DRAFT: DO NOT CITE

Factors driving temporal and spatial patterns in suicide risk in the U.S., 1976-2000

Julie A. Phillips, PhD

Department of Sociology

Institute for Health, Health Care Policy and Aging Research

Rutgers University

112 Patterson Street

New Brunswick, NJ 08901

(732) 932-4105 Ext 2-1824

jphillips@sociology.rutgers.edu

Abstract

Using pooled cross-sectional time-series data for the 50 U.S. states over a 25 year period, the paper examines how well four conceptual groups of social correlates – demographic, economic, social, and cultural factors – are associated with the 1976-2000 patterns in overall suicide rates and suicide by firearms and other means. Unlike past research that typically considers only one dimension, this analysis differentiates between spatial and temporal variation in suicide rates to determine whether and how social correlates operate differently in these two contexts. Results indicate that suicide rates correspond closely to social correlates – declines in *overall* suicide rates between 1976 and 2000 were associated with demographic change (drops in the relative size of white, male, and young populations, and population growth). States with declining unemployment and numbers of Episcopalians, and with slower growth in the percentage divorced, were also more likely to show declines in the overall suicide rate. However, findings differ importantly by type of suicide, and across time and space. Reasons for these distinct patterns are discussed.

Introduction

Suicide presents a serious public health problem in the U.S. as the eleventh leading cause of death that accounts for over 30,000 deaths annually (Centers for Disease Control (CDC) 2009). This issue received a great deal of attention during the 1960s, 1970s and 1980s as suicide rates, particularly among youth, climbed steeply. However, since the mid-1980s, U.S. rates have declined steadily, from 12.5 per 100,000 in 1985 to 10.4 per 100,000 in 2000, although these national-level figures mask geographic variation in rates of change during this time (see Figure 1a). The majority of states experienced declines between 1985 and 2000 – California led the pack, with its suicide rate declining at an annual rate of about 3%, from 14.3 to 8.8 per 100,000. Still, a number of states exhibited fairly stable suicide rates, and two, Alaska and Hawaii, actually registered statistically significant *increases* in suicide during this time. The suicide rate for Alaska rose on average by 2.9% annually, from 14.1 per 100,000 in 1985 to 21.4 per 100,000 in 2000.

In addition to geographic variation in temporal changes in suicide, substantial geographic variation in suicide *levels* persists within the U.S. Research has long shown that the West exhibits the highest rates of suicide compared to other regions of the country, particularly the Northeast, the region with the lowest recorded rates of suicide (CDC 2009). Figure 1b displays the average suicide rate from 1976-2000 for the 50 states. Nevada had the highest average suicide rate over this 25-year period – 26.5 per 100,000. The corresponding figure for New Jersey, the state with the lowest average suicide rate, was just 7.1 per 100,000. Thus, U.S. suicide rates are characterized by geographic differences in both levels and change over time.

Research that attempts to understand such temporal and geographic variation in suicide rates has a long tradition, beginning with Durkheim's (1951) classic study on the subject. While suicide risk is undoubtedly affected by individual circumstances and characteristics, such as a history of mental illness and/or substance abuse, environmental social conditions also importantly affect suicide rates. According to Durkheim, low levels of social integration within a society lead to instability and lack of cohesion, producing excessive individualism and high rates of *egoistic suicide*. Lack of social regulation produces anomie, an absence of norms and an inability of society to meet the population's needs and expectations, and corresponds to high rates of *anomic suicide*. As

Durkheim demonstrated using European data from the 1800s and others have shown since (see Stack 2000a, 2000b for a review), the extent of social integration, usually captured by variables measuring family structure and religiosity, and social regulation, often proxied by economic conditions, across time and place tend to correspond in the expected fashion with suicide rates.

Such ecological studies of suicide adopt both cross-sectional and time-series research designs and thus exploit different components of overall variation in suicide rates. The connection between economic conditions, often measured with unemployment rates, and suicide rates appears stronger in time-series studies (Gruenewald et al. 1995; Wasserman 1984) than in cross-sectional studies. While the majority of time-series studies support the unemployment-suicide link, cross-sectional analyses using U.S. states typically do not find support (Burr et al. 1994; Girard 1988) although the opposite is true when smaller units of analysis, such as counties, are used (Breault 1988; Faupel et al. 1987; Kowalski et. al. 1987; Stack 2000a). Considerable evidence supports the notion that weak family structure, measured by the percent divorced, is positively associated with suicide rates (Stack 2000b). However, in this case, cross-sectional analyses (Kowalski et al. 1987; Lester 1995; McCall and Land 1994) are more likely to provide support than longitudinal studies (Stack 2000b).

Research on religion is more mixed, with less division by spatial and temporal variation. Some studies support Durkheim's original finding that places where Catholicism, a religion that emphasizes social integration and with strong proscriptions again suicide, is more prevalent exhibit lower suicide rates (Burr, McCall and Powell 1994; Cutright and Fernquist 2004; Faupel, Kowalski and Starr 1987). Others, however, show that these patterns may be attributable to misclassification of suicide deaths among Catholics (van Poppel and Day 1996) or fail to find any association once other factors are taken into account (Bankston, Allen, and Cunningham 1983; Kowalski et al. 1987).

Although Durkheim contended that rates of alcoholism were not linked to suicide rates, a number of aggregate-level studies, the majority of which examine variation over time, document a positive association between alcohol use and suicide rates (Gruenewald et al. 1995; Kalmar et al. 2008; Wasserman 1989). Gruenewald et al. (1995), for example, found that in the U.S., a 10% increase in alcohol consumption was

associated with a 1.4% rise in suicide rates between 1970 and 1989. Finally, some ecological studies have started to investigate the association between guns and suicide, in an attempt to circumvent problems associated with case-control studies (Brent et al. 1991; Kellerman et al. 1992) that are limited geographically and based on small numbers of suicides ((Florentine and Crane 2010; Miller, Azrael and Hemenway 2002). Miller and colleagues, using national-level cross-sectional data, found a positive association between household firearm ownership rates and rates of suicide (Miller et al. 2002; Miller, Azrael, Lippman, and Hemenway 2007; Miller and Hemenway 2008).

Somewhat surprisingly, there has not been, to my knowledge, a comprehensive examination of how such social conditions have influenced the declines in suicide rates in the U.S. during the latter part of the 20th century. Several studies explore the relationship between rising antidepressant drug use and falling suicide rates in the U.S., but these investigations cover only a few years and do not include extensive controls (e.g. Gibbons et al. 2005; Grunebaum et al. 2004; Milane 2006). Furthermore, as the brief review above attests, research on the social correlates of suicide reveals important differences in results depending on the research design used. Similar discrepancies between cross-sectional and time-series studies for other outcomes have been noted elsewhere (Beck 1980; Marvell and Moody 1991; Mouw 2002; Phillips 2006), but have not been examined systematically for suicide.

To address these gaps in the literature, I ask the following research questions in the present paper. First, I examine how well four conceptual groups of social correlates – demographic, economic, social, and cultural factors – can explain the 1976-2000 temporal patterns in overall suicide rates in the U.S. The declines by type of suicide have not been uniform (see Figure 2); the firearm suicide rate actually rose somewhat, from 6.78 per 100,000 in 1976 to 7.59 per 100,000 in 1990, before declining by 22% to the 2000 level of 5.92 per 100,000. On the other hand, the decline in the rate of suicide by means other than firearms was fairly steady over the period, from 5.57 per 100,000 in 1976 to 4.54 per 100,000 in 2000. Hence, I also distinguish between firearm and non-firearm suicide rates.

