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USING A LASSO APPROACH TO ANALYSE THE DETERMINANTS OF MEASURED AND 'NATURAL' SUICIDE RATES

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Using a LASSO approach to analyse the determinants of measured and 'natural' suicide rates

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Abstract

A new empirical approach to testing the hypothesis of a (positive) 'natural' rate of suicides is considered. The clustered variant of the Least Absolute Shrinkage and Selection Operation (LASSO) framework is employed to select the determinants of suicide in the USA and a Least Squares Dummy Variable (LSDV) approach is then employed to estimate the 'natural rate of suicide' at the state level. Our model suggests that over the 2005-2017 period, natural rates for US states ranged from 5.5 (DC) per 100,000 population per year to 18.8 (Montana). Our results support the natural rate hypothesis with a more robust specification. We also consider the use of the natural rate measures as a means of evaluating progress in increasingly influential zero suicide initiatives.

Keywords: Zero suicide; LASSO; Natural rate of suicides; USA

JEL codes: C23, I12

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1. Introduction

Suicide is recognised as a serious mental and public health issue by the World Health Organisation (WTO, 2018). It not only inflicts emotional burden on the surviving family but also causes economic loss estimated at billions of dollars per year (see for example O'Dea and Tucker, 2005; Corso et al., 2007; Shepard et al., 2016; Kinchin and Doran, 2017).

Suicide cuts through all regions and socio-demographic levels across the globe. In a recent systematic analysis, Naghavi (2019) estimates that around 800,000 lives are lost worldwide to suicide annually. The study further reports that while the total number of deaths from intentional self-inflicted injury rose by 6.7 % globally between 1990 and 2016, the age-adjusted global mortality rate decreased by almost a third (33%) over that time.

In contrast, the age-adjusted suicide rate in the US has been on the rise. Over the 1999-2017 period, the age-adjusted suicide rate was up by 33%, from 10.5 per 100,000 standard population to 14.0. Put another way, around 47,000 lives were lost to suicide in the United States in 2017 (Hedegaard et al., 2018). In line with the 2012 National Strategy for Suicide Prevention, the Federal government is committed to develop, implement and evaluate suicide prevention strategies to reverse the rising suicide rates. This, however, begs the question: what is the suicide rate that authorities should feasibly aim for?

Labouliere et al. (2018) sets out the conceptual and clinical rationale for adopting a "Zero Suicide" (ZS) model as a means of reducing suicides for those in behavioural healthcare in the USA. Essentially, the model is premised on the belief that any suicide mortality by in-patients or outpatients is preventable by systematic improvement to healthcare processes via quality improvement. They point to the correlational and preliminary nature of studies evaluating the efficacy of ZS initiatives (Hampton, 2010; Centerstone, 2018). Nevertheless, experience in this setting has triggered similar initiatives elsewhere, e.g. in the UK (see, for example, Department of Health and Social Care, 2018) and Canada (see for example Olson, 2017).

Moving away from just those populations in behavioural healthcare to a consideration of the wider population, the concept of a 'natural rate of suicide' was first explored by Yang and Lester (1991). They asserted that the societal suicide rate can never be zero, even if social and economic conditions are conducive to a suicide-free society. They tested the hypothesis using 1980 data for 48 contiguous US states and estimated a natural rate of 6.01 per 100,000 population. Using US data over a different time period (1985-1995), Kunce and Anderson (2002) obtained a lower estimate of 1.28 per 100,000 per year. Yang and Lester (2009) further conducted a cross-sectional analysis for 11 nations and a time series estimation for the period 1950 to 1985 for 13 nations to explore the non-zero suicide natural rate

hypothesis. In both instances, when the two explanatory variables in the regressions, divorce and unemployment rates were set to zero, the constant terms were positive and nonzero, indicating that natural rate of suicide was not zero for their chosen sample of countries.

