for these associations based on empirical evidence rather than a specific theory. That is, these associations are consistent with a view that rates of hunting licenses and *Guns & Ammo* subscriptions are capturing different types of firearm ownership than FS/S is. In particular, handguns are predominately used in firearm suicides, while hunting sports almost exclusively use long guns. Siegel, Ross, and King (2014) suggested this explanation for a negative association between hunting licenses and FS/S. In our model, there were no exogenous effects of covariates on either FS/S measure; for example, the changes in rates of FS/S over time are fully explained by changes in HFRs over time.

Hunting license rate. As shown in Table 6, the hunting license measure had the lowest standardized factor loading, although it was still moderately high in absolute terms. The measure was heavily skewed to the right, unlike the direct measures of firearm ownership, so we performed a square root transformation, which increased the standardized factor loading to 0.692 from 0.592. As mentioned earlier, rates of hunting licenses and *Guns & Ammo* subscriptions might be measuring a key common dimension of overall firearm ownership: ownership of long guns and rifles commonly used in hunting. The correlation between the errors and uniqueness of the two measures was quite strong in our model, and removing that correlation reduced nonclustered model fit (down to CFI = 0.926; SRMR = 0.077). In addition, we included the exogenous effect of three time splines estimated for hunting licenses. This positive coefficient shows that, even as the HFR goes down over time nationally during the second spline (roughly 1993–2004), the hunting license rate generally stays stable. More generally, we found that hunting license rates were remarkably stable over time in most states. This is consistent with the observation that the number of such licenses is often determined by relatively stable policies of each state's regulatory agencies (which may be determined, for example, by the population of deer in the state) rather than by the number of firearm owners in the state or by the demand for such licenses. Thus, this proxy measure may have limited use in identifying changes in firearm ownership over time. By including the exogenous effect of the time variables on hunting license rates in the model, we prevent the hunting license variable from biasing the time trend on the latent HFR variable.

Guns & Ammo *subscription rate.* The *Guns & Ammo* subscription measure had the third-lowest factor loading in the final model, and it also required a variety of specification changes to address limitations of the measure (see Table 6). The original measure was positively skewed, so we performed a square root transformation of the variable. This transformation improved the standardized factor loading from 0.608 to 0.677. The *Guns & Ammo* residuals also had strong correlations with hunting licenses (positive) and both male and female FS/S (negative). Most importantly, however, *Guns & Ammo* subscription rates lacked time invariance as an indicator of HFRs; that is, the variable's relationship to HFR changed substantially over time. Essentially, although the HFR declines slowly and steadily over time, the *Guns & Ammo* subscription rate increased slightly from 1980 to 1999 and then declined by 54 percent from 1999 to 2016. The unstandardized variable showed significant evidence of time-varying intercepts controlling for changes in the HFR and significant changes in the factor loadings over time (i.e., the covariance between the HFR and this measure changed over time). To prevent these problems from biasing our latent measure of HFR, we standardized the variable and included constraints, and we discuss this solution in more detail in the next paragraph, on background checks.[7] With these adjustments, the *Guns & Ammo* subscription measure provides only cross-sectional information about relative firearm ownership across states and no information about the overall national trend in the HFR. This standardization improved the standardized factor loading from 0.677 to 0.749.

Background check rate. Our background check measure includes data beginning in 1999 and excludes checks performed for issuing a permit to purchase a firearm or to carry a concealed weapon and rechecks for existing permits (after a certain period); thus, the measure includes only background checks for the sale itself. The measure had a standardized loading of 0.782 in our final model (see Table 6). In the process of selecting the final form of this measure, we investigated using background check rates that included checks for purchases of long guns only; checks for issuing a permit to purchase a firearm or to carry a concealed weapon (and rechecks); and checks for issuing a permit to purchase a firearm or to carry a concealed weapon (and rechecks), but only in states that have a permit-to-purchase law or that issue concealed-carry permits without running a background check. None of these options provided higher loadings or better model fit, so we used the original measure, standardized within year. Similar to the *Guns & Ammo* subscription variable, the background check variable showed very poor time invariance in its relationship to the HFR. This is because the background check rate doubled between 2002 and 2013, with a corresponding increase in variance across states, even though none of the direct measures of firearm ownership (or the better proxies) showed such a dramatic increase in mean or variance over the period. To prevent these problems from biasing our latent measure of HFR, we had two options: include intercepts and loadings that varied over time or standardize the measure to mean zero and unit variance within each year and allow time-varying intercepts (i.e., remove all national time trends from the variable before analysis and do not use them for identifying the time trend in the HFR). We adopted the latter solution of standardizing our background check indicator to have mean zero and unit variance within each year, essentially removing these trends from the data before analysis. We then included effects of two time splines on the standardized variable,[8] and we constrained the exogenous effects of the time splines to allow the national trend in the HFR to deviate from the detrended background check data.[9] Moving to a measure that was standardized within year changed the standardized loading of background check rates from 0.713 to 0.782 and improved model fit. In addition to our concerns about time-invariance, we had some theoretical concerns about this measure. Specifically, the best version of this measure approximated a measure of firearm purchases but excluded background checks that were required to receive a

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[7] This constraint was set to be equal to the negative product of the *Guns & Ammo* factor loading and the exogenous effect of the time splines on the HFR. Appendix B provides the Mplus code for the constraints.

[8] Only two time-effects were included because the data series was missing over the period that was influenced by the first piecewise linear spline of time.

[9] Essentially, the effects of the time variables on HFRs were freely estimated while removing the implied indirect effect on background check rates mediated via HFRs. Thus, background check rates could be perfectly stable over time, due to standardization, while HFRs were free to diverge over time. This constraint was set to be equal to the negative product of the background check factor loading and the exogenous effect of the time splines on the HFR. Appendix B provides the Mplus code for the constraints.

permit (predominantly permits to carry a concealed weapon), which may result in underestimating firearm purchases in the few states in which permits are required for purchasing such a weapon. Similarly, we were concerned that including states that require both private and dealer sales to undergo a background check (i.e., universal background check laws) may overestimate firearm purchases compared with including states that require background checks only for dealer sales. To address these potential biases, we included as exogenous predictors indicators of states with universal background checks and permit-to-purchase laws. Both effects were in the hypothesized direction, and they have been retained in the final model, although neither is statistically significant.

Candidate proxies for firearm ownership that were excluded from the final model. The final model included all of the direct survey measures of firearm ownership, as well as five proxy measures (FS/S separated into two, for male and female) that were highly associated with the latent HFR construct. All had standardized loadings greater than 0.69 in the final model, implying that approximately 48 percent of the variance in the factor indicator was associated with the latent HFR construct. However, we also considered firearm-involved crime measures as potential indicators of household firearm ownership. These included measures of the proportion of homicides, assaults, and robberies committed with a firearm, as well as rates of firearm homicide, assaults, and robberies (see Table 5). None of these variables was sufficiently associated with the HFR to constitute a good indicator, and all were eliminated from the model. Specifically, none of these measures had a standardized loading greater than 0.20 when added to the set of predictors in our final model, suggesting that more than 95 percent of their variance across states and time was attributable to factors other than household firearm ownership rates. Thus, including those variables would offer little additional precision in the estimate of firearm ownership.

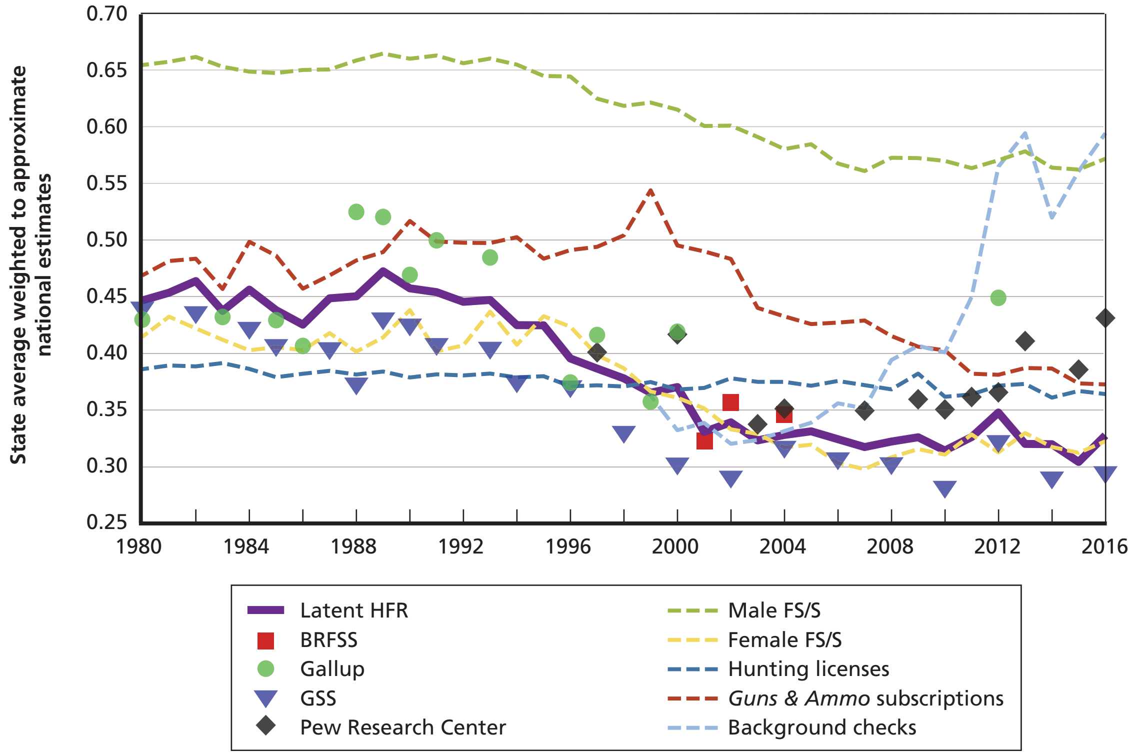
Characteristics of the Household Firearm Ownership Rate

In the model, the HFR is predicted by all exogenous variables, which helps describe the distribution of HFRs across states and over time. As shown in Table 6, the effects of time splines 1 and 3 were near zero or slightly positive, while the slope for spline 2 was substantial and negative. This indicates that, across all states, firearm ownership rates were generally flat over the first third of the time period, declined approximately 1 percent per year in the middle third of the period (1993 to 2004), and showed a very small increase over the final third. We also found that state-years with universal background checks were associated with HFRs that were 2.9 percentage points lower, which was not statistically significant; state-years with permit-to-purchase laws were associated with HFRs that were 20.2 percentage points lower, which was significant.

Figure 1 plots the population-weighted average of the measures used to inform the latent HFR variable alongside the state-year average of the latent factor score over the entire time series.[10] This figure plots the raw individual factor indicators and does not include the adjustments to these indicators used in the model. (That is, the figure presents data that exclude

[10] Each state-level estimate was weighted proportionally to its population size and averaged to provide a national estimate. These weighted estimates approximate a national estimate but may not be fully representative because of missing data (i.e., not all states were represented in all years for certain survey measures). These results may diverge somewhat from published national estimates for each survey because these estimates used MRP, rather than the original survey weights, to achieve population-representative estimates at the state level, which were then averaged up to the national level.

Figure 1
Average of the Household Firearm Ownership Rate and Its Indicators over Time, Weighted by Population, 1980–2016

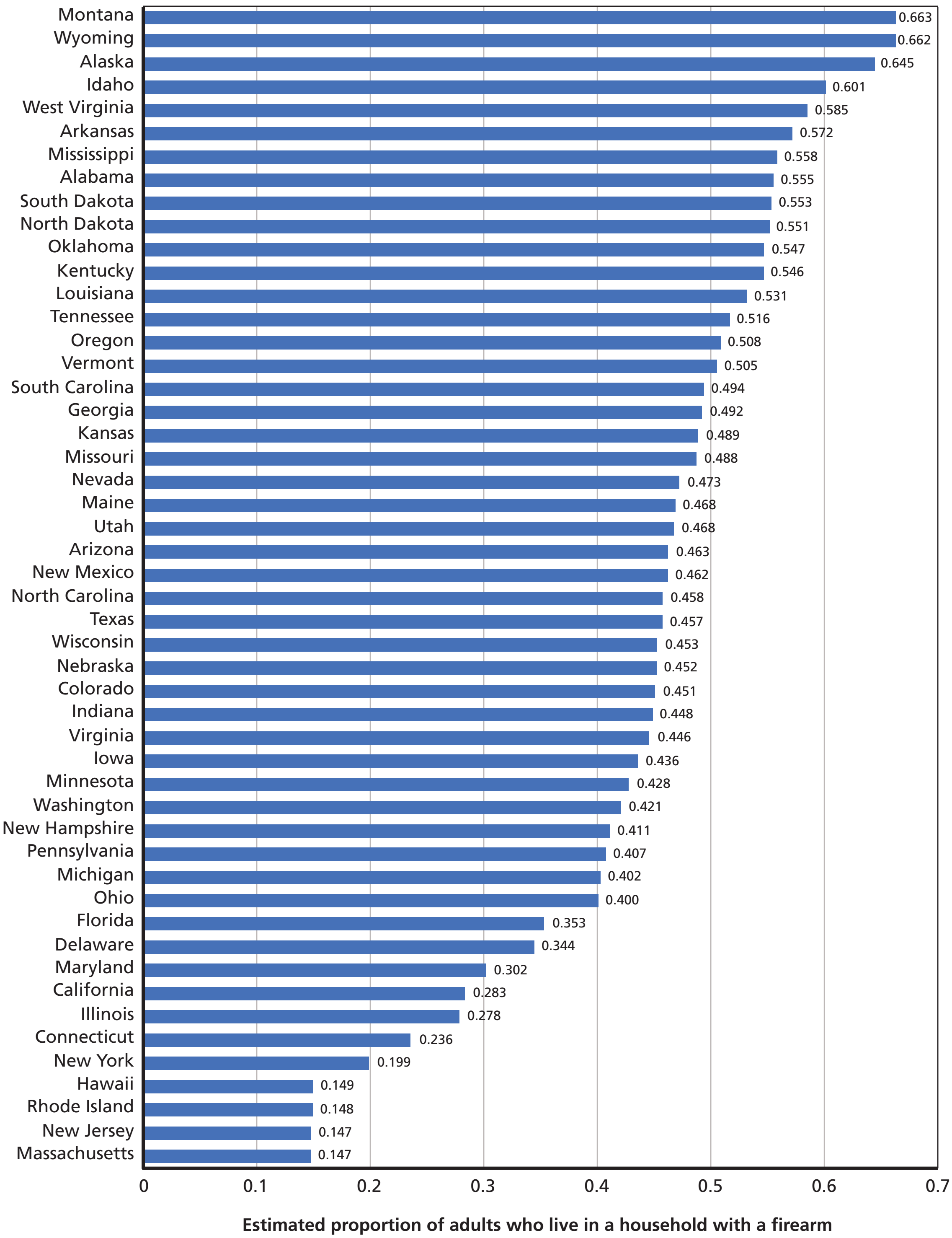


NOTE: The *Guns & Ammo* subscription and background check indicators are presented as rates in this figure but were standardized within year in the final model. Other estimates do not reflect structural equation model adjustments.

the adjustments designed to mitigate biases resulting from changes in Pew Research Center question wording; biases in background checks resulting from state firearm regulations; biased time trends for hunting licenses, *Guns & Ammo* subscriptions, and background checks; and the standardization or detrending of *Guns & Ammo* subscriptions and background checks.) Additionally, the FS/S, *Guns & Ammo* subscription, hunting license, and background check variables are on a different scale, which is reflected in their model intercepts. Figure 1 shows that the latent HFR factor is not dramatically affected by any given yearly increase or decrease present in an individual measure, and it tends to split the survey estimates. Household firearm ownership shows a general decreasing trend over time, with the largest decline between 1993 and 2001.

Additionally, Figure 2 shows the state averages for the latent HFR factor scores from 1980 to 2016, ranked from highest to lowest. Montana, Wyoming, and Alaska have the highest scores (interpreted as the proportion of adults in a state who live in a household with a firearm), while Hawaii, Rhode Island, New Jersey, and Massachusetts have the lowest. Trends over time for each state are shown in Appendix C.

Figure 2
State-Level Estimates of the Average Household Firearm Ownership Rate, 1980–2016



Discussion

This document presents a measure of the proportion of adults in each state-year who live in a household with a firearm. This measure combines the available direct, survey-based measures of household firearm ownership with several proxy measures that have been used to represent firearm ownership in the scientific literature. In general, we found that small-area estimates of HFRs derived from the survey data were the best indicators of the latent HFR construct but suffered from substantial missingness. Several of the proxies were also good indicators of HFRs, although they displayed measurement problems (such as correlations for reasons other than the HFR and a lack of time-invariance), which made it difficult to use the indicators to look at changes over long periods.

This method of creating a measure does not require us to assume that any individual survey-based or proxy measure of gun ownership is reliable or valid as a measure of the HFR (Kline, 2016). Rather, the method estimates the reliability of each measure from the correlations among measures (expressed in the model uniqueness terms) and allows us to directly assess and control for hypothesized threats to validity (e.g., shared unmeasured confounds expressed as correlated errors or item bias expressed as associations with measured confounds). The final model creates a measure of the HFR that mitigates these potential sources of error by combining the survey measures with the proxies and by (1) relaxing assumptions about conditional independence among some of these proxies, (2) controlling for possible biases in the proxies resulting from changes in the relationship with HFRs over time, and (3) accounting for varying levels of reliability across the different measures.