Second, I differentiate between spatial and temporal variation in suicide rates to determine whether and how social correlates operate differently in these two contexts, unlike past research that nearly always considers only one dimension (but see Gibbons et al. 2005). In other words, during this period, I identify the factors that determine varying levels of suicide across states and within states, the factors that explain changes in suicide rates over time. In this way, I aim to provide a more complete understanding of the forces shaping temporal trends and spatial patterns in suicide risk in the U.S. during the latter part of the 20th century.

Data

Dependent Variable. The outcome of interest is the suicide rate per 100,000, defined as the number of suicide deaths divided by the population at risk, by U.S. state and year. I obtain information on suicide victims from the National Center for Health Statistics (NCHS) (U.S. Department of Health and Human Services 1968-2000), focusing only on those who resided in the U.S. at the time of death. Death certificates include information on method of suicide, so I can distinguish between suicide victims who died by firearms and those who died from other means. The denominator for the suicide death rate is the total mid–year population of each state in each year, acquired from the Census Bureau (U.S. Department of Commerce, 1970–2000).

During the time period of study (1976-2000), both the ninth and tenth *International Classification of Diseases* were used by the NCHS, but the revision does not affect the classification of suicide deaths (Anderson, Miniño, Hoyert, and Rosenberg 2001). Still, official mortality data on suicides are an underestimate of all suicide deaths, as some suicides are misclassified as accidental or undetermined (Cooper and Milroy 1995; Pescosolido and Mendelson 1986). However, such errors should not alter the analysis of time trends in suicide rates; studies reveal that misclassification (e.g. coroners who underreport) in one year tends to occur similarly in subsequent years (Cooper and Milroy 1995; Sainsbury and Jenkins 1982).

Independent Variables. I consider a number of structural characteristics shown to be associated with variation in suicide rates, broadly classified into four groups: demographic, economic, social, and cultural factors. Suicide risk varies dramatically over the life course and across demographic groups, with the vast majority of

suicide deaths in the U.S. occurring among white males (Maris, Berman, Silverman and Bongar 2000). Thus, I include controls for demographic composition over time and space, with measures of age structure (percentage aged 15 to 24 and percentage older than 65), sex composition (percentage males), and racial composition (percentage white). The population size of each state in each year, logged since its association with suicide rates is nonlinear (data not shown), is also controlled. These indicators are all readily available from the Census Bureau, which collects population data in five-year age intervals by sex and race.

Two measures of economic conditions, unemployment rates and per capita income by state and year, are incorporated into the analysis as indicators of social regulation. State data on per capita income from 1976 to 2000 are gathered from the Regional Economic Information System (REIS). The per capita income figures are converted to 1982-1984 constant dollars, using the regional Consumer Price Indices (CPI) available from the BLS website. Annual information on state unemployment levels, measured as the percentage of the civilian labor force that is unemployed, is provided by the Bureau of Labor Statistics (BLS).

I include several variables capturing social integration and degree of social control in the analyses. Weak family structure is proxied by the percentage of the state population divorced in each year. Information on state divorce levels for each census year (1970, 1980, 1990 and 2000) is available from the Census Bureau. The geographic and temporal prevalence of religious ties, a potentially important form of both social integration and regulation, is captured by three variables. The first, the religious adherence rate per 1000, is an overall measure of religiosity. Two other measures, the percentages of the population that are Catholic and Episcopalian, distinguish between key religious denominations identified by Durkheim and others (Pescosolido and Mendelsohn 1986; Pescosolido and Georgianna 1989) as offering differing degrees of social integration. These measures were downloaded from the Association of Religion Data Archives (www.TheARDA.com) and are available for 1971, 1980, 1990, and 2000. Linear interpolation techniques, assuming constant growth over the period, were applied to interpolate the divorce and religiosity values for intercensal years.

Finally, I include two measures related to culture: gun ownership and alcohol consumption. The General Social Survey (GSS), conducted annually since 1972, contains a question asking whether or not a gun is present

in the household. This measure is available for each year but at the divisional level only. I compute a three-year moving average of this measure and use it to proxy geographic and temporal patterns in gun ownership. Annual alcohol consumption at the state level is measured with a variable capturing the gallons of ethanol consumed per capita by those aged 21 and older. This measure is available from the National Institutes for Alcohol Abuse and Alcoholism (http://www.niaaa.nih.gov/Resources/DatabaseResources/QuickFacts/AlcoholSales/consum03.htm).

Methods

To analyze the association between these explanatory variables and suicide levels across states and time, I construct a cross-sectional time-series data set, containing repeated measurements on states over time. A model using such data can be expressed in the following general form (Bryk and Raudenbush 1992; Johnston and DiNardo 1997; Judge et al. 1985).

$$(1) \qquad y_{jt} = \alpha + x_{jt}\beta + \nu_j + \varepsilon_{jt}$$

The dependent variable y_{jt} represents the Crude Suicide Rate (CSR) for state j in time t. α denotes the intercept and β represents the estimated set of parameters for x_{jt} , the explanatory variables for each state j and year t. The primary difference between this model and the general linear model is in the treatment of the disturbance terms. The model includes a state-specific residual, ν_j , which varies across states but not across time and allows for correlation among observations from the same state. ε_{jt} is the model residual and captures random variation within states over time.

A fixed effects model treats ν_j, the between-state differences, as fixed and estimable and provides estimates of β only for within-state effects. In contrast, a random effects model treats ν_j as independent and randomly distributed and provide estimates of β that capture the combined effect of the between-state and within-state components (Bryk and Raudenbush 1992; Judge et al. 1985). To distinguish the ways in which selected independent variables are associated with suicide rates over time as opposed to across states, I estimate a 'decomposition model'. This model provides separate estimates for the effect of a covariate on the dependent

variable between units (the between-unit estimator) and for the annual effects of a covariate on the dependent variable within a particular unit (the within-unit estimator) (Allison, 2005; Bryk and Raudenbush 1992; Hsiao 2003; Judge et al. 1985; Phillips 2006).

The decomposition model, estimated using maximum likelihood methods, can be expressed as follows:

$$(2) \qquad y_{jt} = \alpha + \beta X_j + \eta (x_{jt} - X_j) + \nu_j + \varepsilon_{jt}$$

The parameter β measures the effect of the between-state differences, where these differences are represented by state means (all means are denoted by capital letters) for a particular characteristic over the entire period. The parameter η captures the effect of within-state differences, annual state-year deviations from the overall state mean. Thus, the η coefficients tell us how the covariates affect temporal variation in suicide rates (over time within states) while the β coefficients indicate how factors are associated with cross-sectional variation in suicide rates (across states).

The decomposition model (equation 2) incorporates a state-specific residual term, ν_j , which is treated as a random variable and permits correlation among observations from the same state. As states from the same geographic region may be more similar than those located far apart, a four-category regional dummy variable is included in the models to control for time-stable characteristics of regions that may affect suicide rates. The residual error term, ε_{jt} , allows for correlation over time among observations from the same state. An autoregressive error structure was applied, since preliminary analyses indicated this structure to be more appropriate than one in which the correlation of observations within states is assumed to be the same (chi-square = 138.5). The models include year dummies to account for unmeasured characteristics of time periods that affect suicide rates.[1] Finally, exploratory analyses revealed that a few independent variables are highly correlated

[1] Stationarity tests on the various time-series were conducted using the Levin-Lin-Chu test (Levin, Lin and Chu 2002). In most cases, I could reject the null hypothesis of non-stationarity; for a few variables (percent divorced, percent male, percent white and percent Catholic), graphical inspections of these variables suggested that the series are trend-stationary. Since the models include a dummy variable for each year, thus controlling for time trends, the non-stationarity of these series is partialled out. These tests should be treated with caution since the time-series is very short.