Hitherto, there has been a general consensus in the literature that no society can be suicide-free. Durkheim (1897) explained that suicide happens under a broad range of social regulations and social integration while Maris (1981) attributed suicide to the "harshness of the human conditions". Goldney (2003) further added that each nation has a base suicide rate determined by biological and physiological factors. The magnitude of the "nature rate", however, is unclear. As remarked by Yang and Lester (1991), the selection of independent variables included in the model may yield a zero or even negative constant term, thus, reversing the natural rate conjecture. Our findings concur with this observation and suggest that different estimated results in the extant literature are caused by author-determined suites of regressors, the number of which is often constrained by the sample size.

Our paper contributes to the literature in two distinct ways: first, we employ a novel variable selection technique to tease out a subset of covariates amongst potential determinants of suicide as opposed to pre-selecting variables in the model and second, we re-examine Yang and Lester's (1991) proposition and estimate the natural rate for each US State. There is a growing literature on variable selection and inference in a high dimensional setting (see for example Belloni and Chernozhukov, 2011, 2013; Belloni et al., 2012; Belloni et al., 2014 for theoretical explanation and Hoff et al., 2009; Hess, 2013; Panagiotidis et al., 2018; Cui et al., 2019 for empirical work). We follow the method discussed in Belloni et al. (2016) and use a variant of the LASSO that accommodates a clustered covariance structure (Cluster-LASSO) as the model selection. Belloni et al. (2016) is the first paper that addresses additive unobserved individual specific heterogeneity in a high-dimensional setting. Individual specific heterogeneity is eliminated in the variable selection process and overall contribution of the time-varying variables can be captured by a relatively small number of the available variables. Cluster-LASSO approach accommodates within-state dependent, hence partialing out the fixed effects.

The post-double-selection methodology of Belloni et al. (2014, 2016) and the post-regularization approach of Chernozhukov et al. (2015, 2016) are used to select appropriate control variables from a large set of factors and, thereby, improve robustness of estimation of the parameters of interest. This shrinkage approach minimizes the sum of squared deviations between observed and model predicted values much in the same way as Ordinary Least Squares, but imposes a regularization penalty aimed at reducing model complexity. The regularization method that uses l_1-penalization can set some coefficients to exactly zero, is able to produce sparse solutions and, thus, serves as model selection technique. This is a more robust approach in that it allows the data to tell the story rather than limiting the model to pre-selected suicide drivers, which would require very detailed knowledge of the determinants of suicide. Once the suite of

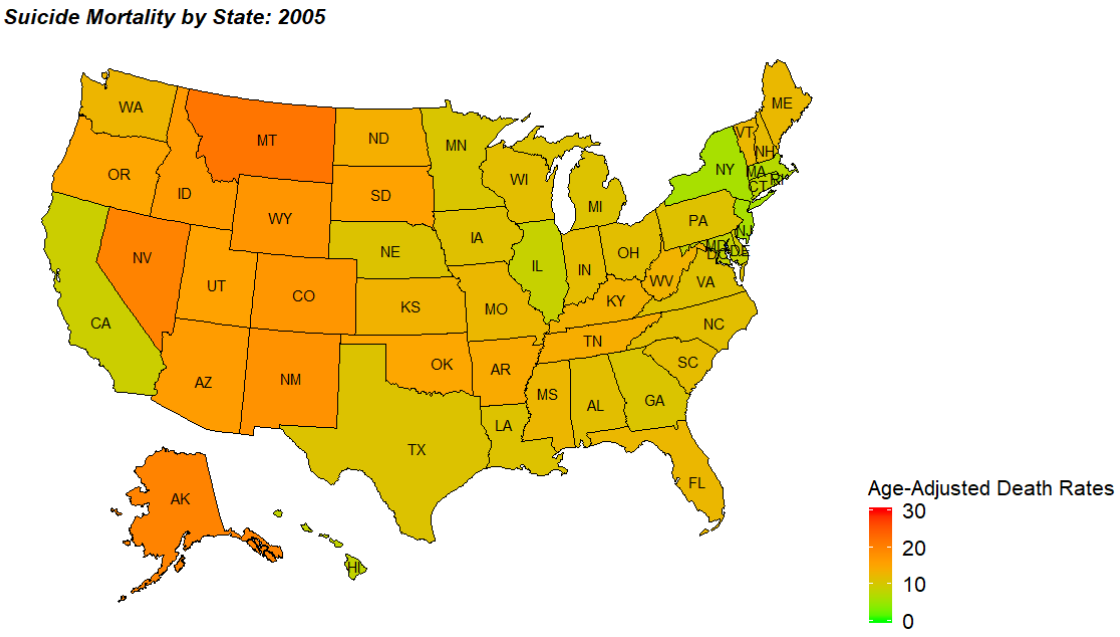
regressors is selected in the Cluster-LASSO model, we use a Least Squares Dummy Variable (LSDV) estimator to obtain the natural rate of suicide for each State.