The final HFR measure was designed to be useful for researchers who wish either to control for the effects of firearm ownership on some outcome of interest in longitudinal models of state data or to study the factors associated with variation in firearm ownership across states and time. Thus, the measure avoids pooling data across years, which could remove abrupt changes from the estimates or shift those changes in time. It is worth noting, however, that HFRs are very stable within states over the period. So, it is possible to achieve lower error of measurement by pooling information over time, but that could result in some loss of precision about the timing of shifts in the HFR.

The resulting latent variable model (including the Mplus code, factor scores, and the underlying data) is available, as part of the RAND State-Level Firearm Ownership Database, for researchers who wish to conduct their analyses in a latent variable framework.[11] These represent an observed variable, for each state-year in the period, that closely approximates the latent variable and can be used in standard statistical analyses. When it is possible, it is generally preferable that researchers using this measure of the HFR conduct those analyses in a latent variable context in which the various sources of error can be explicitly modeled, although the two analyses will generally give similar results.

When using the RAND State-Level Firearm Ownership Database, users should consider the following limitations:

- The data are limited to 1980 to 2016. This may restrict the years that can be used in researchers' analyses. Given the stability in firearm ownership over time, it may be rea-

[11] We also include the standard errors of the factor scores from the nonclustered model. We did not produce standard errors of factor scores for the clustered model.

sonable for a researcher to carry forward or back a year or two of data to extend the analysis to a slightly longer time frame, so long as the imputed period is short and not the primary interest of the analysis.

- We used data sources that were easily available to us. This omits several possible sources that are not publicly available. For example, it appears that Gallup has additional surveys assessing household firearm ownership that are not available through the Roper Center, and including those surveys could substantially reduce missingness on that measure.
- The HFR measure does not estimate the number of individuals who own firearms, and it does not estimate the number of firearms owned in any particular household or by any individual. Such measures may diverge from the proportion of adults who live in a household with a firearm.
- The values of the latent factor are more useful for identifying relative levels of firearm ownership across states over time than for identifying the absolute levels of firearm ownership within each state. The absolute level depends on how one chooses to set the overall scale of the latent variable (i.e., which version of the question). In our case, we set the scale to have the same mean as the BRFSS measure because that is the only survey measure that is designed to be representative at the state level.
- The MRP process produces small-area estimates for each state; that is, it uses a statistical model that partially pools data across states to stabilize the estimates within each state. To the extent that the models we used were consistently misspecified in some way, there may be biased estimates for individual states from this process. Although such a bias would not affect the proxy measures, and thus would be substantially mitigated in our final latent HFR variable, the bias could be present in state-years that have more survey data available.
- The underlying model does not include a process that produces the observed correlations in each state over time in these measures, although it does adjust the standard errors for nonindependence. Including such a mechanism (in either the MRP processing of survey data or the latent variable model) would affect the estimates of household firearm ownership.
- The development of the latent variable model included some exploratory model development. Using an alternative model development procedure or including a different set of factor indicators could result in meaningfully different measures of household firearm ownership.
- Like all forms of factor analysis, the final measure is identified by the associations among the measures that are used as indicators of firearm ownership. To the extent that all of those measures share a common set of biases or common source of error, it will be reflected in the final measure of firearm ownership. Although the measures we combined are conceptually very diverse, it is possible that they have some shared biases. For example, they may all underrepresent firearm ownership by criminals. To the extent that criminals represent a meaningful proportion of all firearm owners, such a bias in the individual measures would also appear in the final HFR measure.

APPENDIX A

Results from the Multi-Level Regression Model Using Data from the 2001 BRFSS Survey

Table A.1 provides the results of the final multi-level regression model for household firearm ownership using data from the 2001 BRFSS survey. These coefficients are from a complex multi-predictor model that was derived in an exploratory fashion. Our goal for these analyses was to develop a parsimonious model with predictors available in most of the surveys but not to precisely identify individual-level predictors of firearm ownership. This model information was used in our poststratification tables for the 2001 BRFSS survey, which we do not present here.

Table A.1
Multi-Level Regression Model of Survey Respondent Household Firearm Ownership Using Data from the 2001 BRFSS Survey

Panel A: Individual-Level Effects

	Estimate	Standard Error	z-Score (Estimate/ Standard Error)	*p*-Value
Intercept	−0.349	0.177	−1.971	0.049
25 ≤ age < 35	0.040	0.023	1.753	0.080
35 ≤ age < 45	−0.227	0.022	10.242	0.000
45 ≤ age < 55	0.355	0.022	15.869	0.000
55 ≤ age < 65	0.453	0.024	19.075	0.000
65 ≤ age < 75	0.085	0.027	3.128	0.002
75 ≤ age < 100	−0.274	0.030	−9.252	0.000
Female	−0.660	0.012	−56.730	0.000
Hispanic	−0.862	0.027	−31.819	0.000
Asian or Pacific Islander	−0.988	0.047	−20.876	0.000
Black	−0.935	0.024	−39.252	0.000
Married	0.857	0.011	76.301	0.000
High school or some college	0.277	0.018	15.378	0.000
College graduate or higher	−0.075	0.020	−3.801	0.000
Age > 65 and male	0.467	0.028	16.571	0.000
Population density (square root)	−0.054	0.005	−9.991	0.000
Incarceration rate (square root)	0.032	0.009	3.801	0.000
Percentage foreign born (square root)	−0.242	0.037	−6.602	0.000

NOTE: The 2001 survey had 191,038 respondents.

Table A.1—Continued

Panel B: State and Census Region Random Effects

FIPS Code	State or Region	Intercept
States		
1	Alabama	0.070308
2	Alaska	0.312022
4	Arizona	−0.11055
5	Arkansas	0.157409
6	California	0.243514
8	Colorado	−0.17452
9	Connecticut	−0.0805
10	Delaware	−0.28514
12	Florida	0.176084
13	Georgia	0.191462
15	Hawaii	−0.67577
16	Idaho	0.167847
17	Illinois	−0.28051
18	Indiana	−0.00322
19	Iowa	−0.0758
20	Kansas	−0.06066
21	Kentucky	0.218785
22	Louisiana	−0.23578
23	Maine	−0.18739
24	Maryland	0.132242
25	Massachusetts	−0.02648
26	Michigan	0.173127
27	Minnesota	0.16457
28	Mississippi	0.129714
29	Missouri	−0.00058
30	Montana	0.087034
31	Nebraska	−0.20851
32	Nevada	−0.04497
33	New Hampshire	−0.29512
34	New Jersey	0.256775
35	New Mexico	−0.03604

Table A.1—Continued

FIPS Code	State or Region	Intercept
36	New York	0.166385
37	North Carolina	−0.00731
38	North Dakota	−0.00783
39	Ohio	−0.19607
40	Oklahoma	−0.28364
41	Oregon	−0.01334
42	Pennsylvania	0.175106
44	Rhode Island	−0.02694
45	South Carolina	0.024026
46	South Dakota	0.051787
47	Tennessee	−0.01467
48	Texas	0.037324
49	Utah	0.202815
50	Vermont	−0.12486
51	Virginia	0.081969
53	Washington	−0.06629
54	West Virginia	0.14026
55	Wisconsin	0.030166
56	Wyoming	0.134138
Census Regions		
1	Northeast	−0.03245
2	Midwest	−0.09381
3	South	0.120925
4	West	0.005876

NOTE: FIPS = Federal Information Processing Standards.

Detailed Structural Equation Model Description and Mplus Syntax

The structural equation model is a series of regression equations estimated simultaneously. Our final model is defined by the following system of equations:

$$
\begin{aligned}
&BRFSS = HFR + \varepsilon_1 \\
&Pew = \lambda_2 HFR + \beta_{2.1} Pew\_Q\_change + \alpha_2 + \varepsilon_2 \\
&GSS = \lambda_3 HFR + \alpha_3 + \varepsilon_3 \\
&Gallup = \lambda_4 HFR + \alpha_4 + \varepsilon_4 \\
&Male\_FS\_S = \lambda_5 HFR + \alpha_5 + \varepsilon_5 \\
&Female\_FS\_S = \lambda_6 HFR + \alpha_6 + \varepsilon_6 \\
&\sqrt{Hunting\_licenses} = \lambda_7 HFR + \beta_{7.1} BS1 + \beta_{7.2} BS2 + \beta_{7.3} BS3 + \alpha_7 + \varepsilon_7 \\
&Std\_backgrnd\_chks = \lambda_8 HFR - \lambda_8 \beta_{8.1} BS1 - \lambda_8 \beta_{8.2} BS2 - \lambda_8 \beta_{8.3} BS3 + \beta_{8.4} UniversalBC + \\
&\qquad \beta_{8.5} Permit\text{-}to\text{-}purchase + \alpha_8 + \varepsilon_8 \\
&\sqrt{Std\_Guns\ \&\ Ammo} = \lambda_9 HFR - \lambda_9 \beta_{9.1} BS1 - \lambda_9 \beta_{9.2} BS2 - \lambda_9 \beta_{9.3} BS3 + \alpha_9 + \varepsilon_9 \\
&HFR = \beta_{10.1} BS1 + \beta_{10.2} BS2 + \beta_{10.3} BS3 + \beta_{10.4} UniversalBC + \beta_{10.4} Permit\text{-}to\text{-}purchase + \alpha_{10} + \varepsilon_{10} \quad ,
\end{aligned}
$$

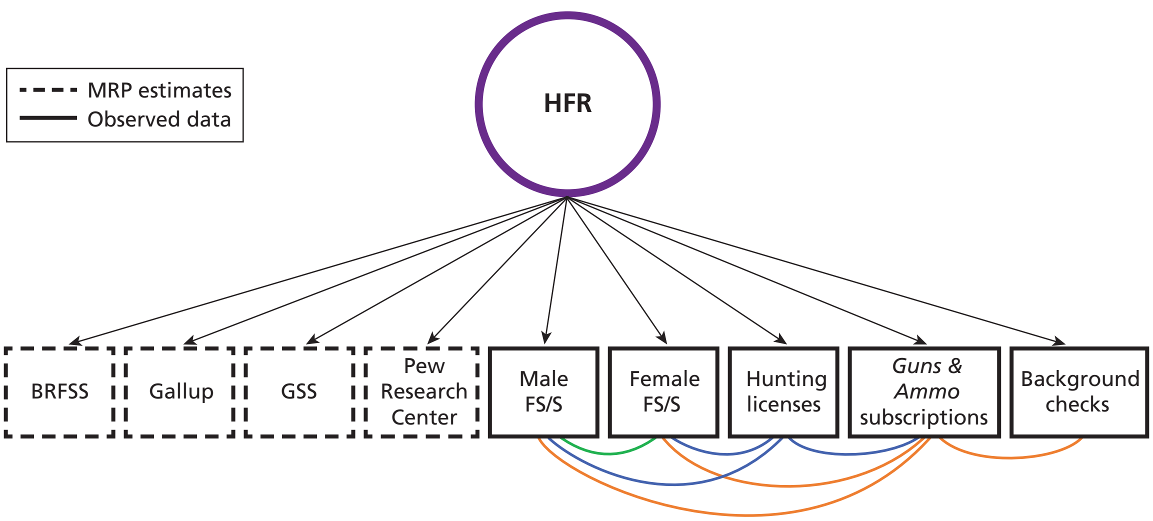
where each ϵ is assumed to be normally distributed error, the α's are constants, and *BS1* through *BS3* are blended, piecewise linear splines of time.

Although the variable *HFR* is not in the data set, the model identifies this latent variable by assuming that 29 of the 36 pairwise associations between the observed criterion variables are independent, conditional on the system of equations (i.e., that the ε's are independent). The observed covariance between those indicators must be explained by the HFR or the exogenous variables, with the exception of the following seven pairwise associations among proxy indicators, which are freely estimated:

$$\sqrt{Std\_Guns \,\&\, Ammo} \text{ with } Male\_FS\_S$$
$$\sqrt{Std\_Guns \,\&\, Ammo} \text{ with } Female\_FS\_S$$
$$\sqrt{Std\_Guns \,\&\, Ammo} \text{ with } Std\_backgrnd\_chks$$
$$\sqrt{Std\_Guns \,\&\, Ammo} \text{ with } \sqrt{Hunting\_licenses}$$
$$\sqrt{Hunting\_licenses} \text{ with } Male\_FS\_S$$
$$\sqrt{Hunting\_licenses} \text{ with } Female\_FS\_S$$
$$Male\_FS\_S \text{ with } Female\_FS\_S$$

Figure B.1 presents the conceptual model of the latent HFR variable.

Figure B.1
Conceptual Model of the Latent Household Firearm Ownership Rate



The following is the MPlus syntax used to obtain the final structural equation model results discussed earlier. This syntax can be used along with the RAND State-Level Firearm Ownership Database to reproduce our findings.

```
Title: SEM Final Model-Clustered;
Data: FILE IS TL-354- RAND State-Level Firearm Ownership Database.csv;
Variable: Names Are FIP Year
   Universl !Universal background checks state indicator
   Permit !Permit to purchase state indicator
   Fem_FS_S !Female firearm suicides/total suicides
   Male_FS_S !Male firearm suicides/total suicides
   BRFSS GALLUP GSS PEW !BRFSS, Gallup, GSS, and Pew survey estimates
   HuntLic !Square root of state resident hunting license rate
   GunsAmmo !Square root of Guns & Ammo subscription rate and standardized within year
   BackChk !Background checks rate standardized within year
   PewQChng !Binary indicator for Pew surveys that changed ownership question
   BS1 !First blended linear spline-represents roughly 1980-1992
   BS2 !Second blended linear spline-represents roughly 1993-2004
   BS3; !Third blended linear spline-represents roughly 1993-2004
CLUSTER = FIP; !Remove to estimate standardized loadings & modindices
USEVARIABLES ARE
         BRFSS GALLUP GSS PEW Male_FS_S Fem_FS_S BackChk GunsAmmo HuntLic Universl
         Permit BS1 BS2 BS3 PewQChng;
MISSING = ALL (-9);
Analysis:
   Estimator = MLR;
   Type = Random; !Remove to estimate standardized loadings & modindices
   Type = COMPLEX; !Remove to estimate standardized loadings & modindices
   Coverage = .02;
   Iterations = 10000;
   H1ITERATIONS = 20000;
Model:
   !Factor Loadings
   HFR BY BRFSS GALLUP GSS PEW Male_FS_S Fem_FS_S
         BackChk (HFRBC) !Model name for parameter
         GunsAmmo (HFRGA) !Model name for parameter
         HuntLic;
   !Exogenous Effects
   HFR ON BS1 (S1HFR) !Model name for parameter
          BS2 (S2HFR) !Model name for parameter
          BS3 (S3HFR) !Model name for parameter
          Universl Permit;
   BackChk ON BS2 (S2BC) !Model name for parameter
              BS3 (S3BC) !Model name for parameter
              Universl Permit;
```

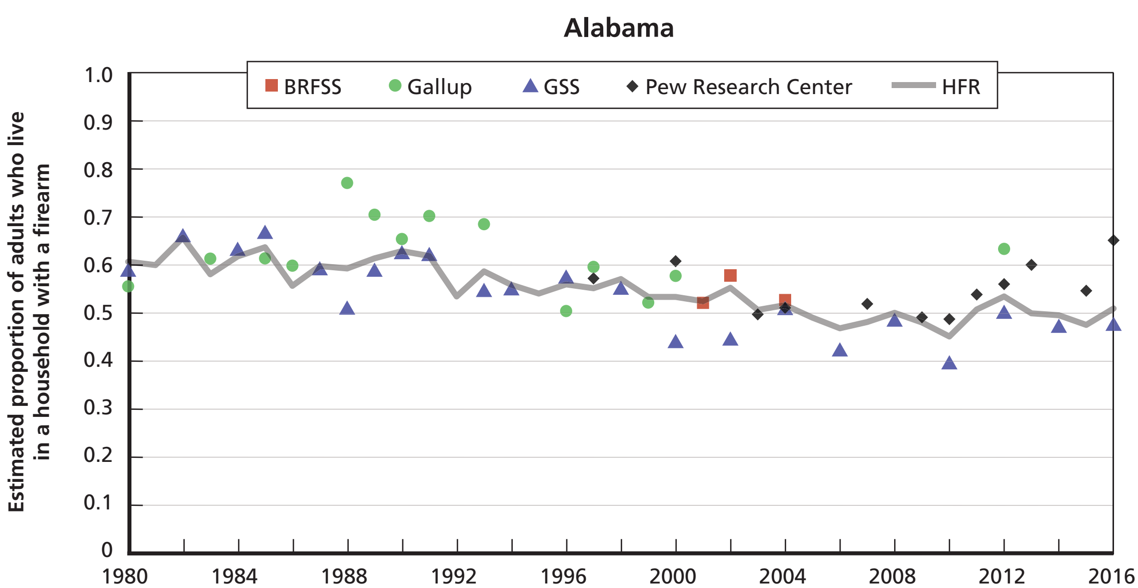
```
    GunsAmmo ON BS1 (S1GA) !Model name for parameter
                BS2 (S2GA) !Model name for parameter
                BS3 (S3GA); !Model name for parameter
    HuntLic ON BS1 BS2 BS3;
    PEW on PewQChng;
    !Correlated errors
    GunsAmmo WITH HuntLic Fem_FS_S Male_FS_S BackChk;
    HuntLic WITH Fem_FS_S Male_FS_S;
    Male_FS_S WITH Fem_FS_S;
    !Free factor intercept and set BRFSS intercept to 0
    [HFR*];
    [BRFSS@0];
Model Constraint:
      S1GA = -S1HFR*HFRGA; !-Exog. effect of BS1 on GunsAmmo = -exog. effect of BS1 on HFR*
          factor loading of GunsAmmo on HFR
      S2GA = -S2HFR*HFRGA; !-Exog. effect of BS2 on GunsAmmo = -exog. effect of BS2 on HFR*
          factor loading of GunsAmmo on HFR
      S3GA = -S3HFR*HFRGA; !-Exog. effect of BS3 on GunsAmmo = -exog. effect of BS3 on HFR*
          factor loading of GunsAmmo on HFR
      S2BC = -S2HFR*HFRBC; !-Exog. effect of BS2 on BackChk = -exog. effect of BS2 on HFR*
          factor loading of BackChk on HFR
      S3BC = -S3HFR*HFRBC; !-Exog. effect of BS3 on BackChk = -exog. effect of BS3 on HFR*
          factor loading of BackChk on HFR
Output: SAMPSTAT; !STANDARDIZED MODINDICES(10);!For non-clustered model
SAVEDATA: FILE IS FS_GunOwnership_TypeRandomComplex.csv;
    SAVE IS fscores;
    FORMAT = F15.3; !Save factor scores to 3 decimal places
```