(r>0.50). In these cases, I excluded correlated measures most likely to be subject to multicollinearity and report any notable changes in results below.

Results

Descriptive Statistics. Table 1a displays descriptive statistics for these variables, showing the mean values as well as overall, spatial and temporal variation in these characteristics. The mean suicide rate across the fifty states between 1976 and 2000 was 13.08 per 100,000. Suicide by firearms (8.04 per 100,000) was more common than suicide by other means (5.04 per 100,000). There is far greater variation in suicide rates across states than within states over time, as evidenced by the much larger spatial standard deviation compared to the temporal standard deviation. Indeed, exploratory analyses (not shown) indicate that about 83% of the overall variation in suicide rates is attributable to variation between states and only 17% to temporal variation within states.

[TABLE 1A ABOUT HERE]

I also find considerable variation across states in demographic, economic, social and cultural characteristics, as indicated by the size of the standard deviations. In addition, there is ample variation in these characteristics within states over time. For example, the percentage white varies quite substantially across states and over time – a standard deviation of 11.44 and 2.02 percentage points across states and time, respectively.

To provide some context to these numbers, Table 1b shows the mean, minimum and maximum values for these characteristics in 1976 and in 2000. The statistics reveal a wide-ranging suicide rate across states in both periods, from states with suicide rates below 10 per 100,000 to others with rates exceeding 20. The racial composition of states is highly variable in both years, and we observe increasing racial heterogeneity (declining percentage white) over the 25-year period. Economically, the U.S. as a whole appears better-off at the end of the period than at the beginning, although these endpoints alone cannot show the substantial fluctuation in unemployment rates during the period and the increasing mean per capita income figure masks growing income

inequality. Although the mean percentage divorced doubled over the 25-year period, little temporal change is observed in terms of religiosity. However, we do find substantial variation in religiosity across the U.S. states over the period. Finally, both alcohol consumption and gun ownership declined between 1976 and 2000, from 3.4 to 2.6 gallons consumed per capita and from 53.1% to 36.3% of households, respectively. In sum, these general temporal trends in demographic, economic, social and cultural factors would predict a declining suicide rate over the period.

[TABLE 1B ABOUT HERE]

Overall Suicide Rates. Table 2 displays the results from the decomposition model, which separates the effects of covariates on suicide rates into those between states and those within states over time. Positive coefficients suggest that the social correlate and suicide move in the same direction while negative coefficients indicate an inverse relationship. I find a number of statistically significant differences in the magnitude and sometimes direction of association of these covariates across states as opposed to over time.

[TABLE 2 ABOUT HERE]

Looking first at how these social correlates affect temporal variation in suicide, I find that shifts in demographic composition (percent white, percent male, and percent young) are associated with changes in suicide rates. For instance, states with declining white populations are more likely to exhibit declining suicide rates over the period. Consistent with prior findings (Stack 2000a), decreases in unemployment rates are associated with decreases in suicide over time ($p<0.10$), but unemployment levels are not associated with geographic variation in suicide rates. Social factors, such as the percent divorced and percent Episcopalian, are also positively associated with temporal variation ($p<0.10$) in suicide rates – for every one percentage point decline in Episcopalians, we see a drop on average of 0.755 per 100,000 in the suicide rate over time. Note that changes in unemployment levels, the percent divorced and the percent Episcopalian achieved significance at the $p=0.05$ level when highly correlated variables (e.g. percent white, gun ownership and population size) were removed from the model. Cultural factors do not affect temporal variation in the overall suicide rate, but states with increasing populations over the time period tend to have declining suicide rates.

Looking at the coefficients under the heading 'across states', I find that seven of the twelve factors predict cross-sectional variation and in the anticipated fashion. States with higher percentages of whites and males exhibit higher overall suicide rates as do poorer states and those with a larger divorced population. Although changes in cultural factors such as alcohol consumption and gun ownership do not affect changes in suicide rates over time, they are important predictors of overall suicide levels across states. Among the religiosity variables, states with a higher percentage of Episcopalians register higher suicide rates. Although neither variable measuring age structure is statistically significant, this may be due to multicollinearity. The two age measures are highly correlated (r=-0.66); when the percentage aged 65 and older is removed from the model, the coefficient for percent aged 15-24 becomes statistically significant (b=-0.620; p=0.047). The coefficient for percent aged 65 and older equals 0.172 (p=0.094) when percent aged 15-24 is removed.

Suicide Rates by Method. Table 3 displays analogous models for the firearm and non-firearm suicide rate. The findings reveal important distinctions in the determinants of suicide rates by method, which are masked when examining only the overall suicide rate. They also offer insight into some of the discrepancies in between-state and within-state effects found in Table 2.

In general, the firearm suicide rate is more closely associated with demographic characteristics than the non-firearm suicide rate, both across states and over time. Firearm suicides are less likely to occur in places and time periods with smaller percentages of whites and a larger old population. Although states with relatively more males exhibit higher firearm suicide rates, increases in the percentage male within states over time decrease the firearm suicide rate. States with relatively more young people (percentage aged 15-24) have a lower firearm suicide rate, but decreases in the percentage young are associated with falling firearm suicide rates within states over time. In contrast, suicide by means other than firearms is less common only in states with relatively few old people, and in time periods when the percentage male is increasing and the percentage young is decreasing.

[TABLE 3 ABOUT HERE]

Economic factors are more closely tied to the non-firearm suicide rate. Wealthier states have a higher suicide rate by means other than firearms although increases in per capita income over time are associated with

declines in the non-firearm suicide rate. States with higher unemployment exhibit lower non-firearm suicide rates, but decreases in unemployment over time within states are associated with decreases in non-firearm suicide rates. At the 5% level, the firearm suicide rate is associated only with per capita income (and not with unemployment), with a negative association across states.

States with a higher percentage of the population divorced exhibit higher suicide rates of both types, but only the non-firearm suicide rate is positively associated with increases in family instability over time. States with a relatively large Catholic population exhibit a lower firearm suicide rate ($p<0.10$) but a higher suicide rate by other means. Over time, increases in the percentage of Catholics are associated with declines in the firearm suicide rate. In contrast, firearm suicide is more common in states with more Episcopalians. Decreases over time in the percentage of Episcopalians do not appear to affect the firearm suicide rate, but are associated with decreases in the non-firearm suicide rate.

Cultural factors such as alcohol consumption and gun ownership predict state variation in firearm suicide rates but not in non-firearm suicide rates. However, additional tests for multicollinearity showed that the between-state coefficient for alcohol consumption ($b=0.341$; $p=0.102$) achieved significance at the 5% level when certain variables were removed from the non-firearm suicide model. Consistent with prior findings (Miller et al. 2007), gun ownership increases the risk of firearm suicide, as expected, but there is no concomitant negative association with non-firearm suicide. Over time, only alcohol consumption is associated with suicide rates, in a positive fashion for non-firearm suicide and negatively for the firearm suicide rate. Finally, population size is differentially associated with firearm and non-firearm suicide rates – states with increasing populations over the period tend to exhibit declines in firearm suicide but increases in non-firearm related suicides.