The rest of the paper is set out as follows: Section 2 presents some brief background on suicide rates across US States. Section 3 briefly reviews the relevant literature. Data and methodology are discussed in Section 4. Estimation results and discussion are presented in Section 5. Section 6 concludes.

2. Background on Suicide Rates across US States

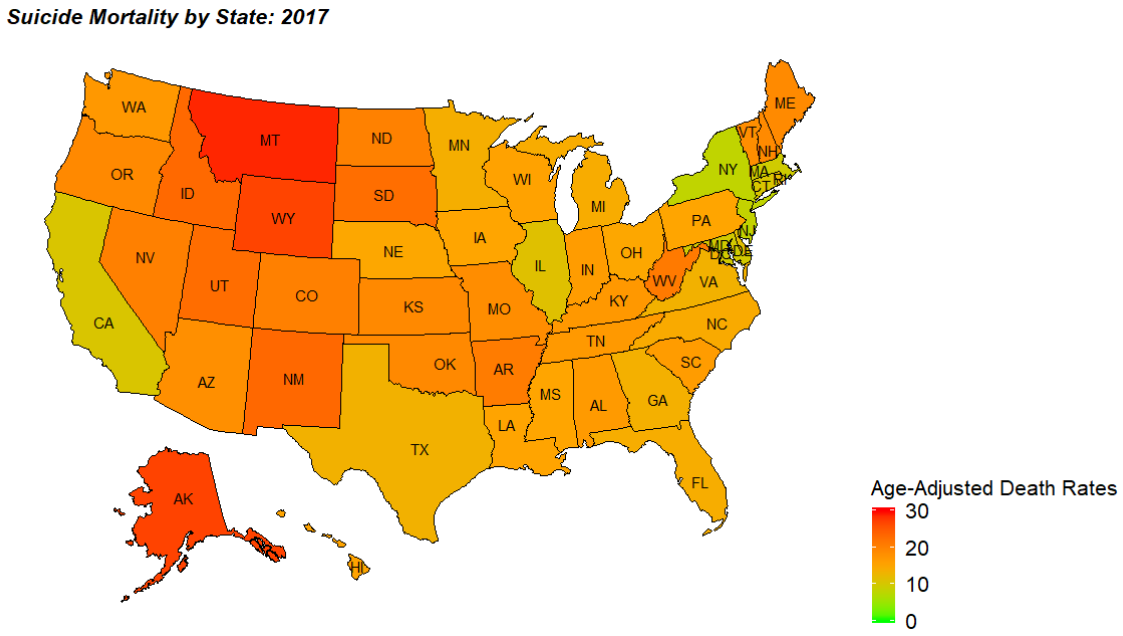
Since the mid-1980s, suicide rates in the US dropped from 12.4 per 100,000 in 1985 to 10.4 per 100,000 in 2000, with the majority of US states registering declines (see Phillips et al., 2013 for a descriptive overview for 1985-2000 period). By the turn of the century, however, there has been a noticeable reversal in this trend. As shown in Figures 1 and 2, since 2005, nearly every state registered an increase in the suicide rate, ranging from a 2.53% increase in Nevada to a 114.81% increase in Delaware. Alarmingly, thirty-two states experienced a rise of more than 30%.