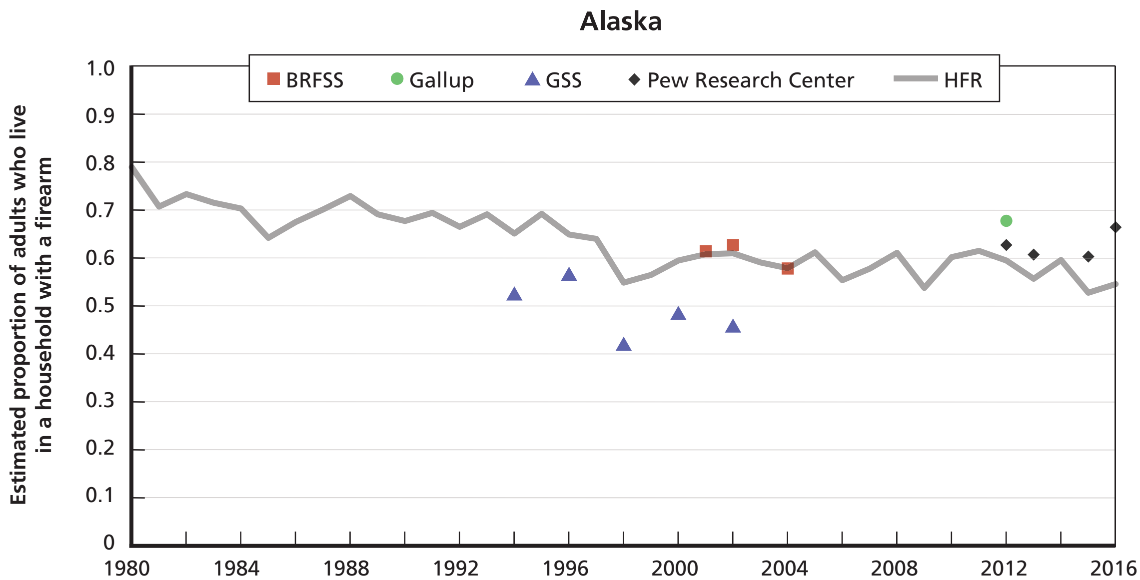
APPENDIX C

Estimated State Trends in Household Firearm Ownership

The 50 panels in Figure C.1 represent yearly estimates of household firearm ownership by state from 1980 to 2016, resulting from the final structural equation model presented in this document. The gray line is the factor score of the latent HFR variable for each state-year. This estimate is derived from a model that was estimated using state-level clustering to account for nonindependence. These figures also include the small-area estimates for each survey from our MRP analyses that were inputs to the latent variable modeling. Furthermore, the HFR estimate incorporates other state-level measures that are not pictured in these figures, as well as model effects designed to address potential sources of bias, as described in the main section of this document. (Note that the Pew Research Center surveys changed the question wording beginning in 2013, which resulted in a 7-percentage-point increase in the measured prevalence. The HFR trend line adjusts for this bias, but the MRP estimation did not.)

Figure C.1.
Estimated Household Firearm Ownership Rates, by State, 1980–2016




Alaska
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
1.0
0.9
0.8
0.7
0.6
0.5
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1980
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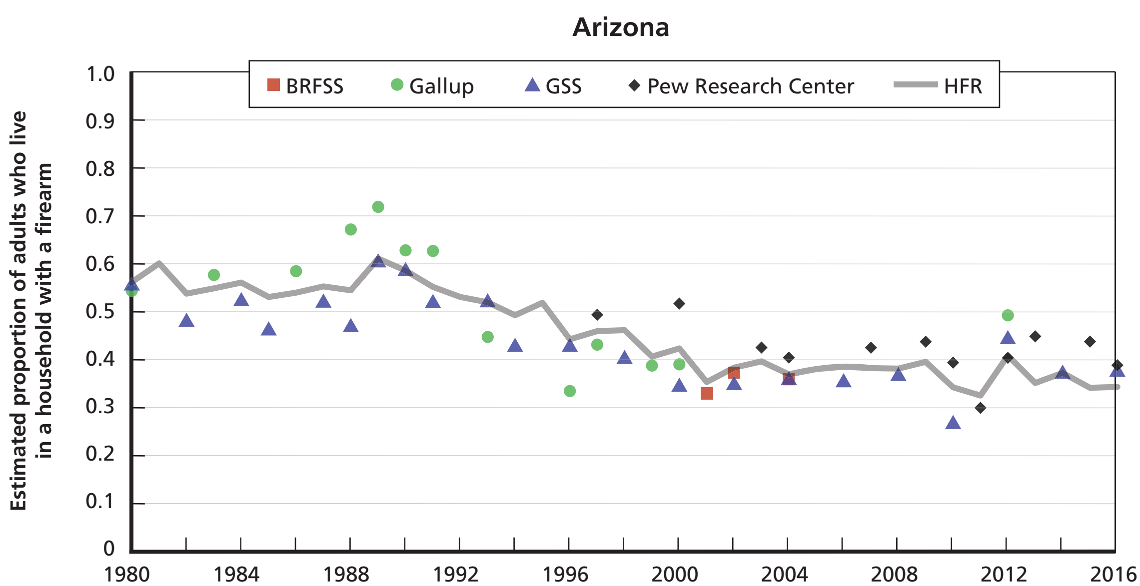
Arizona
BRFSS
Gallup
GSS
Pew Research Center
