Population factors and rates of suicide in U.S. counties

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ISCTM — THE INTERNATIONAL SOCIETY FOR CNS CLINICAL TRIALS AND METHODOLOGY

This study was conducted as an activity of the Policy and Education Team of the International Society for CNS Trials and Methodology (ISCTM) Working Group on Suicidal Ideation and Behavior

OBJECTIVES

- Define the contributions of demographic, environmental, socioeconomic and health-related factors to U.S. suicide rates
- Provide data to inform policy and education recommendations on suicide prevention for population health stakeholders

BACKGROUND

U.S. suicide rates[1]

- The annual age-adjusted rate of suicide is 12.93 per 100,000
- There are 42,773 suicide deaths per year; 117 suicides each day
- Since 2005, the rate of suicide has increased by 16%
- The male-to-female ratio for suicide deaths is 3.5:1
- The most common method for suicide in the U.S. is firearms, accounting for 49.9% of all suicide deaths
- Suicide is most common in the elderly, and more common in whites and Native Americans than other racial/ethnic groups

Suicide risks

Many studies have addressed factors contributing to increased rates of suicide. Potential risk factors include socioeconomic status, race, social isolation, mental and physical impairments, environmental factors such as altitude, and access to methods for suicide including firearms, potentially lethal medications and structures such as bridges, tall buildings and train platforms. Geographic patterns have been described, e.g. the "suicide belt" of the western U.S., and various explanations proposed including social isolation, cultural factors, firearms access and high elevations.

Figure 1 presents a population model for suicide risk incorporating factors that are known or proposed contributors to increased suicide incidence. Measures are available to assess the association of several of these factors to population risks for suicide.
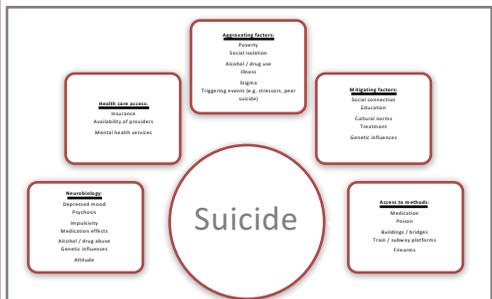

Figure 1. Potential contributors to population suicide risk

[1]American Foundation for Suicide Prevention (2016). Suicide Statistics. www.afsp.org

METHODS

We assessed the relationship between rates and potential predictors of suicide in a sample of U.S. counties.

Variables

Candidate explanatory variables included county-level data on race/ethnicity, population density, poverty, educational attainment, social affiliation, indicators of physical and mental health and measures of health care access (see Table 1 for variables and data sources). Suicide data for the years 1999-2013 were obtained from the National Vital Statistics System (NVSS) and mortality tables generated using the CDC Wonder database. Mean, annual, age-adjusted incidence data were compiled for suicide from all causes and due to the most common methods: firearms, hanging, self-poisoning and medication overdose. The natural log (loge) was calculated for variables not conforming to a normal distribution. If log-transformation did not yield normally distributed values, a 2-step transformation was performed (as described by Templeton, 2011).

Derived variables

Ratio of firearm to non-firearm suicide. Mean, annual, crude rates for 1999-2013 were used to calculate ratios of firearm/non-firearm suicide; the resulting values, and all-cause suicide rates, were grouped into quartiles and both were displayed on a county-level map of the U.S. (Figure 2).

Population-adjusted altitude. Because populations are concentrated at lower elevations, altitude data were adjusted for population by zip code tabulation areas (ZCTAs), geographic units utilized by the Census Bureau to approximate postal code regions. Elevation mapfiles were obtained from the U.S. Geological Survey, converted to text files using GPS Visualizer and merged with geospatial coordinate. An altitude variable adjusted for population residing at each elevation was derived from the sum of the products of altitude and proportional population for ZCTAs in a given county. For ZTCAs that crossed county boundaries, allocation of the altitude*population value was distributed by land area.

Prevalence of federally licensed firearms dealers. Numbers of federally-licensed firearms dealers (FLFDs) by zip code in January, 2010 were obtained from the Bureau of Alcohol, Tobacco and Firearms, mapped to counties and summed to yield number of FLFDs per county. County FLFDs per 100,000 population were then calculated. When zip codes crossed county borders, FLFDs were allocated to counties in proportion to total number of businesses.

Categorical variables for state firearm laws. For firearm suicide, dummy variables representing grades on a scorecard that rated state firearm laws[2] were assigned to all counties in a given state and incorporated into a second, sequential regression analysis.

Other derived variables. The reciprocal of population density ("population dispersion") and the inverse of percent of adults over age 25 with a college degree were used in analyses.