Discussion

The analyses indicate that the set of social correlates are important predictors of cross-sectional and temporal variation in U.S. suicide rates. The declines in *overall* suicide rates between 1976 and 2000 appear to respond primarily to demographic shifts over the period – drops in the relative size of the white and young population are associated with decreases in suicides. The results also suggest that states with declining

unemployment and numbers of Episcopalians, and with slower growth in the percentage divorced, were more likely to show declines in the overall suicide rate. Disaggregated by type of suicide, declines in firearm suicide are associated with increasing numbers of Catholics and population growth, but increases in per capita income and drops in alcohol consumption appear to raise the firearm suicide rate. The fall in non-firearm suicide is correlated with declines in unemployment, the percent divorced, the percentage Episcopalian, and alcohol consumption.

Demographic, economic (per capita income), social (percentage divorced and percentage Episcopalian) and cultural (alcohol consumption and gun ownership) factors all predict geographic variation in overall suicide rates. The patterns differ, however, once we consider the type of suicide. The collective group of factors explains well cross-sectional variation in *firearm* suicide rates – the majority of social correlates are statistically significant and operate in the expected direction. In contrast, the factors often do not operate as expected in explaining spatial variation in the non-firearm suicide rate. Thus, taken as a whole, these factors are consistent with theoretical conjectures and work better as an explanatory model for geographic variation in firearm suicide rates and for temporal variation in non-firearm suicide rates.

In part, these patterns may be due to displacement -- the kinds of places with more suicides by methods other than guns (wealthier states with more Catholics and elderly) will be the opposite of those with high rates of firearm suicide (poorer places with more guns and alcohol consumption, and a larger white, male population and relatively more Episcopalians). As a result, models of the overall suicide rate can be misleading. In this analysis, the percentage Catholic in a state is not an important predictor of either cross-sectional or temporal variation in the overall suicide rate. Yet when the suicide rate is disaggregated by method, we find that the percentage Catholic is negatively associated with both spatial and temporal variation in firearm suicides but positively associated with cross-sectional variation in the non-firearm suicide rate. The latter association is likely explained by the fact that Catholics are concentrated in the Northeast region of the U.S., where gun ownership is tightly regulated and non-firearm suicide is more common (Kaplan and Geling 1998). Take as another example per capita income: The overall suicide model suggests that changes in per capita income over time have virtually no

effect on total suicide rates, but this is because the coefficient is actually washed out. Although the coefficients are similar in size by type of suicide, the association is positive and significant for firearm suicide rates but negative and significant ($p<0.10$) for non-firearm suicides.

The distinct effects of these correlates on firearm and non-firearm suicide rates offer insights into the different etiology of the two types of suicide. The findings are in line with research suggesting that some suicides are due to fleeting impulses and arise from temporary crises (Miller and Hemenway 2008; Simon et al. 2001). The firearm suicide rate is closely tied to two cultural measures, alcohol consumption and gun ownership; alcohol consumption reduces inhibitions and may increase impulsive behavior while the ready presence of a firearm enhances the likelihood that individuals who act on impulse will be successful in their suicide attempt. Furthermore, the finding that gun ownership does not affect the non-firearm suicide rate is consistent with the notion that impulses subside and that access to means of suicide matter – individuals do not always shift to another method of suicide if access to guns is restricted (Miller et al. 2007). Finally, social correlates, such as unemployment rates, per capita income, and percent divorced, are more effective in predicting changes over time in non-firearm suicide rates, suggesting that these suicides are characterized less by impulse but rather driven by deteriorating social circumstances.

The analysis also reveals important distinctions in effects of social correlates over time and space. In the overall suicide model, six (percentage male, per capita income, percentage divorced, alcohol consumption, gun control ownership, and population size) have significantly different effects across the two dimensions. In the firearm suicide model, eight covariates differ and in the non-firearm suicide model, five covariates exhibit different effects. Many of these differences correspond to prior observations (Stack 2000a, 2000b). For example, unemployment is statistically significant in predicting change in suicide over time but not across states. The cross-sectional effect of percent divorced tends to be larger and significant in comparison to the temporal association.

Past researchers often attribute such discrepant findings to differences in units of analysis, measurement of variables or other features of the sample, but such explanations can be ruled out here. Mairesse (1990) argues

that between and within estimates should be similar in the absence of omitted variables so it is important to recognize the potential role excluded factors may play in this regard. Region is a significant predictor of suicide rates across states and if there are time-varying factors specific to region that are excluded from the within-state model, they may contribute to some of the observed discrepancies in the between-state and within-state associations. Within states, the time period dummies control for omitted variables that have a uniform effect on all states over time. However, such factors may not be controlled in the between-state model of suicide rates, introducing another potential source of difference between the two estimates. Finally, it is possible that measurement error affects the between-state and within-state estimates differently. Several variables (the percent divorced and religion variables) are interpolated for inter-census years, and this interpolation makes the differences more smoothly related to each other than they would be if based on the actual measured phenomenon. Such differences are averaged out in the between-state model but may not be such accurate measures in the within-state models.

Still, it is possible that the different effects may be partly attributable to actual differences in how factors affect variation in behavior across place as opposed to time. The long-term (stock) effect of a variable, typically captured with cross-sectional studies, may be distinct from the transitory (flow) impact on the outcome, usually measured by time-series analyses (Kennedy 2003; Phillips 2006). The literature on poverty and well-being often makes such a distinction – many studies demonstrate that cumulative or persistent poverty is more strongly correlated with adverse health and education outcomes than short-term or recent measures of poverty (Korenman and Miller 1997). Applied to suicide, long-term exposure to adverse conditions may have a larger effect on suicide risk than short-term fluctuations, and indeed, the different effects of per capita income and percentage divorced in the overall suicide models are consistent with this idea. Similarly, alcohol consumption and gun ownership, two measures of varying cultural climates across areas, are positively associated with the overall suicide rate across states, but do not predict change in overall suicide rates over time within states, perhaps because the shifts over time in culture that these variables are intended to capture are likely to be slow and incremental.

These results must be interpreted with caution. As noted earlier, measurement error and omitted variable bias may affect the findings. A notable omitted variable that undoubtedly influences the risk of suicide over the period is antidepressant drug usage, which rose dramatically during the latter portion of the time period studied. State-level measures of this variable are not available for the time period. Measures of norms and/or attitudes towards suicide across states, shown to be a predictor of suicide (Cutright and Fernquist 2004), are also not available. Cautions must be raised regarding the ecological fallacy, as aggregate-level relationships may not reflect individual behavior. While the analysis shows that gun ownership is positively associated and percentage Catholic negatively associated with firearm suicide, we cannot say whether it is those individuals in households with guns and who are not Catholic who commit suicide. Finally, while I disaggregate analyses by type of suicide, I do not distinguish by age group and/or sex. Future analyses should consider incorporating such distinctions as spatial and temporal patterns in suicide can differ by demographic group (Gunnell, Middleton, Whitley, Dorling and Frankel 2003).

These limitations notwithstanding, the present analysis and methodological approach offer new insights into aggregate patterns of U.S. suicide. First, there are clear differences in the cross-sectional and longitudinal effects of important covariates on suicide rates, distinctions that are missed by estimates from either random effects or fixed effects models. Second, the approach mitigates somewhat the potential problem of omitted variable bias and thus better isolates the true effect of each social correlate on the suicide rate. While I cannot control for all possible factors, the within-state estimates do control for time-stable state characteristics and the inclusion of year dummies control for omitted variables that have a uniform effect on all states over time. Some of the influence of antidepressant drug use changes over the period may be picked up by these controls. Finally, the time-series portion of the analysis yields more reliable estimates than those from national-level time-series work, as it uses fifty replications (corresponding to the fifty states) of the time-series.