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Estimated proportion of adults who live in a household with a firearm
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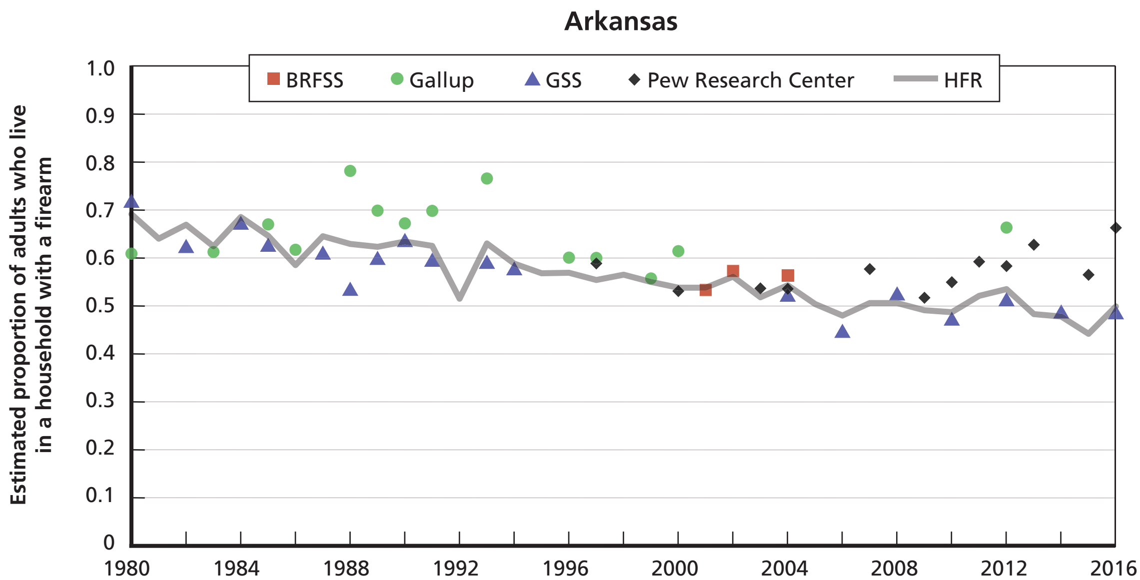
Arkansas
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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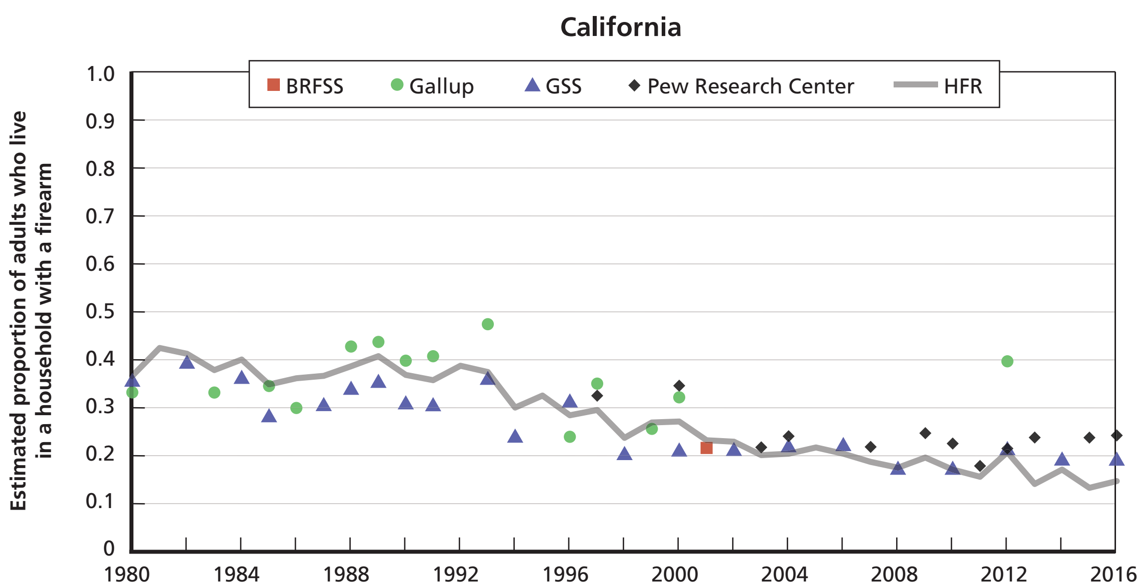
California
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
1.0
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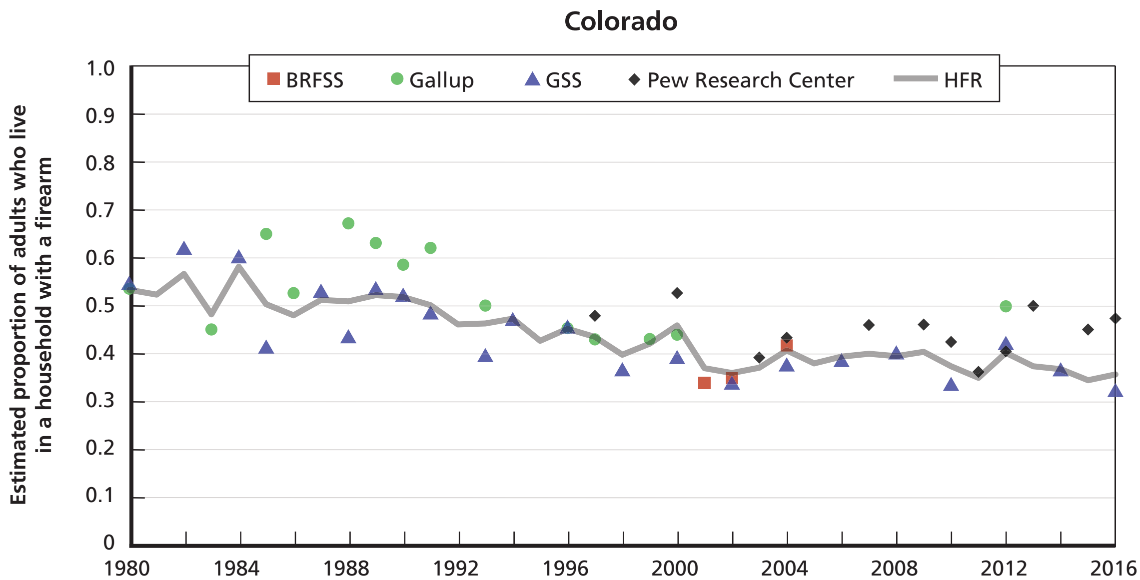
Colorado
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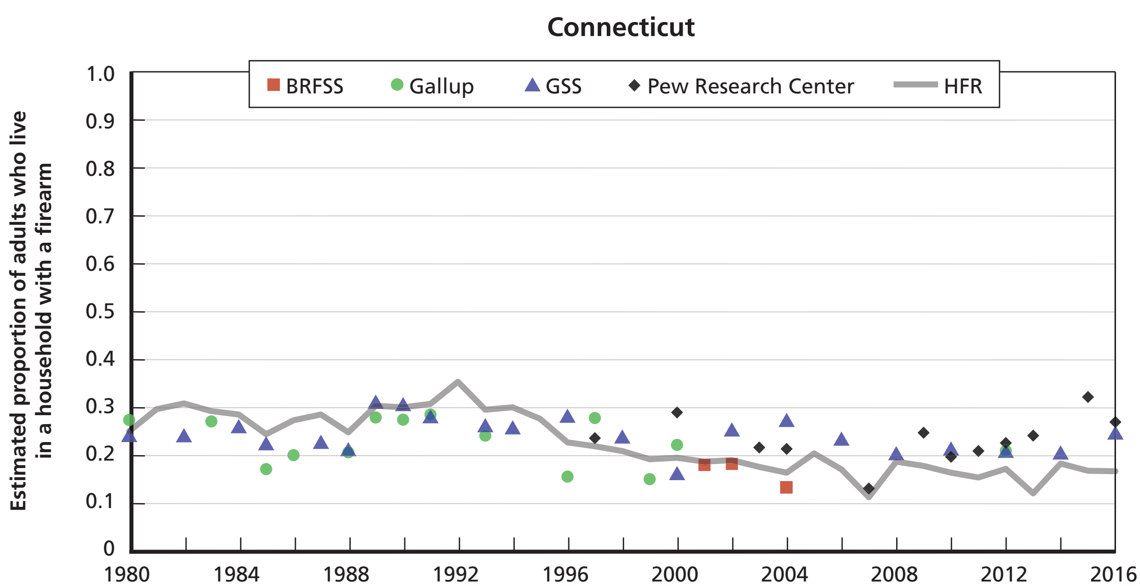
Connecticut
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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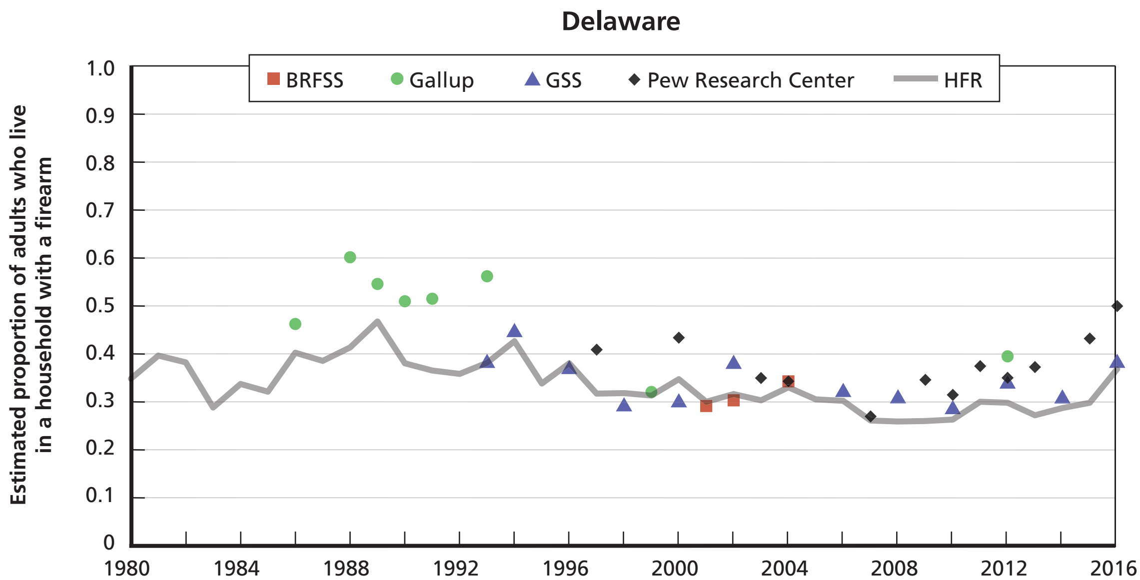
Delaware
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
1.0
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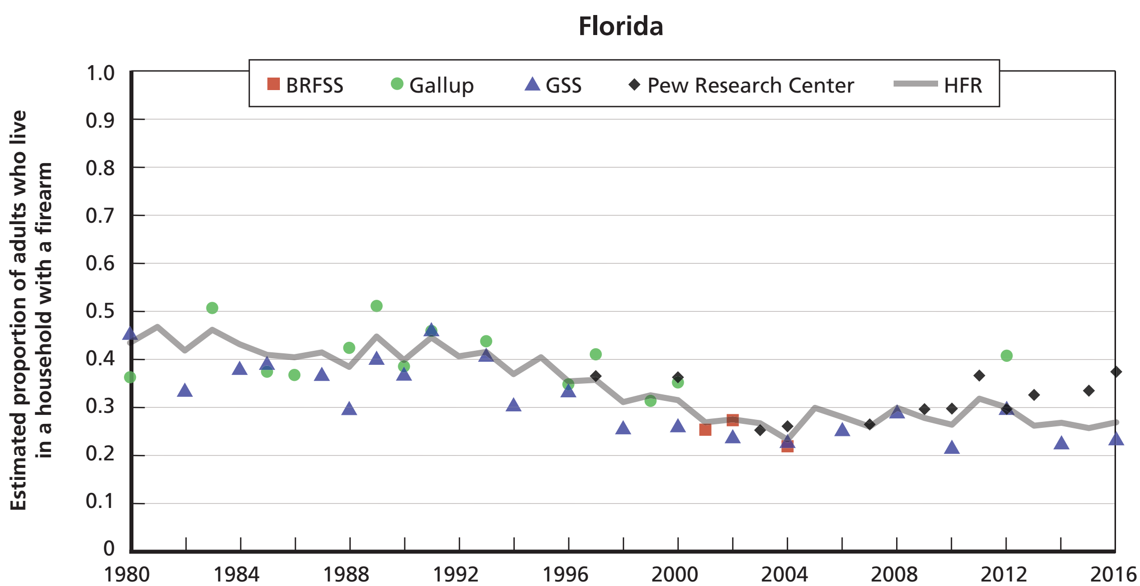
Florida
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Gallup
GSS
Pew Research Center
HFR
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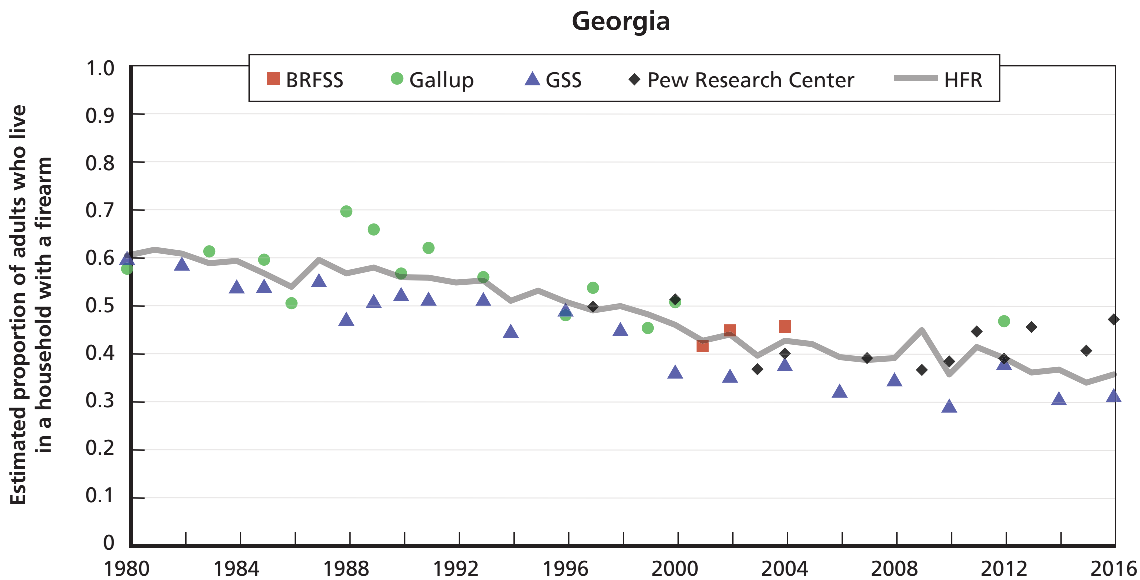
Georgia
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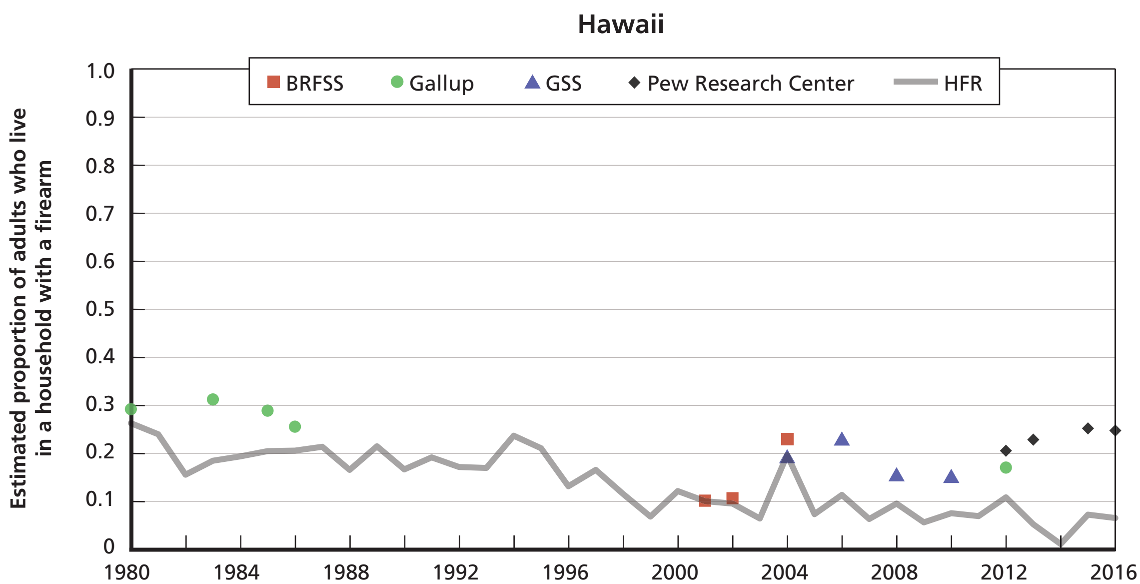
Hawaii
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GSS
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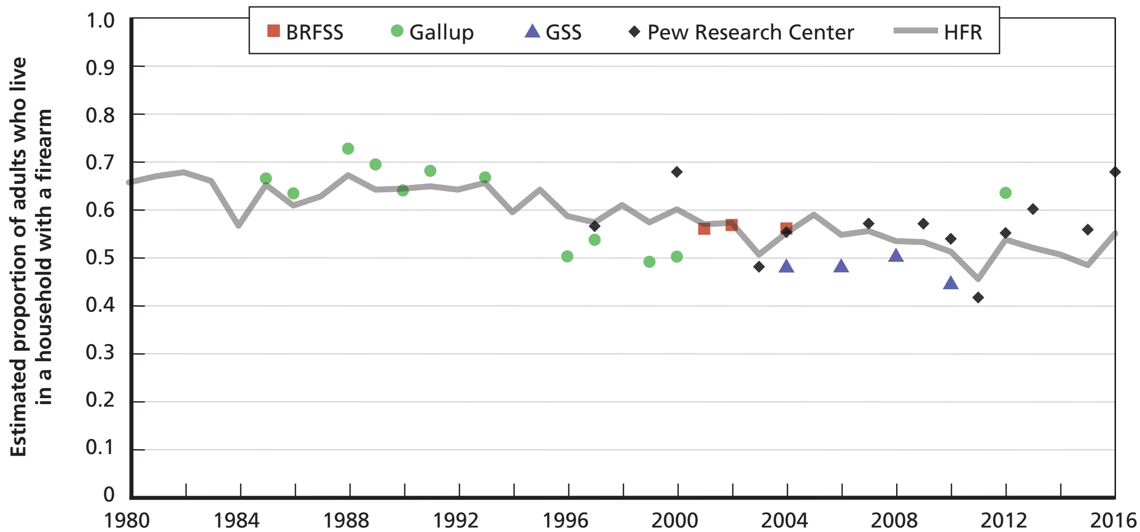
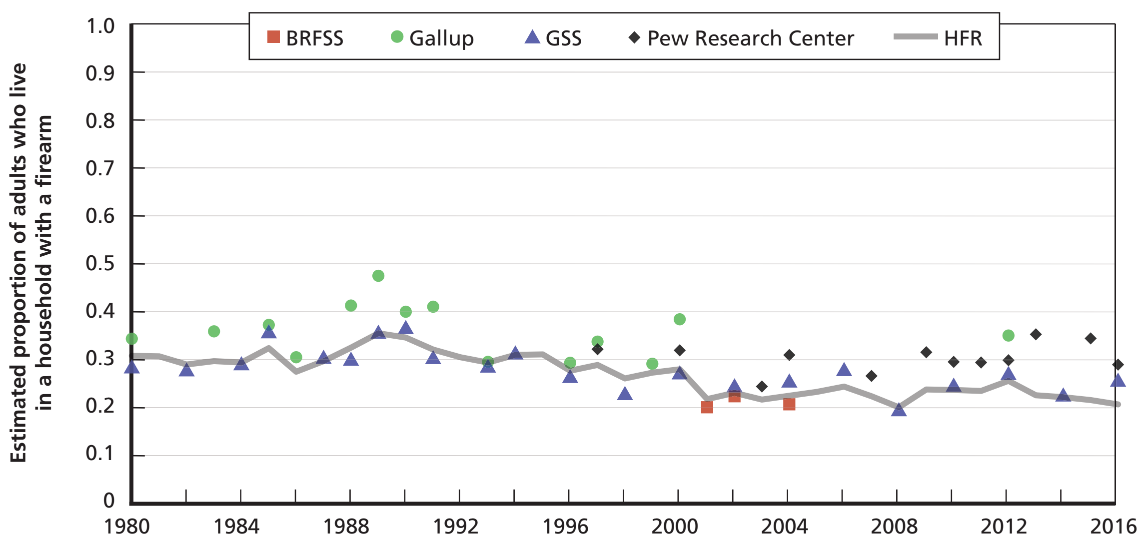
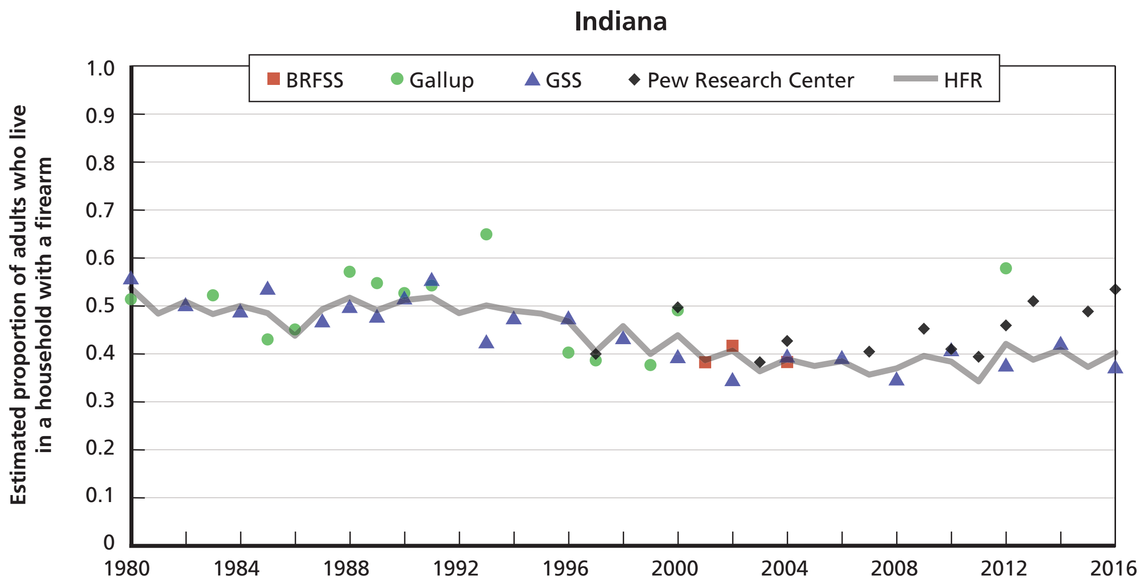
Idaho