Data analysis

Analyses were conducted using IBM SPSS Statistics for Macintosh, Version 22.0. A correlation matrix was generated from bivariate comparisons of suicide outcomes and candidate explanatory variables. Pairwise comparisons of candidate independent variables and suicide outcome measures that yielded a Pearson's correlation coefficient $\geq$ 0.1 and two-tailed significance <0.05 were included in stepwise, multiple regression analyses.

Table 1. Potential population contributors to suicide and corresponding analysis variables

Category and factor		Measures	Data source[a] Primary (secondary, if applicable)	Data year(s)
Neurobiology	Depressed mood	Average number of mentally unhealthy days (in past 28 days)	BRFSS (RWJF)	2002-2008
		Altitude[1,3]	USGS	2010
	Genetics	Race / ethnicity	Census (CHSI)	2008
Health care access	Insurance	Percent of adults without health insurance	Census (CHSI)	2008
	Mental health providers	Mental health provider ratio: number of mental health providers per 1,000 population	HRSA (RWJF)	2010-2011
	Physicians	Primary care physician ratio: number of primary care physicians per 1,000 population	HRSA (RWJF)	2006
		Percent of individuals not able to access a physician due to cost in the past 30 days	BRFSS (RWJF)	2005-2011
Aggravating / mitigating factors	Economic status	Percent of individuals in below poverty level	Census (CHSI)	2008
	Social isolation / connection	Population dispersion (reciprocal population density)[3]	Census (CHSI)	2008
		Percent of adults reporting no social/emotional support	BRFSS (RWJF)	2005-2008
	Physical illness	Mean number of physically unhealthy days reported in the past month	BRFSS (RWJF)	2002-2008
	Alcohol use	Percent of adults reporting heavy drinking (past 30 days)	BRFSS	2002-2008
	Cultural norms	Race/ethnicity	Census (CHSI)	2008
	Education	Percent of adults over age 25 without a college degree[3]	Census (RWJF)	2000, 2005-2007
Access to methods	Firearms	Prevalence of federally-licensed firearms dealers[3]	ATF	2010
	State firearms laws	Categorical variables for state firearm law scorecard ratings[2]	Brady Campaign	2013
Outcomes (dependent variables)	Suicide mortality	Age-adjusted rates of suicide • All cause suicide • Leading causes of suicide: Firearms, hanging, medication overdose, self-poisoning • Ratio of firearm to non-firearm suicide (crude rates)[3]	CDC Mortality Tables	1999-2013

[1]ATF=Bureau of Alcohol, Tobacco and Firearms; Brady Campaign=Brady Campaign to Prevent Gun Violence and the Law Center for Gun Violence; BRFSS=Behavioral Risk Factor Surveillance System ; CDC=Centers for Disease Control; CHSI=Community Health Status Indicators; RWJF=Robert Wood Johnson Foundation County Health Rankings; SAMHSA=Substance Abuse and Mental Health Services Administration; Census=US Census Bureau, 2007 American Community Survey 3-Year Estimate, 2008 Mid-Year Population Estimates, or 2000 US Census
[2]Derived variables
[3]Alterations of neurotransmitter physiology have been proposed as the mechanism for increased suicide risk at higher elevations

Table 2. County suicide rates (all counties and analysis sample)

	Age-adjusted suicide rates per 100,000 population						
	All counties		Analysis sample				
Suicide Outcome	N	Mean	N	Mean	Min	Max	S.D.
All-cause	2328	14.45	602	14.70	4.8	70.5	5.50
Firearms	2005	8.92	517	9.15	0.46	44.80	4.24
Hanging	907	3.30	234	3.37	1.30	34.30	2.82
Medication	994	1.83	247	1.80	0.50	5.90	0.80
Poisoning	711	2.38	175	2.41	0.60	7.30	0.94
Jumping from height	107	0.42	28	0.42	0.20	1.20	0.23
Jumping in front of moving object	47	0.22	12	0.28	0.10	0.50	0.10
Drowning	45	0.18	9	0.18	0.10	0.40	0.18
Other	176	0.48	49	0.45	0.30	0.70	0.11
Non-firearm	1392	6.07	365	6.10	2.80	40.50	3.00

RESULTS

Figure 2. All-cause suicide rates and ratio of firearm to non-firearm suicide in U.S. counties, 1999-2013