A clear conclusion from the analysis is that both geographic and temporal variation in suicide rates are closely tied to varying social conditions across states and over time, although the ways in which firearm and non-firearm suicide are affected differ in important ways. Overall improvements in economic conditions (as measured

by increasing per capita income and lower unemployment) and declines in the percentage Episcopalian and consumption of alcohol are all associated with the substantial drop in non-firearm suicide. Changes in demography (declines in the white male population and in the percentage young) are more closely tied to the declines in firearm suicide. Researchers should pay close attention to how the rapidly changing demographic and social context of the U.S. will affect suicide patterns in years ahead.

References

Allison, P. (2005). *Fixed effects regression using the SAS system*. Cary, NC: SAS Institute, Inc.

Anderson, R. N., Miniño, A. M., Hoyert, D. L., & Rosenberg, H. M. (2001). Comparability of cause of death between ICD–9 and ICD–10: Preliminary estimates. *National Vital Statistics Reports, 49*(2), 1-32.

Bankston, W. B., Allen, H. D., & Cunningham, D. S. (1983). Religion and suicide: A research note on sociology's 'one law'. *Social Forces, 62*, 521-528.

Beck, E. M. (1980). Labor unionism and racial income inequality: A time-series analysis of the post-world war II period. *American Journal of Sociology, 85*, 791-814.

Breault, K. D. (1988). Beyond the quick and dirty: Reply to Girard. *American Journal of Sociology, 93*, 1479-1480-1486.

Brent, D. A., Perper, J. A., Allman, C. J., Moritz, G. M., Wartella, M. E., & Zelenak, J. P. (1991). The presence and accessibility of firearms in the homes of adolescent suicides. A case control study. *JAMA: The Journal of the American Medical Association, 266*, 2989-2990-2995.

Burr, J., McCall, P., & Powell-Griner, E. (1994). Catholic religion and suicide. *Social Science Quarterly, 75*, 300-301-318.

Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, Division of Violence Prevention. (2009). *National suicide statistics at a glance.* Retrieved June 28, 2010, from http://www.cdc.gov/violenceprevention/suicide/statistics/index.html

Cooper, P. N., & Milroy, C. M. (1995). The coroner's system and under-reporting of suicide. *Medicine, Science, and the Law, 35*(4), 319-326.

Crawford, M. J., & Prince, M. (1999). Increasing rates of suicide in young men in England during the 1980s: The importance of social context. *Social Science & Medicine, 49*(10), 1419-1423.

Cutright, P., & Fernquist, R. M. (2004). The culture of suicide through societal integration and religion: 1996-1998 gender-specific suicide rates in 50 American states. *Archives of Suicide Research, 8*, 271-272-285.

Durkheim, É. (1951). In Simpson G. (Ed.), *Suicide, A study in sociology* (J. A. Spaulding, G. Simpson Trans.). Glencoe, Ill: Free Press.

Faupel, C. E., Kowalski, G. S., & Starr, P. D. (1987). Sociology's one law: Religion and suicide in the urban context. *Journal for the Scientific Study of Religion, 26*, 523-524-534.

Florentine, J. B., & Crane, C. (2010). Suicide prevention by limiting access to methods: A review of theory and practice. *Social Science & Medicine, 70*(10), 1626-1632.

Gibbons, R. D., Hur, K., Bhaumik, D. K., & Mann, J. J. (2005). The relationship between antidepressant medication use and rate of suicide. *Archives of General Psychiatry, 62*(2), 165-172.

Girard, C. (1988). Church membership and suicide reconsidered: Comment on Breault. *American Journal of Sociology*, *93*, 1471-1472-1479.

Gruenewald, P. J., Ponicki, W. R., & Mitchell, P. R. (1995). Suicide rates and alcohol consumption in the United States, 1970-1989. *Addiction, 90,* 1063-1064-1075.

Grunebaum, M. F., Ellis, S. P., Li, S., Oquendo, M. A., & Mann, J. J. (2004). Antidepressants and suicide risk in the United States, 1985-1999. *Journal of Clinical Psychiatry, 65*(11), 1456-1457-1462.

Gunnell, D., Middleton, N., Whitley, E., Dorling, D., & Frankel, S. (2003). Why are suicide rates rising in young men but falling in the elderly?—a time-series analysis of trends in England and Wales 1950–1998. *Social Science & Medicine, 57*(4), 595-611.

Hsiao, C. (2003). *Analysis of panel data*. Cambridge: Cambridge University Press.

Johnston, J., & DiNardo, J. (1997). *Econometric methods.* New York: McGraw Hill.

Judge, G. G., Griffiths, W. E., Hill, R. C., Lutkepohl, H., & Lee, T. (1985). *The theory and practice of econometrics*. New York, NY: Wiley.

Kalmar, S., Szanto, K., Rihmer, Z., Mazumdar, S., Harrison, K., & Mann, J. J. (2008). Antidepressant prescription and suicide rates: Effect of age and gender. *Suicide & Life-Threatening Behavior, 38*(4), 363-374.

Kaplan, M. S., & Geling, O. (1998). Firearm suicides and homicides in the United States: Regional variations and patterns of gun ownership. *Social Science & Medicine, 46*(9), 1227-1233.

Kellermann, A. L., Rivara, F. P., & Somes, G. (1992). Suicide in the home in relation to gun ownership. *The New England Journal of Medicine, 327*, 467-468-472.

Kennedy, P. (2003). *A guide to econometrics*. Cambridge, MA: The MIT Press.

Korenman, S., & Miller, J. E. (1997). Effects of long-term poverty on physical health of children in the national longitudinal survey of youth. In G. Duncan, & J. Brooks-Gunn (Eds.), *Consequences of growing up poor* (). New York, NY: Russell Sage Foundation.

Kowalski, G. S., Faupel, C. E., & Starr, P. D. (1987). Urbanism and suicide: A study of American counties. *Social Forces, 66*, 85-86-101.

Lester, D. (1995). Is divorce an indicator of general or specific social malaise? *Journal of Divorce and Remarriage, 23*, 203-204-205.

Levin, A., Lin, C., & James Chu, C. (2002). Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of Econometrics, 108*(1), 1-24.

Mairesse, J. (1990). Time-series and cross-sectional estimates on panel data: Why are they different and why should they be equal? In J. Hartog, G. Ridder & J. Theeuwes (Eds.), *Panel data and labor market studies* (pp. 81-82-95). North-Holland: Elsevier Science Publishers.

Maris, R. W., Berman, A. L., Silverman, M. M., & Bongar, B. M. (2000). *Comprehensive textbook of suicidology*. New York: Guilford Press.

Marvell, Thomas B., Moody, Carlisle E. (1991). Age structure and crime rates: The conflicting evidence. *Journal of Quantitative Criminology, 7*(3), 237-273.

McCall, P. L., & Land, K. C. (1994). Trends in white male adolescent, young-adult, and elderly suicide: Are there common underlying structural factors? *Social Science Research, 23*(1), 57-81.

Milane, M. S., Suchard, M. A., Wong, M., & Licinio, J. (2006). Modeling of the temporal patterns of fluoxetine prescriptions and suicide rates in the United States. *PLOS Medicine, 3*(6), 816-817-824.

Miller, M., Azrael, D., & Hemenway, D. (2002). Household firearm ownership and suicide rates in the United States. *Epidemiology, 13*(5), 517-518-524.

Miller, M., & Hemenway, D. (2008). Guns and suicide in the united states. *The New England Journal of Medicine, 359*(10), 989-990-991.