Illinois

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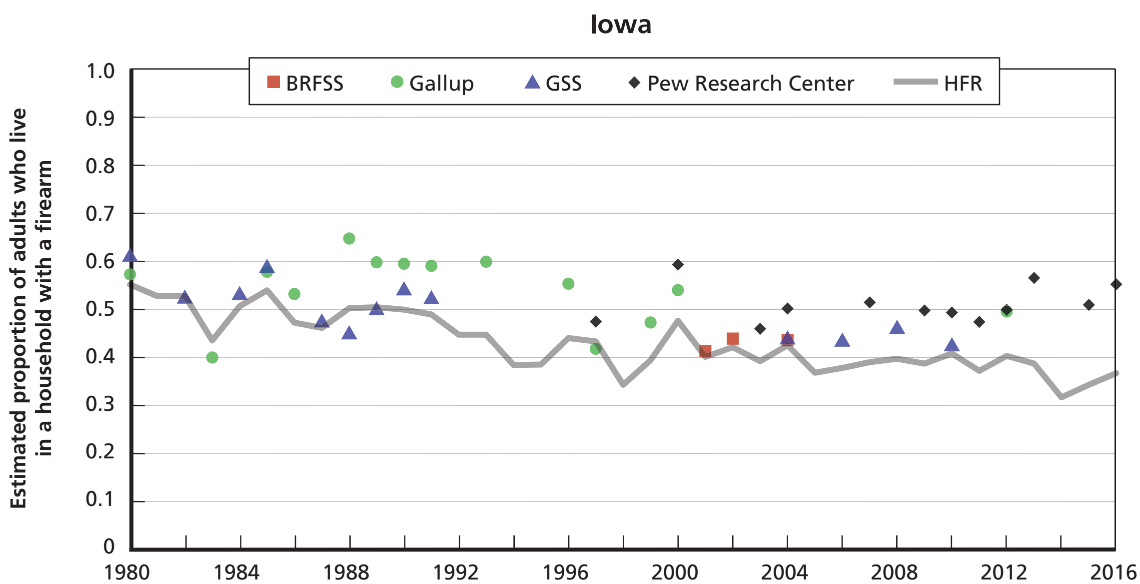
Iowa
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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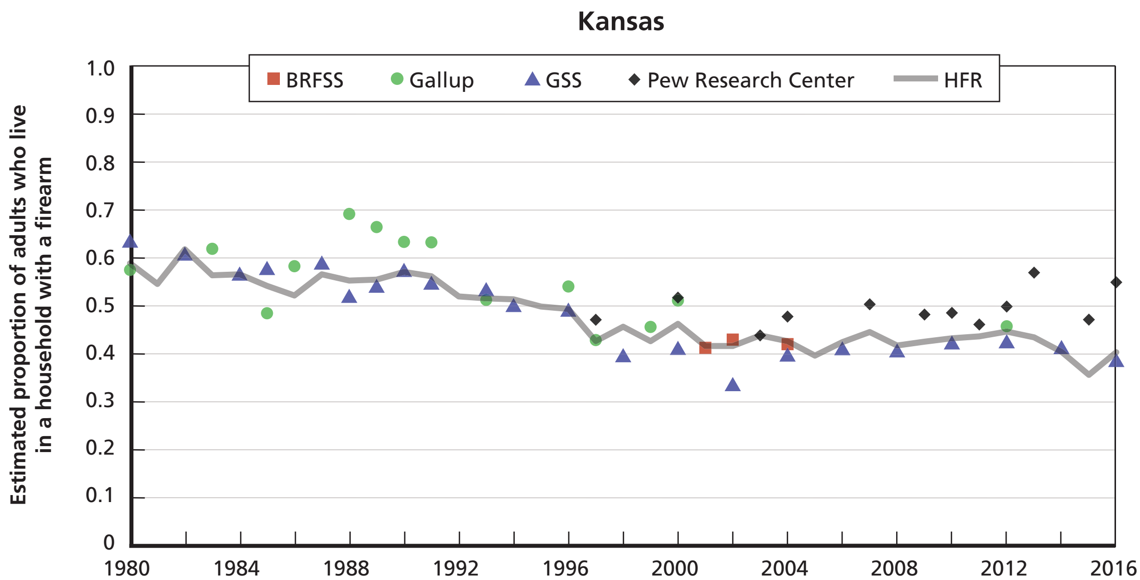
Kansas
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Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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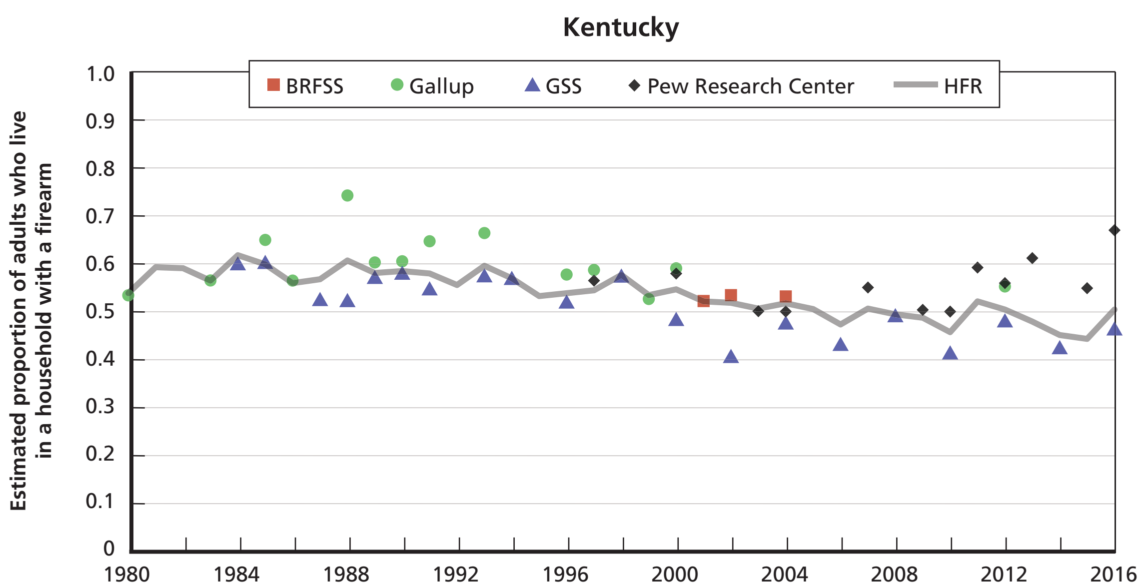
Kentucky
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Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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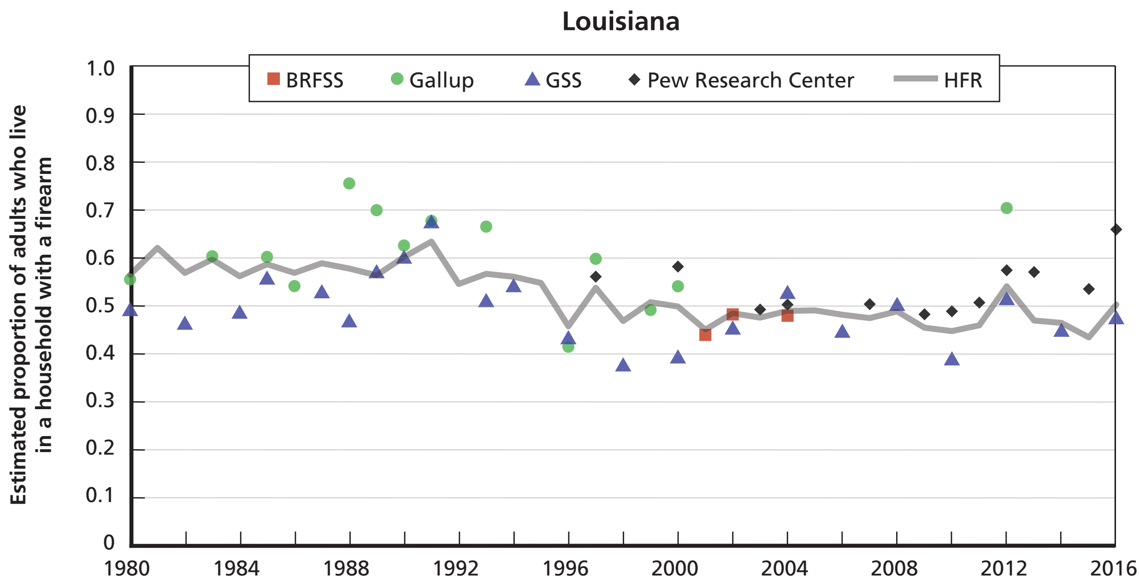
Louisiana
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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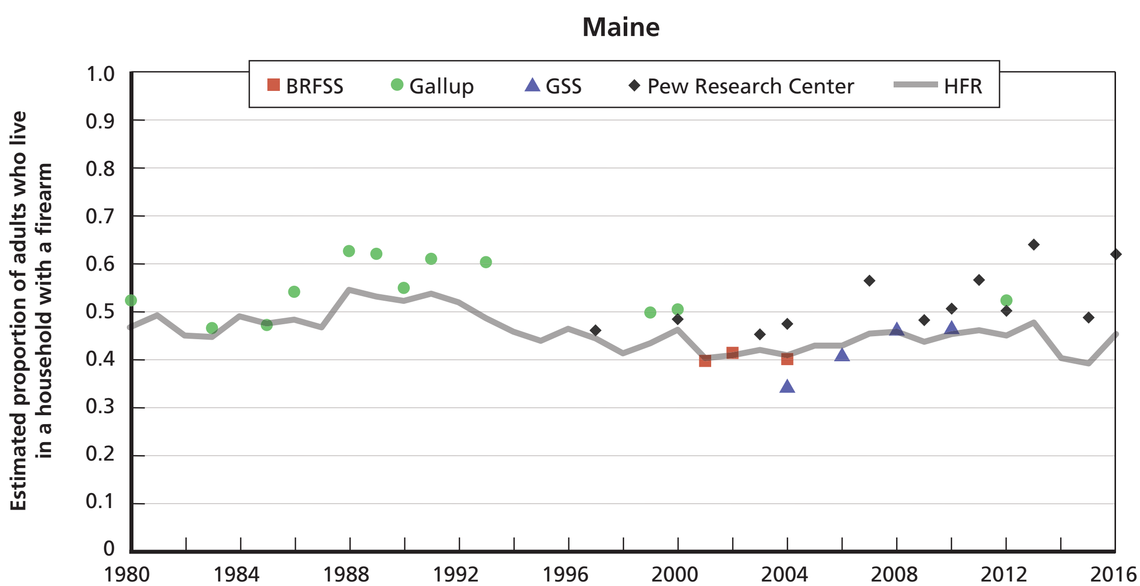
Maine
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Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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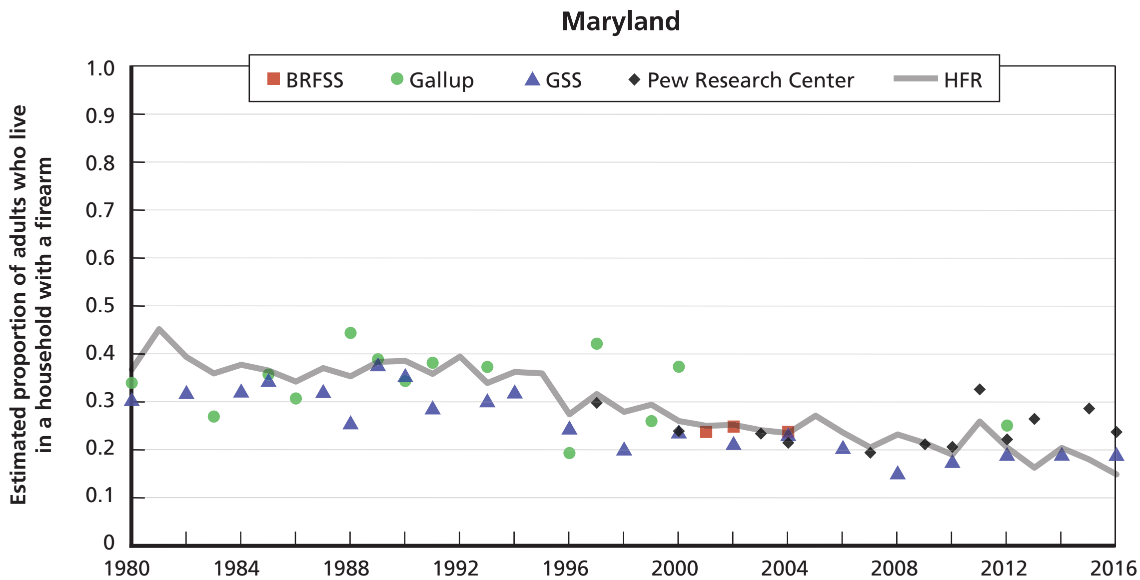
Maryland
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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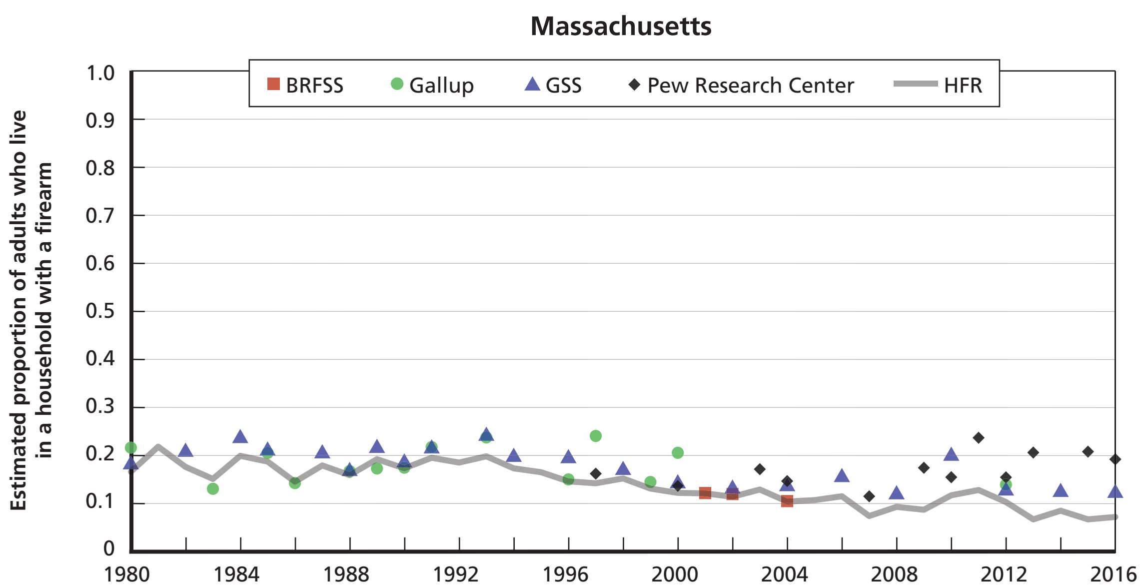
Massachusetts
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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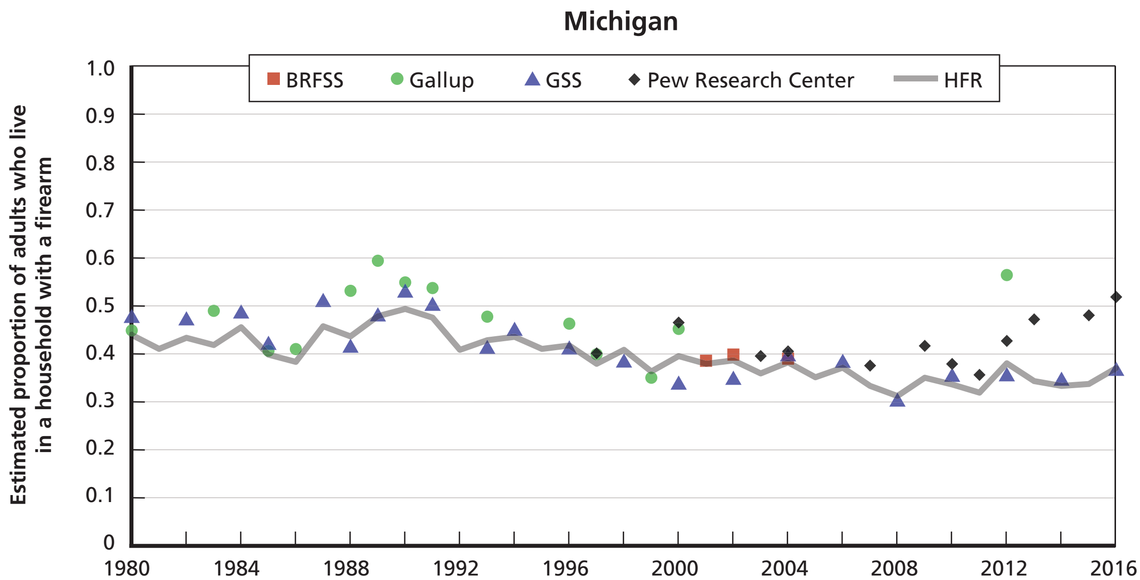
Michigan
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Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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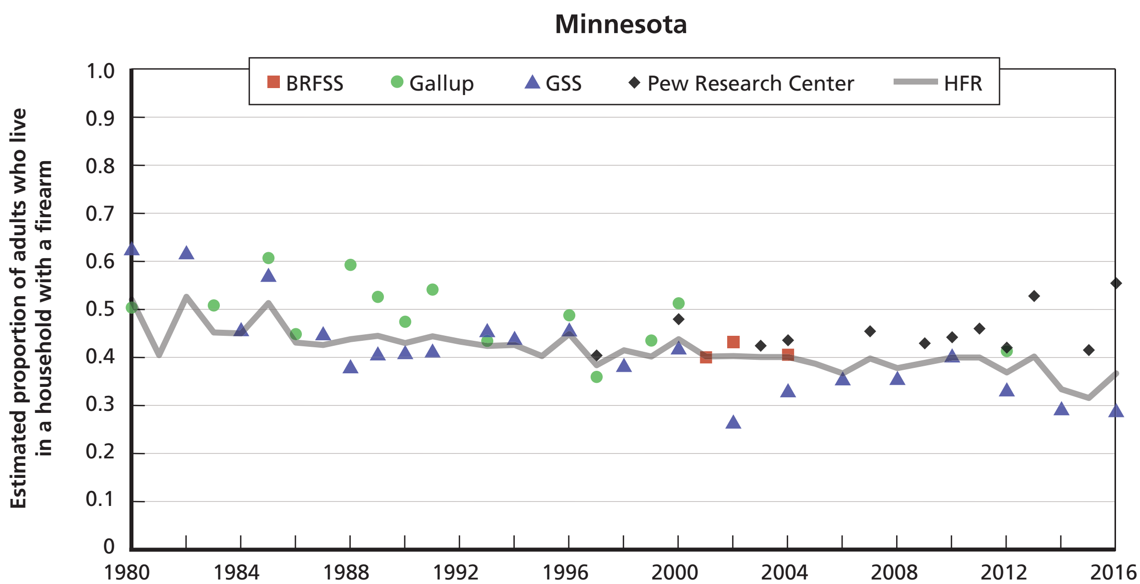