Figure 1: Age-adjusted suicide rates for all US states, 2005



Authors' computation. *Data source*: WISQARS, Injury Mortality Reports, Centers for Disease Control. www.cdc.gov

Figure2: Age-adjusted suicide rates for all US states, 2017



Authors' computation. *Data source*: WISQARS, Injury Mortality Reports, Centers for Disease Control. www.cdc.gov

States in the west and mid-west regions exhibit the most significant increase in suicide rates over the time period. Concurrently, states in the east such as Virginia and North Carolina are amongst the lowest changers over time. Mirroring the large geographic variation in rates of change of suicide, there is an equally sizeable geographic difference in the levels of death from self-harm in the US. In 2005, Montana had the highest number of suicides at 21.7 per 100,000 and increased to 28.9 in 2017. The lowest recorded figure is for District of Columbia. The mountainous mid-western region of America is home to a collection of states, sometimes referred to as the 'Suicide Belt' (Harper et al., 2008). This area consists of 9 states, Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah and Wyoming. These states are geographically close and have consistently higher rates of suicide than most other states in the U.S. This suggests the mountainous landscape and the labour market could be potentially influencing factors.

3. Suicide and the natural rate of suicide: A brief retrospect

There is a rich body of theoretical and empirical work examining the motivations of suicides (see for example Platt, 1984; Stack, 2000; Stuckler et al., 2009; Chen et al., 2012; Vandoros et al., 2019). Durkheim's (1897) seminal work theoretically explains suicide from a sociological perspective with low levels of social integration leading to egoistic suicides and lack of social regulation causing anomic suicides. Medical professionals attribute suicide to depression and psychiatric disorders (see for example Mann et al., 2005). Hamermesh and Soss (1974) are the first to propose an economic explanation to

suicide through the utility maximisation framework. In particular, when discounted lifetime utility drops below a certain threshold, suicide becomes an attractive option. The real option perspective to suicide was later considered by Dixit and Pindyck (1994). It was further developed by Cutler et al. (2001) through a three-stage dynamic optimization model with uncertainty. Suicide decisions have also been explained through the risk-taking implications of the utility maximization approach by Becker and Posner (2004); a real option approach and Knightian uncertainty by Miao and Wang (2007); and via comparative statics by Suzuki (2008).

Empirical studies typically use regression analysis and a range of estimation method applied to different datasets at country, regional or group level (see for example Chen et al., 2012,) to find the determinants of suicide. Different measures of suicide rates have been used as dependent variable and the set of socio-economic factors vary across studies. Chen et al. (2012) group these factors into three: major economic factors (income, education as an important determinant of income, income inequality, economic growth and unemployment), demography and household (female labour force participation, divorce, birth rate, migration and population, household size, and age, gender and cohorts effect) and others (include religion, homicide, geographical and climatic conditions, civil liberty and quality of governance and health care and alcohol consumption). The authors employ a meta-regression method to investigate how the existing empirical results vary and find evidence of publication bias with respect to several socio-economic factors. For detailed review of studies on drivers of suicide, see Chen et al. (2012) and Okada and Samreth (2013).

Another strand of the literature tests the natural rate of suicide hypothesis. Yang and Lester (1991) were the first to estimate the natural rate for 48 continental US states for 1980. They estimated several regression equations using socio-economic variables such as divorce rates, interstate migration rates and church non-attendance. When social conditions were assumed to be "ideal" i.e., no divorce, no interstate migration and 100% church attendance, the natural rate of suicide was 6 per 100,000 per year (compared to 12 per 100,000 actual suicide rate). The rate remained unchanged when Lester (2001) re-tested the hypothesis using 1990 Census data. Meanwhile, Kunce and Anderson (2002) also examined the validity of Yang and Lester's (1991) proposition for a balanced panel of 50 US States plus District of Columbia over 1985-1995 period. They used age-adjusted suicide rates and several predictor variables, including the unemployment rate, median household income, divorce rate, nonmetropolitan residents, Christian church adherents, poverty rate, single occupant households and percent of non-white population. Their fixed effects estimates lent support to the positive non-zero hypothesis, albeit at a magnitude of 1.28 per 100,000 population, much lower than Yang and Lester (1991). Despite using state-level data, however, the study does not provide natural rates for each state.