Miller, M., Lippmann, S. J., Azrael, D., & Hemenway, D. (2007). Household firearm ownership and rates of suicide across the 50 united states. *The Journal of Trauma, Injury, Infection, and Critical Care, 62*(4), 1029-1030-1035.

Mouw, T. (2002). Racial differences in the effects of job contacts: Conflicting evidence from cross-sectional and longitudinal data. *Social Science Research, 31*(4), 511-538.

Phillips, J. A. (2006). Explaining discrepant findings in cross-sectional and longitudinal analyses: An application to U.S. homicide rates. *Social Science Research, 35*(4), 948-974.

Sainsbury, P., & Jenkins, J. S. (1982). The accuracy of officially reported suicide statistics for purposes of epidemiological research. *Journal of Epidemiology and Community Health, 36*(1), 43-48.

Simon, T. R., Swann, A. C., Powell, K. E., Potter, L. B., Kresnow, M., & O'Carroll, P. W. (2001). Characteristics of impulsive suicide attempts and attempters. *Suicide and Life-Threatening Behavior, 32*(Supplement), 49-50-59.

Stack, S. (2000). Suicide: A 15-year review of the sociological literature part II: Modernization and social integration perspectives. *Suicide and Life-Threatening Behavior, 30*(2), 163-164-176.

Stack, S. (2000). Suicide: A 15-year review of the sociological literature part I: Cultural and economic factors. *Suicide and Life-Threatening Behavior, 30*(2), 145-62.

van Poppel, F., & Day, L. H. (1996). A test of Durkheim's theory of suicide -- without committing the "ecological fallacy". *American Sociological Review, 61*, 500-501-507.

Wasserman, I. M. (1992). The impact of epidemic, war, prohibition, and media on suicide: United states, 1910-1920. *Suicide and Life-Threatening Behavior, 22*, 240-241-254.

Wasserman, I. M. (1984). Imitation and suicide: A reexamination of the werther effect. *American Sociological Review, 49*, 427-428-436.

Wasserman, I. M. (1989). The effects of war and alcohol consumption patterns on suicide: United States, 1910-1933. *Social Forces, 68*(2), 513-530.

Figure 1a

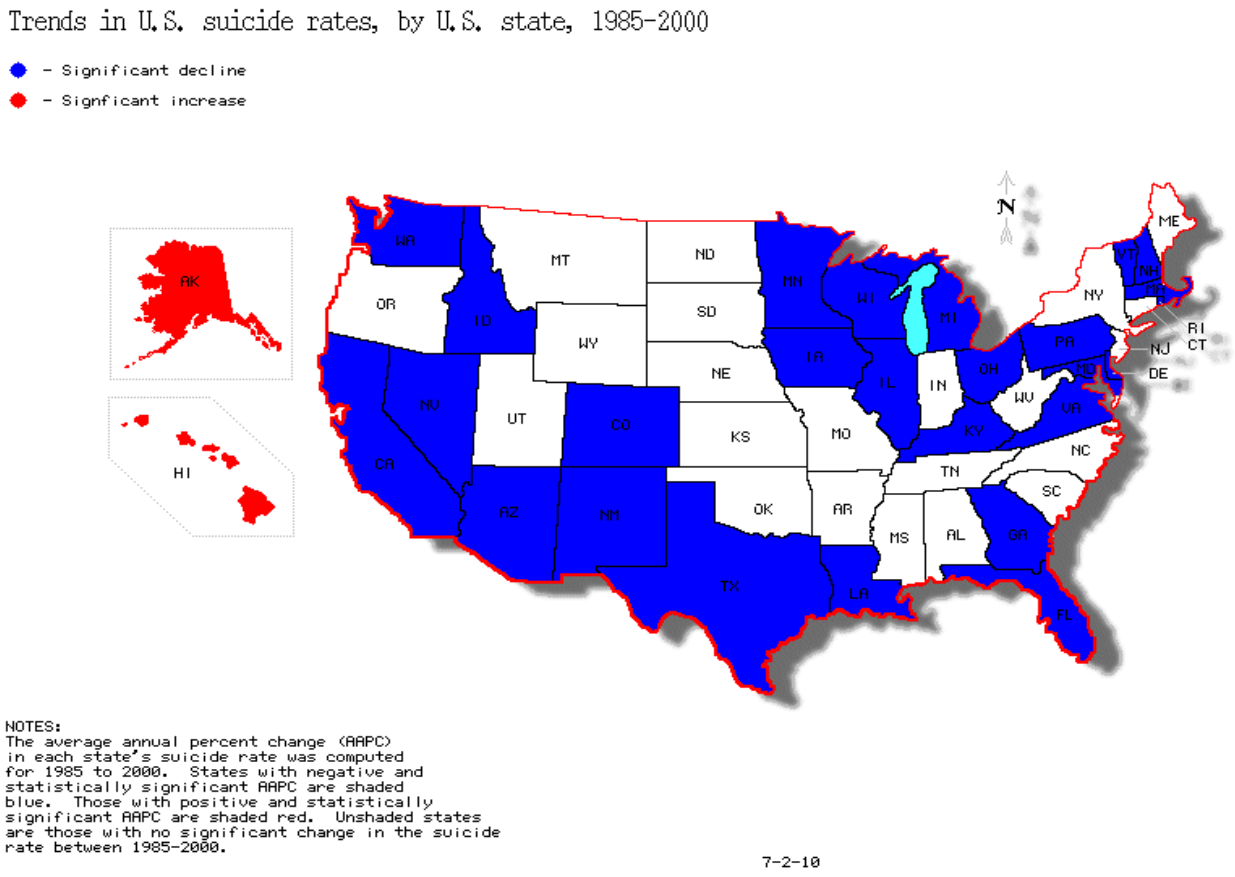

Trends in U.S. suicide rates, by U.S. state, 1985-2000
- Significant decline
- Signficant increase
N
WA
OR
CA
ID
NV
MT
WY
UT
AZ
CO
NM
ND
SD
NE
KS
OK
TX
MN
IA
MO
AR
LA
WI
IL
MS
MI
IN
KY
TN
AL
OH
WV
GA
FL
SC
NC
VA
PA
NY
MD
DE
NJ
CT
RI
VT
NH
ME
AK
HI
NOTES:
The average annual percent change (AAPC) in each state's suicide rate was computed for 1985 to 2000. States with negative and statistically significant AAPC are shaded blue. Those with positive and statistically significant AAPC are shaded red. Unshaded states are those with no significant change in the suicide rate between 1985-2000.
7-2-10