Minnesota
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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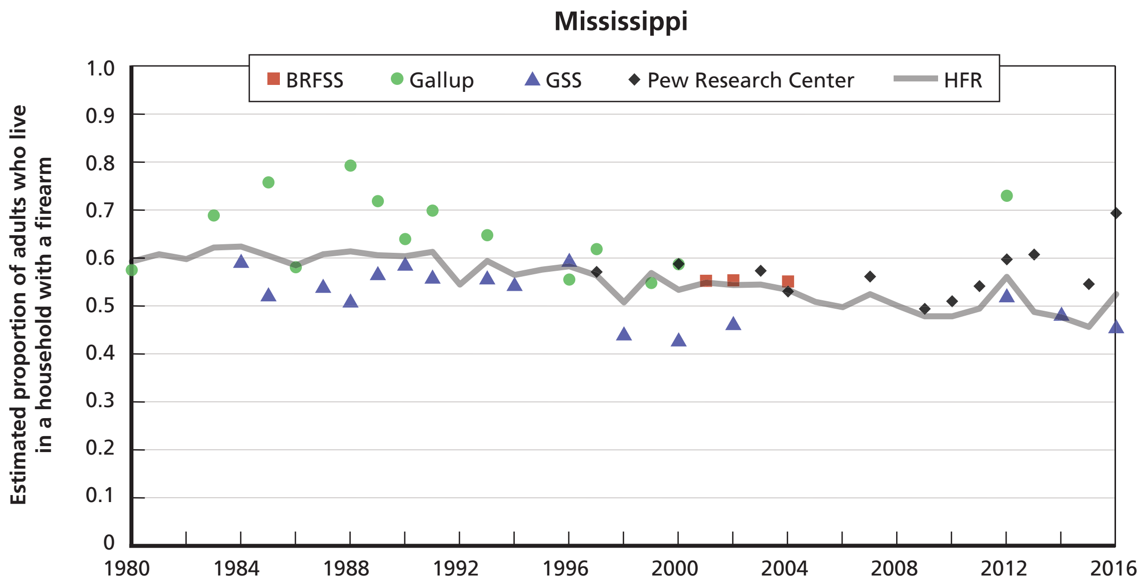
Mississippi
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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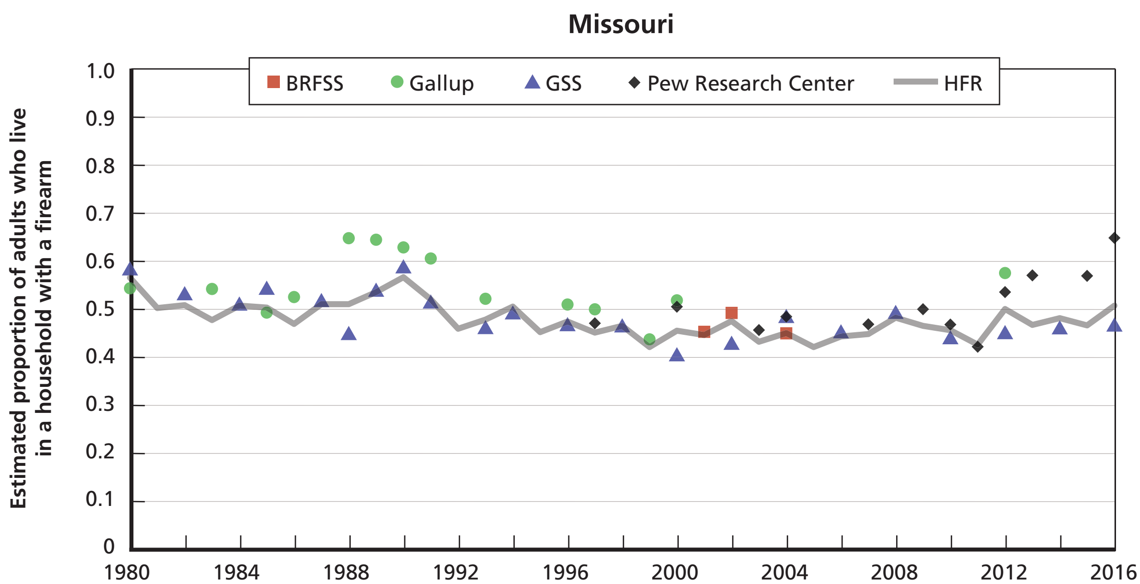
Missouri
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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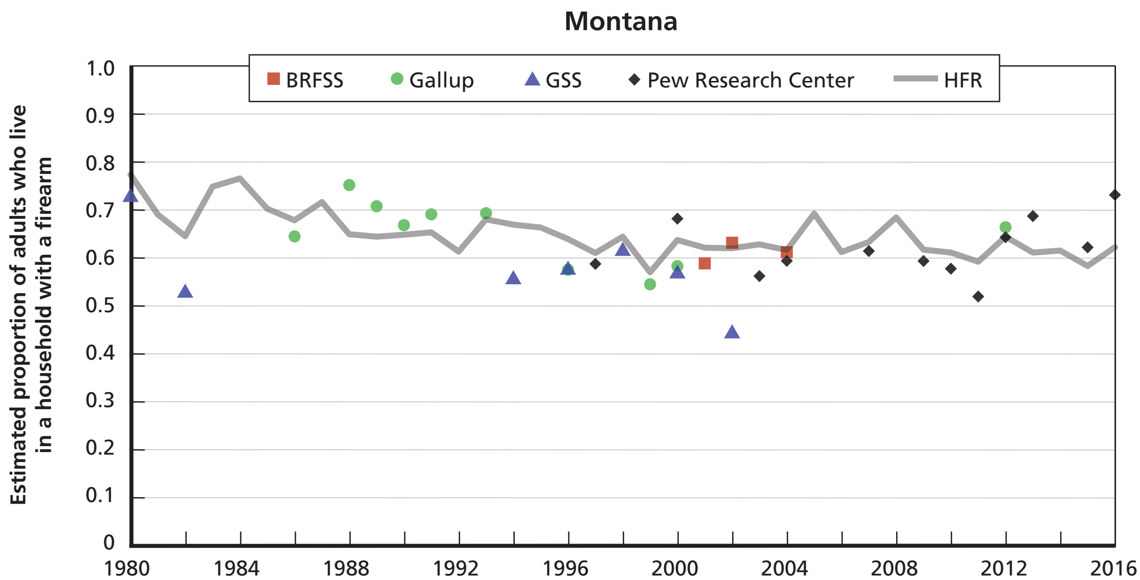
Montana
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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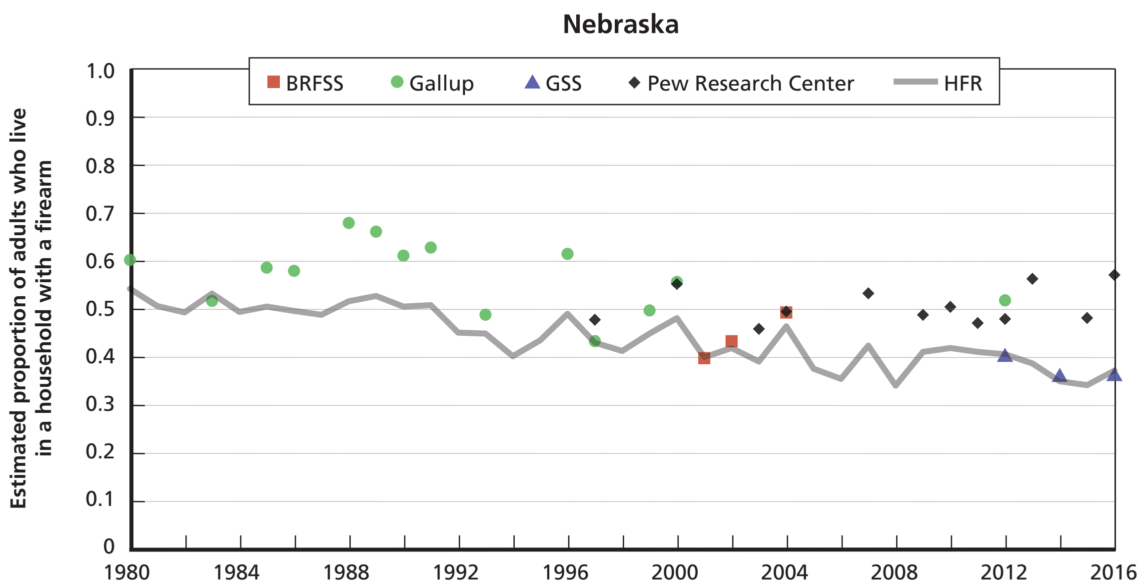
Nebraska
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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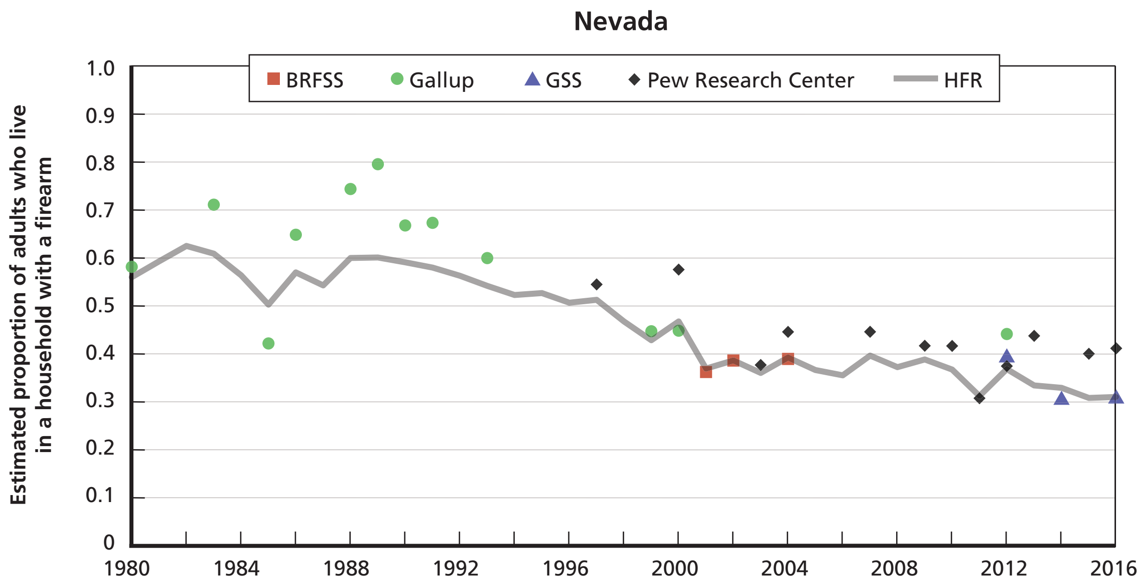
Nevada
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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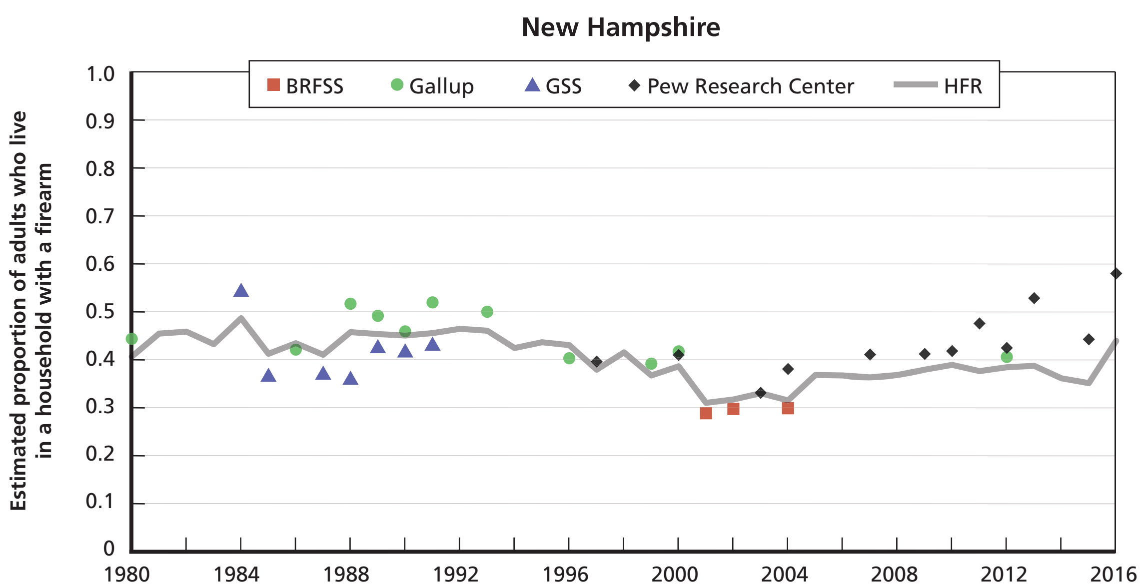
New Hampshire
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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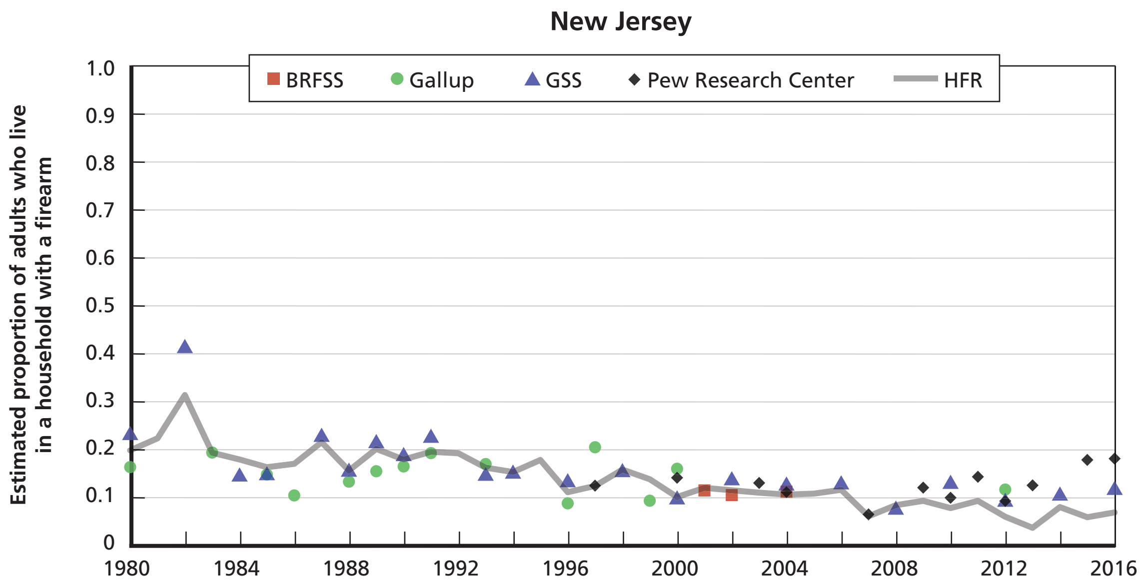
New Jersey
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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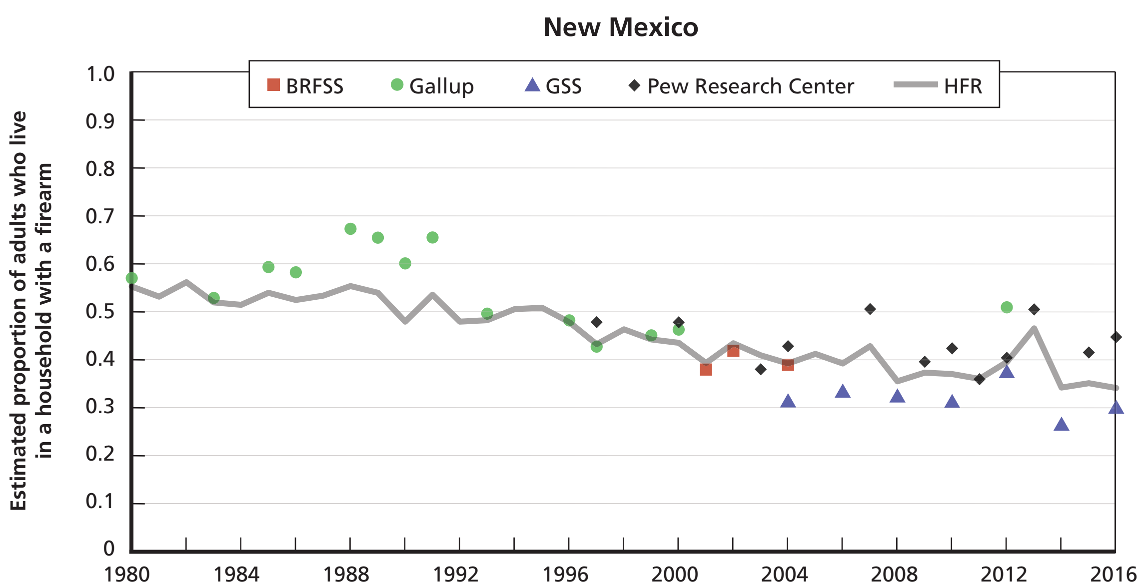
New Mexico
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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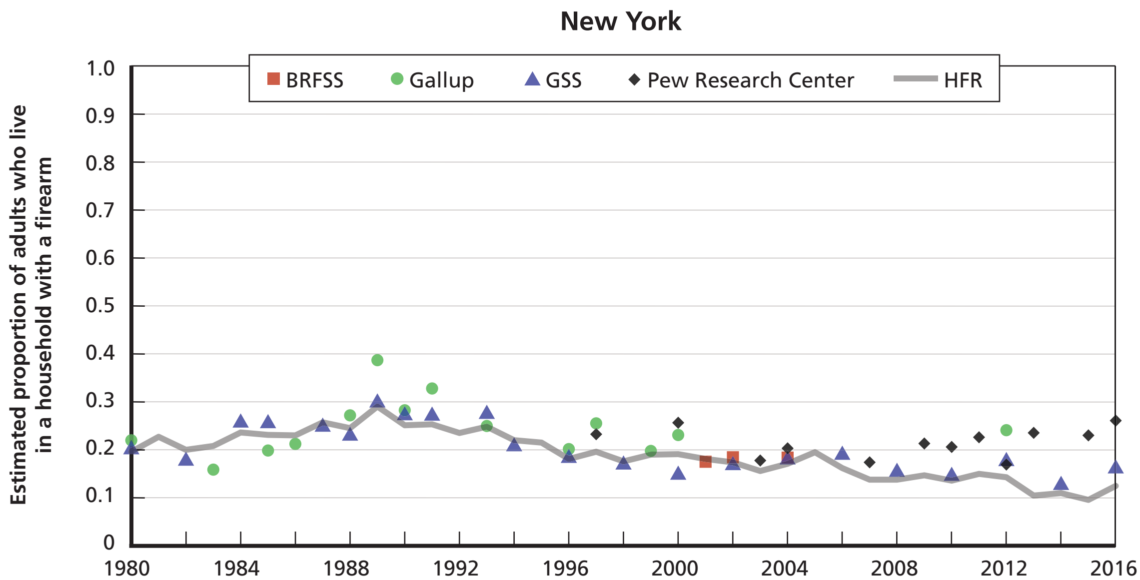
New York