Suicide incidence quartile[1]: 66.6-86.1, 13.9-16.5, 12.1-13.8, 10.4-11.3

Firearm/non-firearm suicide ratio quartiles[1]: 0.11-1.20, 1.21-1.73, 1.74-2.40, 2.41-66.0
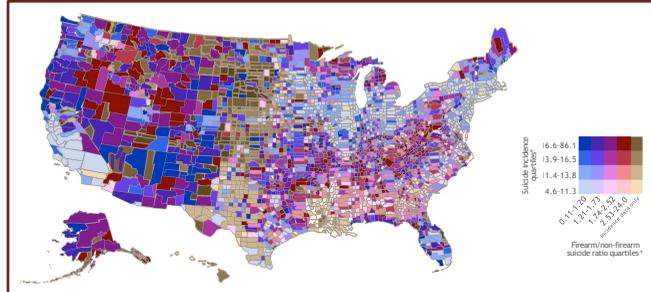
For counties having data on incidence of all-cause, firearm and non-firearm suicide (N=2,326), quartiles of firearm to non-firearm suicide ratios (based on crude rates per 100,000 population) are indicated by hue, red indicating higher relative rates of firearm suicide and blue indicating higher relative rates of non-firearm suicide. The median ratio was 1.73. Quartiles of crude suicide rates (all causes, per 100,000) are indicated color intensity, the darkest colors indicating the top incidence quartile. The median rate was 13.8 per 100,000. Incidence data were imputed for the remaining counties (shaded in brown, N=809): first, at the county level using predicted values from a regression model with crude rate of all-cause suicide as dependent variable (374 counties); if predictor variable data was not available at the county level, state suicide rate was used as the imputed value (435 counties). *Suicide incidence quartiles (crude rates per 100,000); [1] Quartiles of firearm to non-firearm suicide incidence ratios (ratios of crude rates per 100,000 population)

Figure 3. Multiple regression – All-cause suicide
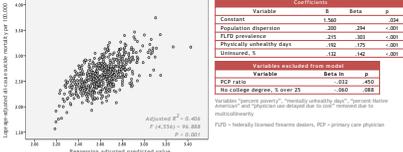
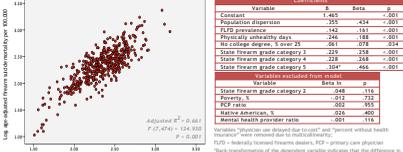

Figure 4. Multiple regression – Firearm suicide
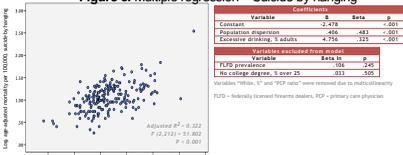

Figure 5. Multiple regression – Suicide by hanging

Table 6. Other regression analyses

Suicide method	Adjusted R[2]	F	Degrees of freedom	p	Variable	Beta	p
Poisoning	.326	41.327	2,165	<.001	Population dispersion	.545	<.001
					Excessive drinking, % adults	-.209	<.001
Medication overdose	.195	29.742	2,236	<.001	Population dispersion	.471	<.001
					Uninsured, % adults	<.001	

Table 3. Bivariate correlations of suicide outcomes and variables for potential risk factors

Cells are highlighted in color when R > .100 and p < .05 (two-tailed). R = Pearson correlation coefficient; N=number of counties in analysis sample for a given correlation; FLFD = federally licensed firearms dealers; GINI = Gini index, a measure of income inequality ranging from 0 (perfect equality) to 1 (complete inequality).

SUMMARY AND CONCLUSIONS

Several population characteristics were individually correlated with suicide rates; fewer of these were independent predictors in multiple regression analyses

- Population predictors of suicide differed by method
- For all causes, population density was a significant factor
- Prevalence of federally licensed firearms dealers was associated with increased rates of all-cause and firearm suicide
- State firearms laws were significant predictors of firearm suicide rates, corresponding to a difference of 1.45 firearm suicides/100,000/year for states with the least restrictive vs. most restrictive firearm regulations; i.e. for a state of 10 million population, a difference of 145 firearm suicides each year, beyond the effect of other model variables.
- Statistically significant, positive predictors for suicide in other regression analyses included measures of educational attainment, physical health, alcohol abuse and limitations in health care access
- When corrected for population, altitude was not significantly associated with rates of suicide
- Mental health indicators (other than self-reported heavy drinking) and racial/ethnic population percentages were not statistically significant, independent predictors of suicide rates
- There were distinct, county-level, geographic patterns of suicide occurrence
- Within the suicide belt, there was between-county variability in the proportions of firearm and non-firearm suicide
- Besides the suicide belt, regions of high suicide incidence were seen in counties of the southeastern U.S., and also those of New England and the northernmost Midwest.
- Because of the nature of the analyses, there are limitations in assessments of causality, some of which could be addressed by other analytic methods; also, for some of the regression models, a substantial proportion of the variance was not explained
- These findings can inform selection, prioritization and geographic allocation of policy and education initiatives in suicide prevention, and also suggest areas for further research

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