Figure 1b

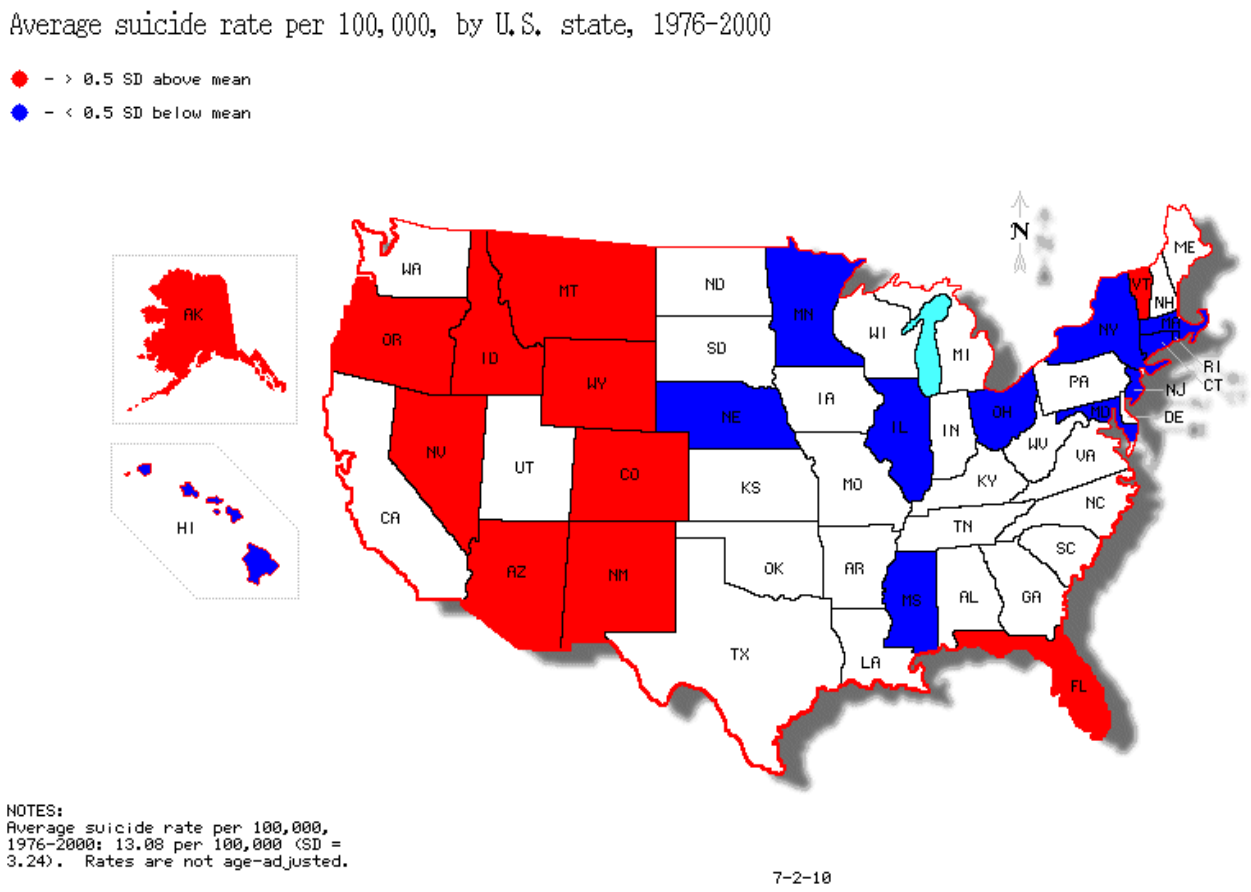
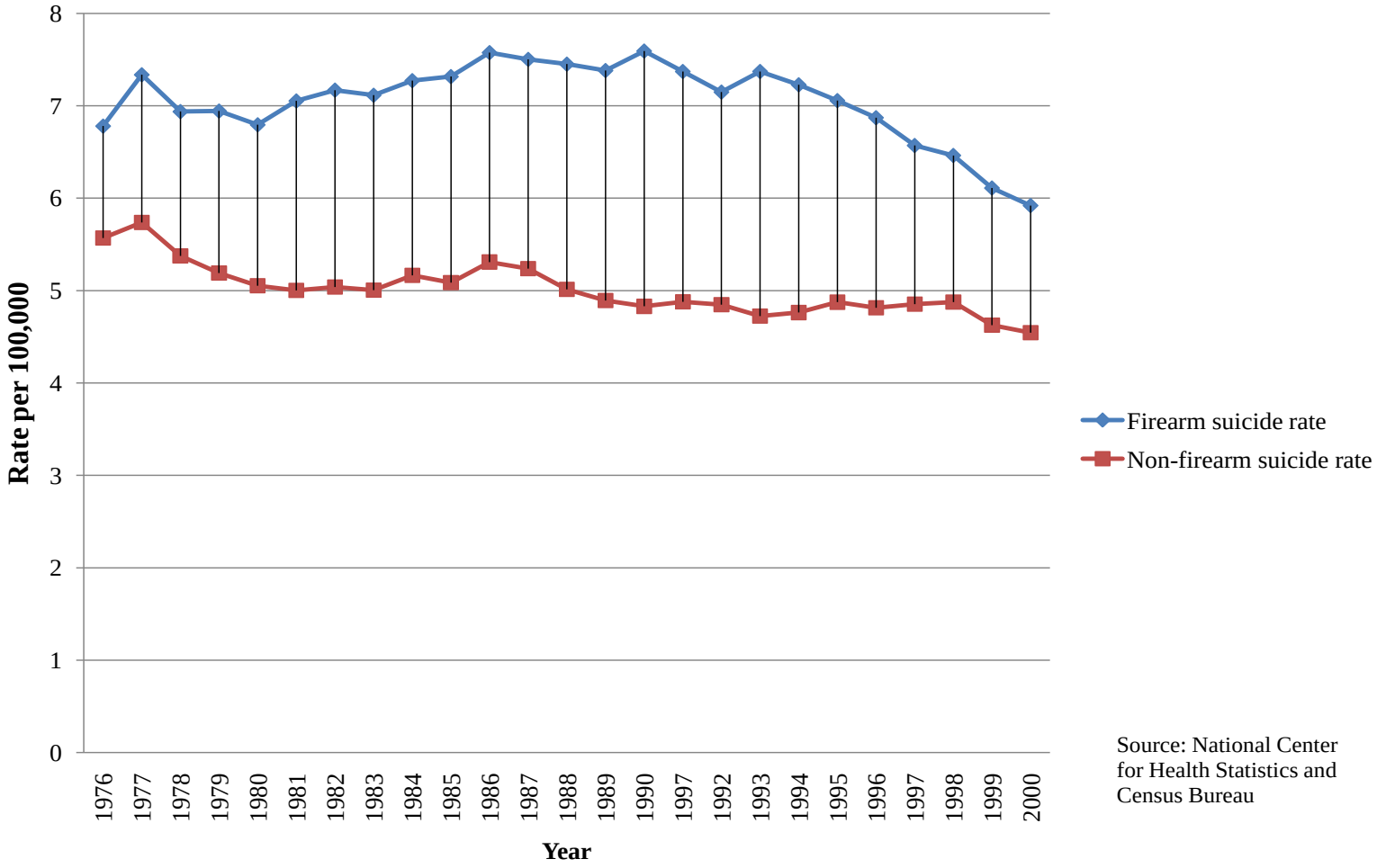

Average suicide rate per 100,000, by U.S. state, 1976-2000
- > 0.5 SD above mean
- < 0.5 SD below mean
N
WA
OR
CA
AK
HI
ID
NV
MT
WY
UT
AZ
CO
NM
ND
SD
NE
KS
OK
TX
MN
IA
MO
AR
LA
WI
IL
MS
MI
IN
KY
TN
AL
OH
WV
GA
FL
SC
NC
VA
PA
NY
MD
DE
NJ
CT
RI
VT
NH
ME
NOTES:
Average suicide rate per 100,000,
1976-2000: 13.08 per 100,000 (SD =
3.24). Rates are not age-adjusted.
7-2-10

Figure 2. Trends in U.S. firearm and non-firearm suicide rates per 100,000 1976-2000



Source: National Center for Health Statistics and Census Bureau

Table 1a. Descriptive statistics for dependent and independent variables

Variable	Mean	Standard Deviations		
		Overall	Spatial	Temporal
Suicide				
Suicide rate per 100,000	13.08	3.51	3.24	1.35
Firearm suicide rate per 100,000	8.04	3.13	2.96	0.99
Non-firearm suicide rate per 100,000	5.04	1.56	1.38	0.74
Demographic characteristics				
Percent white	85.97	11.62	11.44	2.02
Percent male	48.95	0.92	0.90	0.16
Percent aged 15-24	16.16	2.23	0.74	2.10
Percent aged 65 and older	12.25	2.39	2.07	1.20
Population (000)	4906.58	5282.54	5231.09	735.52
Economic characteristics				
Per capita income ('00 $)	13.71	2.44	1.82	1.63
Unemployment rate	6.15	2.12	1.21	1.74
Social integration				
Percent divorced	7.70	2.04	1.35	1.53
Religious adherence rate	520.51	117.24	114.44	25.48
Percent Catholic	19.14	13.20	13.14	1.19
Percent Episcopalian	1.14	0.68	0.65	0.21
Cultural characteristics				
Alcohol consumption	2.92	0.81	0.69	0.41
Percent households w/gun	48.00	13.29	11.07	7.35

Based on 50 U.S. states from 1976-2000.