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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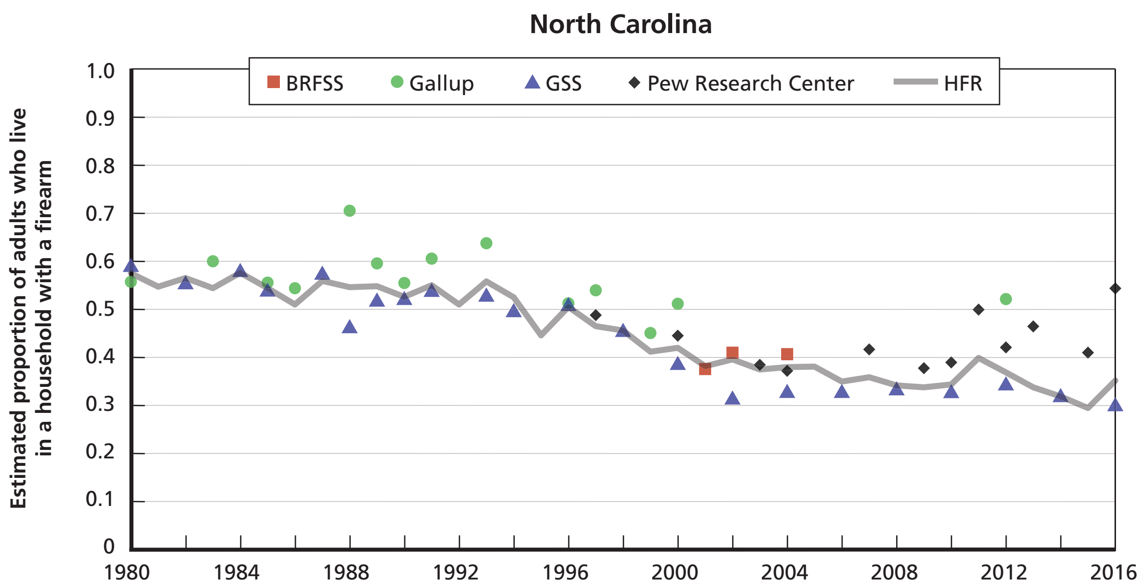
North Carolina
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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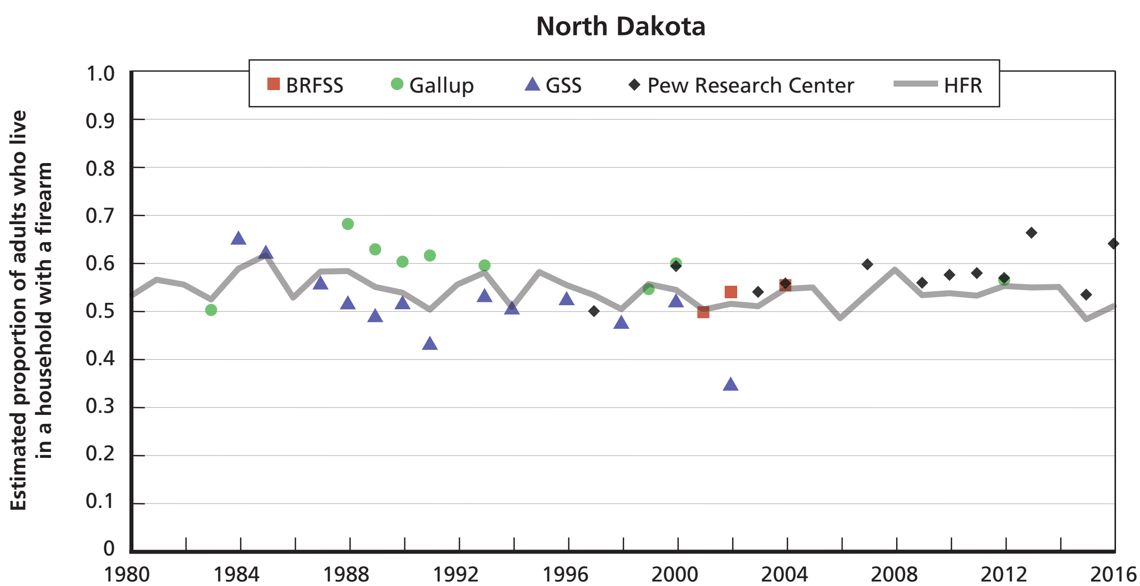
North Dakota
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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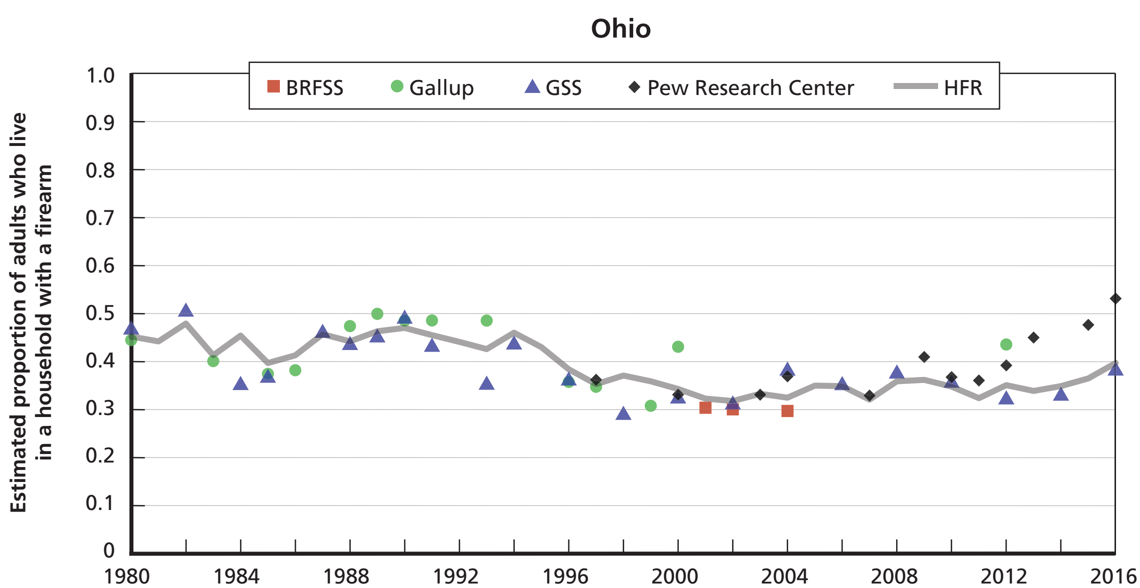
Ohio
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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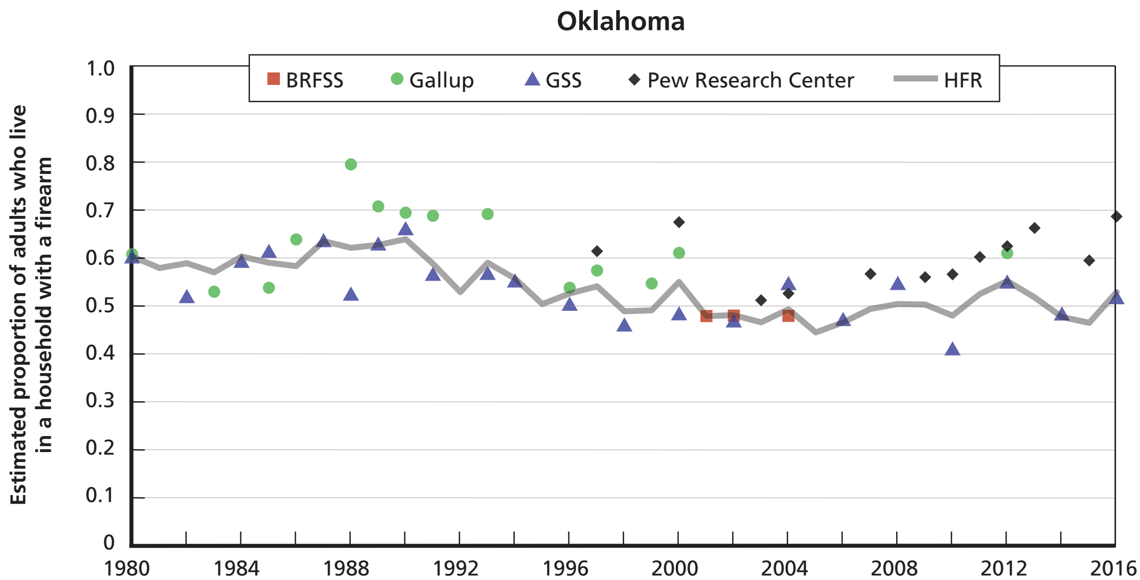
Oklahoma
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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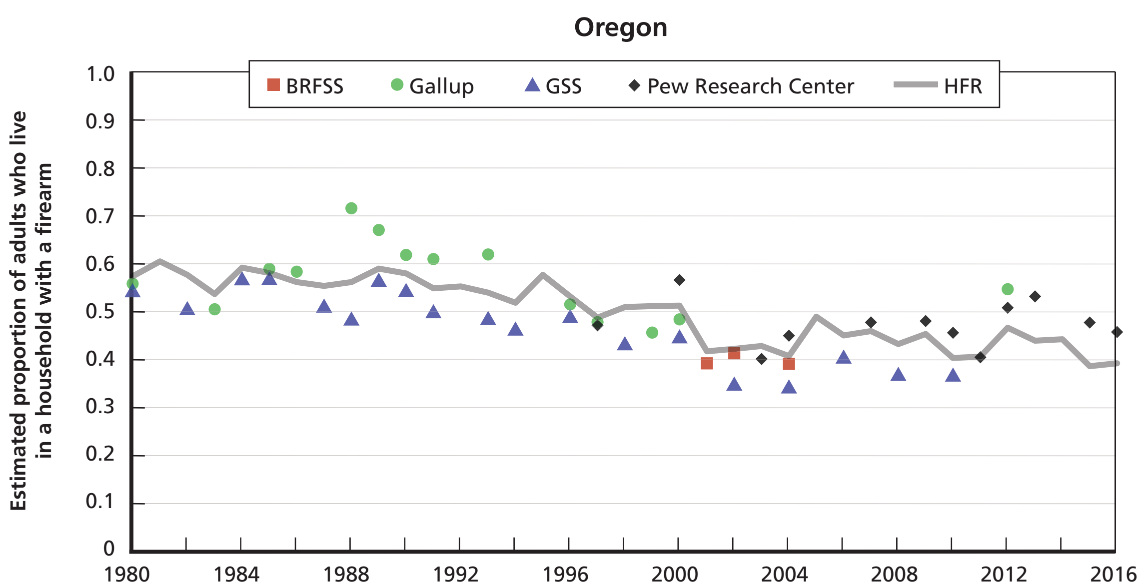
Oregon
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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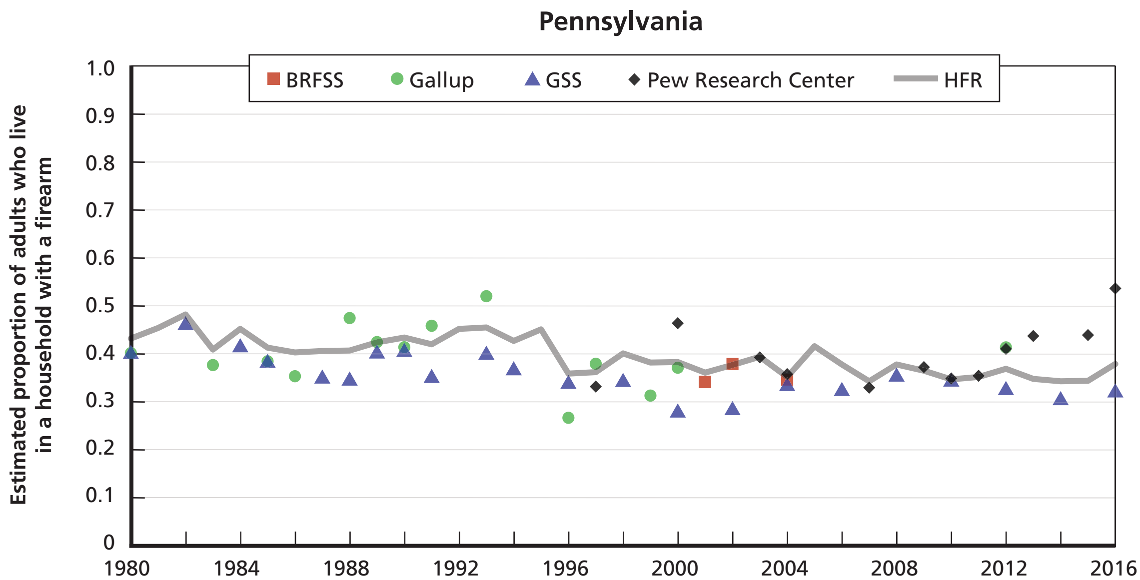
Pennsylvania
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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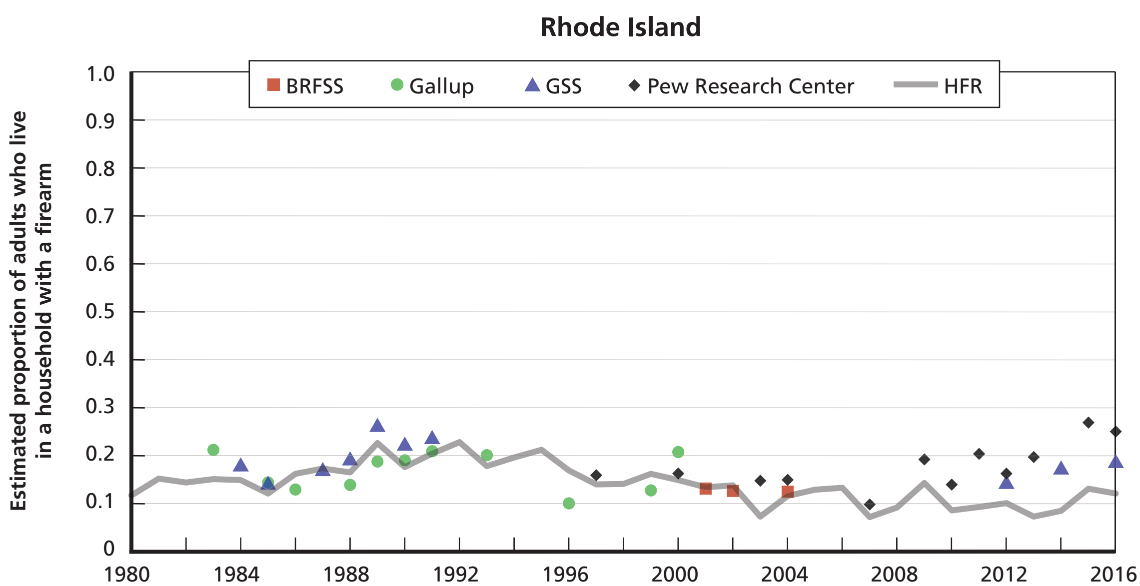
Rhode Island
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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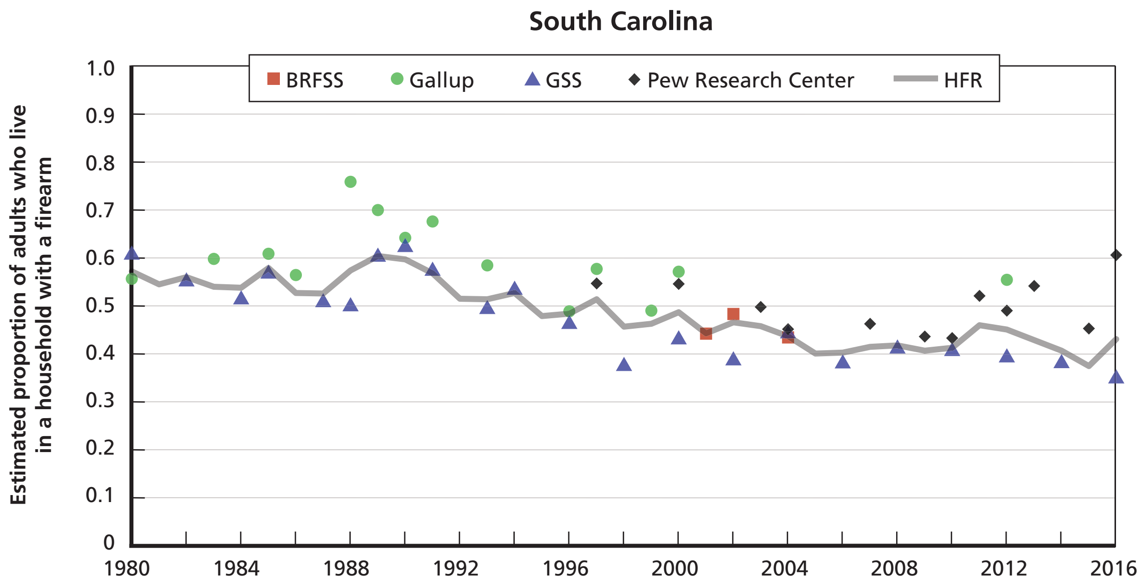
South Carolina
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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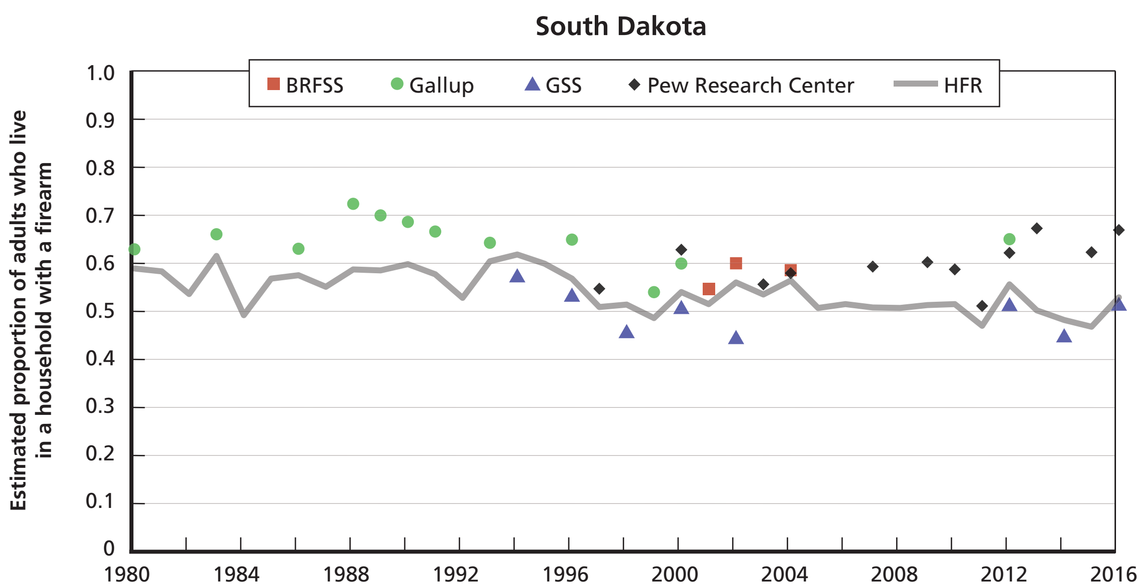
South Dakota