Spatial variation represents between-state variation in these characteristics while temporal variation represents variation within states over time.

Table 1b. Descriptive statistics for dependent and independent variables

	1976			2000		
Variable	Mean	Min	Max	Mean	Min	Max
Suicide						
Suicide rate per 100,000	13.00	7.18	28.72	11.88	5.96	21.37
Firearm suicide rate per 100,000	7.84	2.19	18.38	6.95	1.69	14.98
Non-firearm suicide rate per 100,000	5.16	1.65	10.35	4.93	2.63	8.98
Demographic characteristics						
Percent white	87.91	37.46	99.42	79.46	24.28	96.95
Percent male	49.02	47.67	52.45	49.17	48.04	51.70
Percent aged 15-24	19.33	17.17	21.28	14.15	11.87	19.77
Percent aged 65 and older	10.39	2.23	16.28	12.53	5.69	17.57
Population (000)	4336.37	336.97	21940.25	5617.09	493.78	33871.65
Economic characteristics						
Per capita income ('00 $)	11.56	8.45	21.59	16.46	12.56	23.12
Unemployment rate	7.11	3.36	10.43	3.90	2.21	6.61
Social integration						
Percent divorced	4.74	2.56	9.98	10.05	7.53	13.82
Religious adherence rate	505.50	325.02	784.32	500.88	313.11	747.30
Percent Catholic	19.28	1.47	63.34	19.61	3.22	51.73
Percent Episcopalian	1.45	0.41	4.41	0.91	0.27	2.55
Cultural characteristics						
Alcohol consumption	3.40	2.01	8.44	2.59	1.55	4.56
Percent households w/gun	53.01	23.00	77.19	36.34	20.09	49.23

Based on 50 U.S. states from 1976-2000.

Table 2. Regression results of suicide rate on selected covariates
50 U.S states, 1976-2000

	Total Suicide Rate					
	Across states			Over time		
	Coeff.	(SE)		Coeff.	(SE)	
Fixed Effects						
Demographic Factors						
Percent white	0.039	(0.02)	b	0.088	(0.04)	b
Percent male	1.264	(0.40)	a,d	-1.594	(0.37)	a
Percent aged 15-24	-0.629	(0.60)		0.366	(0.08)	a
Percent aged 65 plus	-0.003	(0.20)		-0.074	(0.14)	
Economic Factors						
Per capita income	-0.716	(0.21)	a,d	0.010	(0.08)	
Unemployment rate	-0.084	(0.16)		0.069	(0.04)	c
Social Factors						
Percent divorced	0.955	(0.19)	a,d	0.342	(0.18)	c
Religious adherence rate	-0.001	(0.00)		0.000	(0.00)	
Percent Catholic	-0.002	(0.03)		-0.030	(0.06)	
Percent Episcopalian	0.754	(0.42)	c	0.755	(0.40)	c
Cultural Factors						
Alcohol Consumption	1.163	(0.35)	a,d	-0.057	(0.19)	
Gun ownership rate	0.116	(0.03)	a,d	-0.008	(0.01)	
Controls						
Logged Population Size	0.243	(0.25)	d	-2.392	(0.83)	a
Region (West=ref)						
Northeast	-0.060	(1.14)				
South	-1.506	(0.65)	b			
Midwest	-1.326	(0.67)	b			
Intercept	-50.281	(25.53)				
Random Effects						
State	0.7706	0.177	a			
AR(1)	0.356	0.03	a			
-2 Log Likelihood	3923.1					

a denotes p<0.01; b denotes p<0.05; c denotes p<0.10; d denotes a statistically significant difference (p<0.05) in the between- and within-state coefficients.
SE=standard error.

Table 3. Regression results of suicide rates on selected covariates, by method of suicide
50 U.S. states, 1976-2000

	Firearm Suicide Rate					Non-Firearm Suicide Rate				
	Across states			Over time		Across states			Over time	
	Coeff.	(SE)		Coeff.	(SE)	Coeff.	(SE)		Coeff.	(SE)
Fixed Effects										
Demographic Factors										
Percent white	0.043	(0.01)	a	0.084	(0.03) a	-0.004	(0.01)		0.011	(0.02)
Percent male	1.442	(0.37)	a,d	-0.783	(0.26) a	-0.185	(0.24)	d	-0.836	(0.20) a
Percent aged 15-24	-1.163	(0.56)	b,d	0.226	(0.06) a	0.539	(0.35)		0.149	(0.05) a
Percent aged 65 plus	-0.340	(0.18)	c	-0.213	(0.09) b	0.338	(0.12)	a	0.128	(0.07) c
Economic Factors										
Per capita income	-0.962	(0.19)	a,d	0.090	(0.05) c	0.243	(0.12)	b,d	-0.080	(0.04) c
Unemployment rate	0.253	(0.15)	c	0.016	(0.03)	-0.341	(0.09)	a,d	0.055	(0.02) b
Social Factors										
Percent divorced	0.654	(0.17)	a,d	-0.078	(0.13)	0.300	(0.11)	a	0.440	(0.10) a
Religious adherence rate	0.001	(0.00)		0.002	(0.00)	-0.003	(0.00)		-0.002	(0.00)
Percent Catholic	-0.047	(0.03)	c	-0.080	(0.04) b	0.046	(0.02)	a	0.046	(0.03)
Percent Episcopalian	1.047	(0.39)	a,d	-0.147	(0.27)	-0.291	(0.25)	d	0.851	(0.22) a
Cultural Factors										
Alcohol Consumption	0.827	(0.33)	b,d	-0.308	(0.14) b	0.341	(0.21)		0.244	(0.11) b
Gun ownership rate	0.133	(0.03)	a,d	-0.007	(0.01)	-0.017	(0.02)		-0.002	(0.01)
Controls										
Logged Population Size	0.370	(0.24)	d	-3.565	(0.56) a	-0.125	(0.15)	d	1.182	(0.45) a
Region (West=ref)										
Northeast	2.081	(1.06)	b			-2.158	(0.67)	a		
South	0.305	(0.60)				-1.826	(0.38)	a		
Midwest	0.409	(0.63)				-1.745	(0.40)	a		
Intercept	-51.711	(23.67)	b			1.687	(15.02)			
Random Effects										
State	0.7104	0.152	a			0.2737	0.0614	a		
AR(1)	0.2637	0.031	a			0.3195	0.0302	a		
-2 Log Likelihood	3244.6					2493.4				

a denotes p<0.01; b denotes p<0.05; c denotes p<0.10; d denotes a statistically significant difference (p<0.05) in the between- and within-state coefficients. SE = standard error.