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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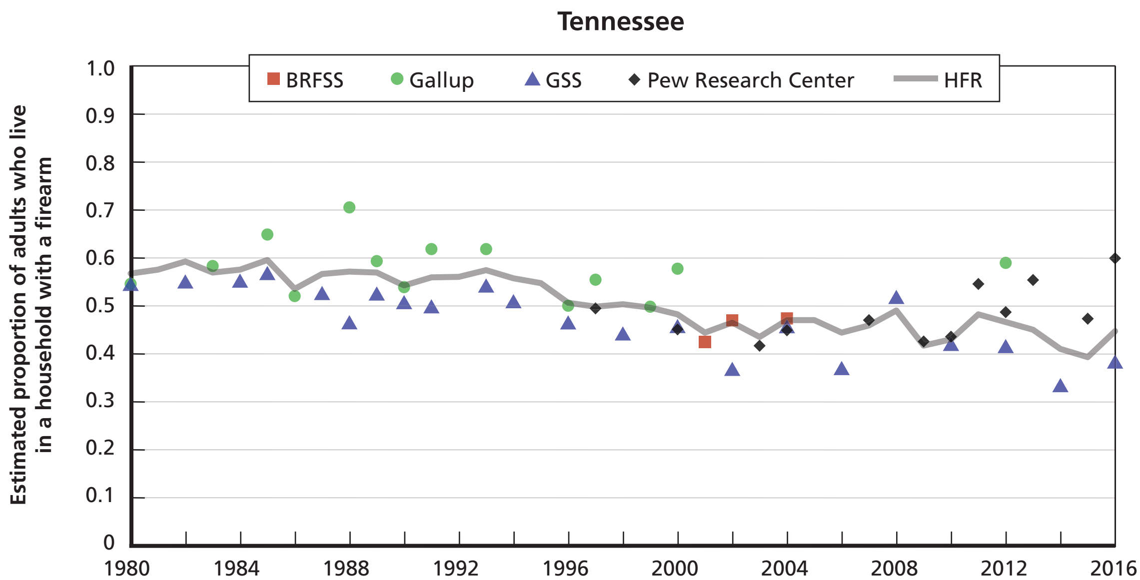
Tennessee
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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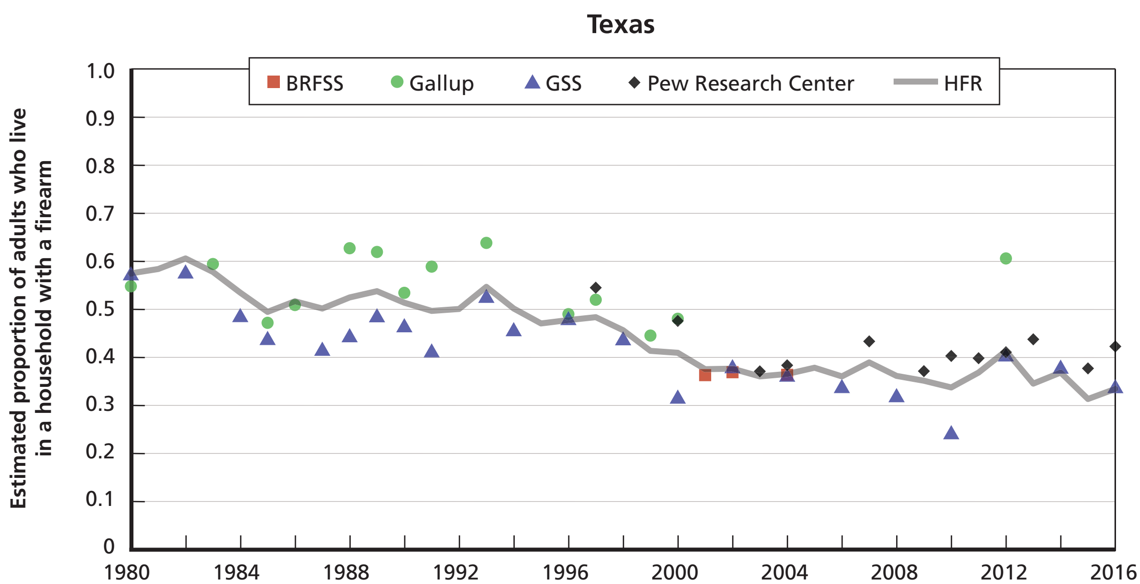
Texas
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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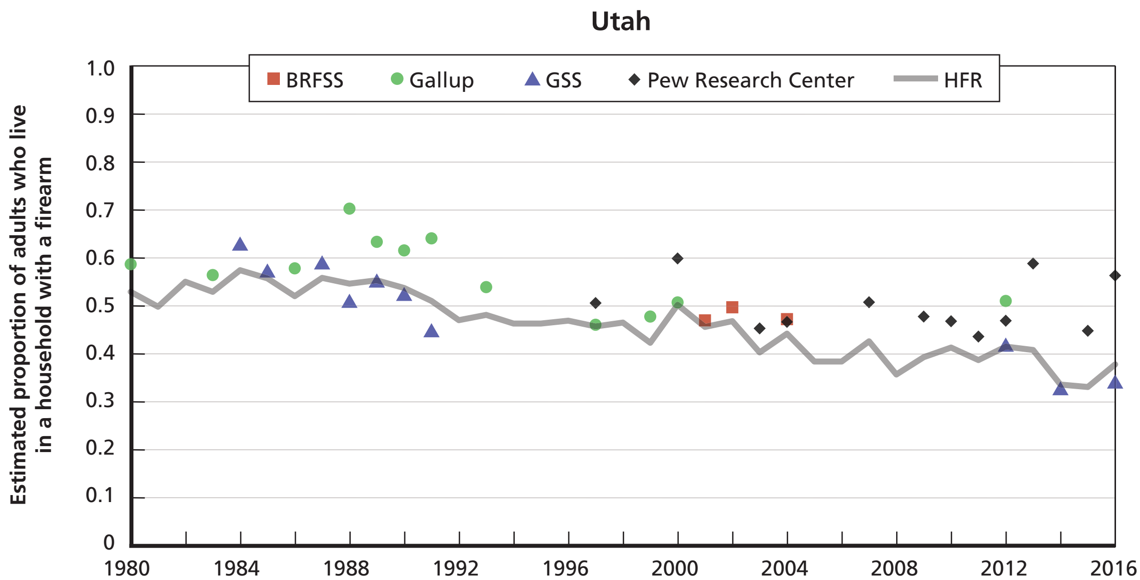
Utah
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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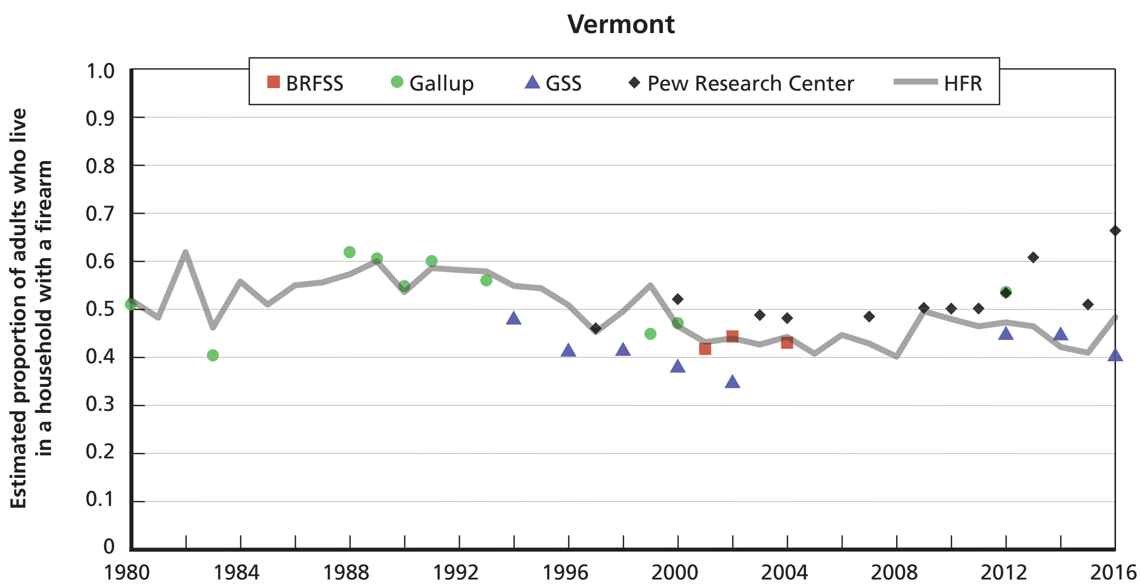
Vermont
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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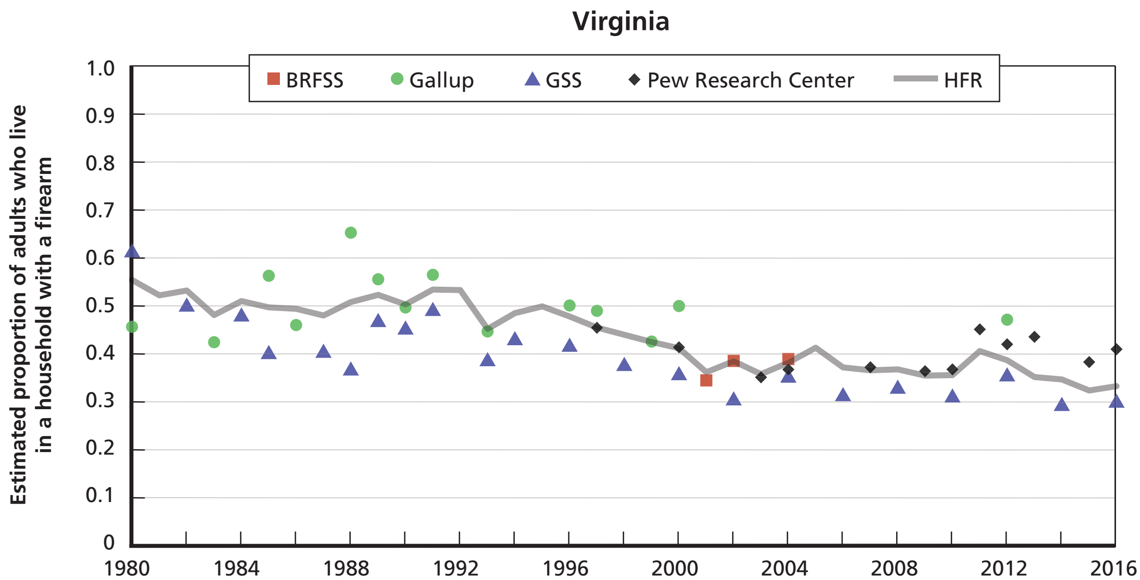
Virginia
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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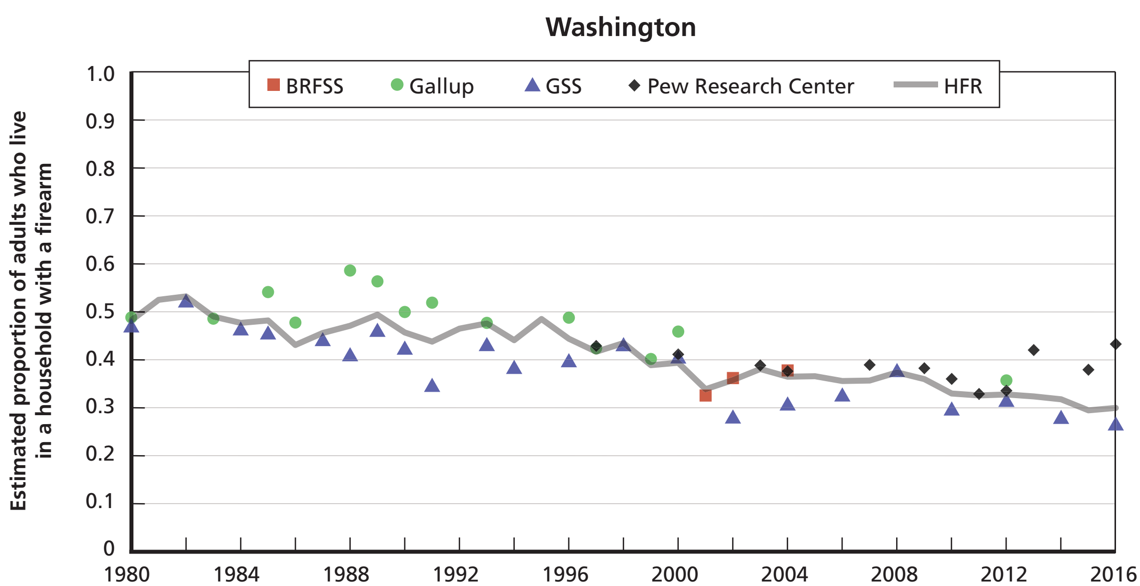
Washington
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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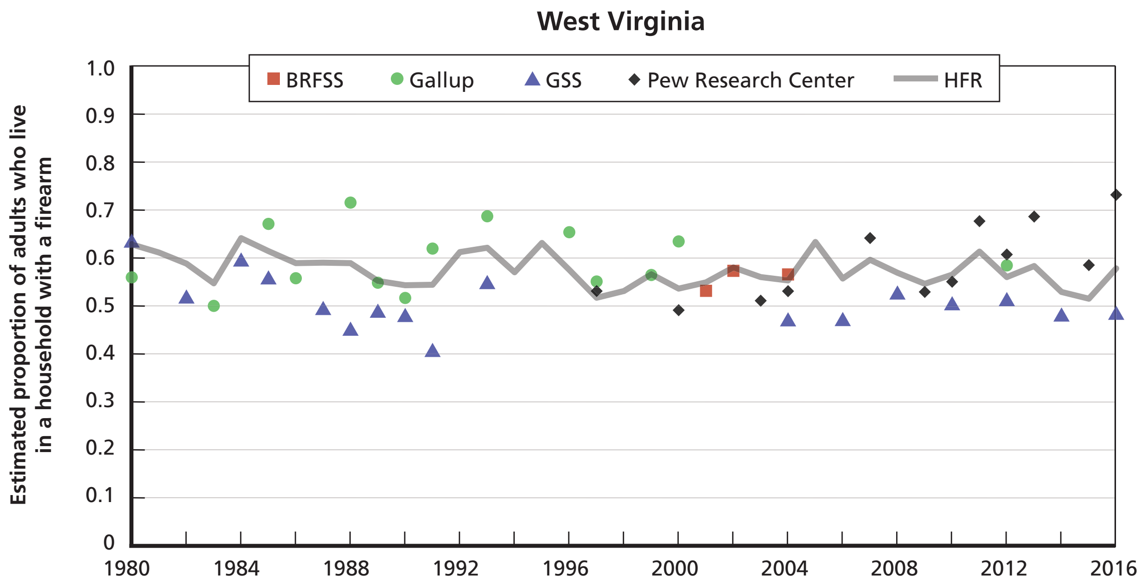
West Virginia
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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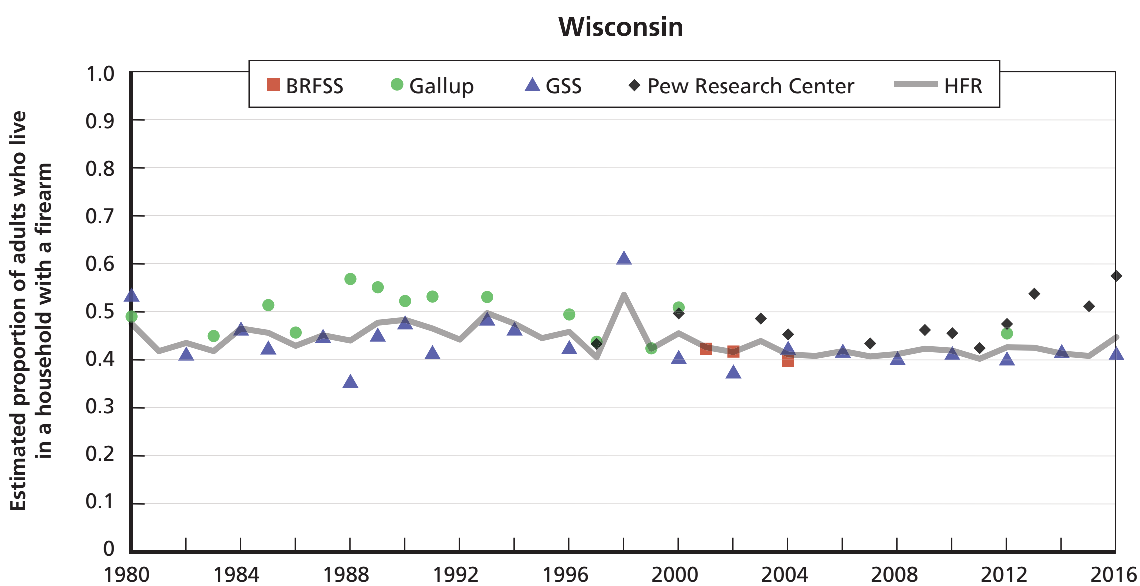
Wisconsin
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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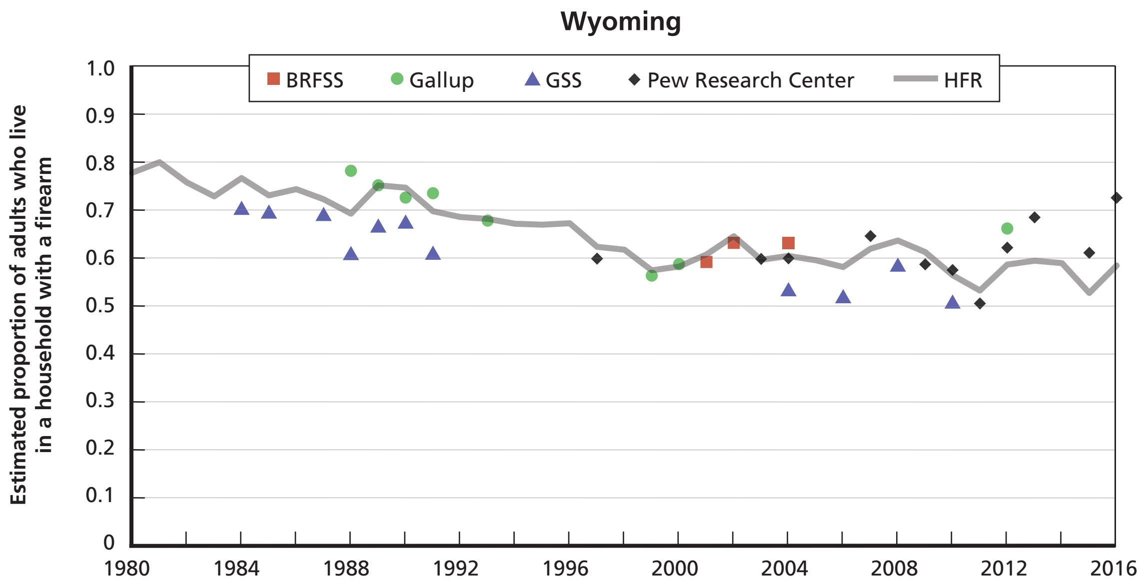
Wyoming
BRFSS
Gallup
GSS
Pew Research Center
HFR
Estimated proportion of adults who live in a household with a firearm
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