A handful of studies have estimated the natural rate of suicide using non-US data. While investigating the economic determinants of suicides in Finland over the 1878-1994 period using the error correction model, Virén (1999) finds support for a positive natural rate. His model included various demographic

and structural variables namely gender distribution, average age and urbanization, GDP per capita, bankruptcies, unemployment. His results were indicative of an association between suicide rate and economic factors. Andres and Halicioglu (2011) provide further evidence on the hypothesis of the natural rate of suicide using autoregressive-distributed lag (ARDL) approach to cointegration for 15 OECD countries over the period 1970–2004. Their results corroborate with positive natural rates, with Turkey registering the lowest and Japan the highest rate.

It is not surprising that the natural rate, gauged by the constant term of the regression model, remains highly sensitive to the set of factors included in the model, as noted by Yang and Lester (1991). While most existing studies capture economic, demographic and social factors in one way or another, the choice of variables remains arbitrary. Hastie et al. (2009) remark that multiple regression models often include variables that are not necessarily related with the response variable resulting in unnecessary model complexity. We propose a novel variable selection approach, the clustered variant of the Least Absolute Shrinkage and Selection Operation (LASSO), to test the natural rate hypothesis. This framework allows us to systematically select variables from a wide array of suicide determinants found in the literature, which are then used to estimate the natural rate. The methodology is described in more detail in the next section.

4. **Data and Methodology**

We consider a balanced panel of time-series, cross-section data from 2005 to 2017, over 51 US states. Table 1 provides the descriptive statistics and expected sign of all variables used in our selection procedure. Variable definitions and data sources are summarised in Table A1 in the Appendix. Choice of regressors and their expected signs are drawn the consensus established in the literature (see for example Chen et al., 2012; Okada and Samreth, 2013; Collins et al., 2019).

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Expected Sign
AGESUICIDE	663	14.056	4.208	4.400	29.600	
Demographic and Economic measures						
POPDEN	663	390.102	1406.047	1.166	11302.480	–
PERCENTAGRI	663	2.645	2.315	0.035	13.060	–
DR	663	6.755	3.908	0.800	14.600	+
CUR	663	6.052	2.174	2.400	13.800	+
GDPPC	663	52725.970	20079.490	32770	183971	–
NONWHITE	663	0.229	0.136	0.034	0.754	–
CRISIS	663	0.462	0.499	0.000	1.000	+
CSI	663	80.923	10.558	63.700	96.800	–
EDUCLESSHS	663	11.447	3.645	4.100	20.500	+

EDUCCOL	663	29.410	6.995	16.100	62.200	–
Health and social measures						
ALCOHOL	663	39.754	18.294	10.600	69.100	+
HHSIZE	663	2.570	0.167	2.080	3.190	–
OBESITY	663	27.705	3.789	17.000	38.100	+/-
SMOKE	663	19.089	3.585	8.800	29.000	+/–
POVLINE	663	5518261	6672103	18479	38800000	+
FERTILITY	663	34.536	6.836	14.100	55.300	–
FLABOUR	663	59.894	3.858	48.093	68.651	–
Geographic measures						
MSD	663	0.157	0.364	0.000	1.000	+
Sunny	663	147.190	36.814	56.600	248.400	+/–
North	663	0.196	0.397	0.000	1.000	–
South	663	0.078	0.269	0.000	1.000	–

Methodology

Least Absolute Shrinkage and Selection Operator (LASSO)

LASSO, proposed by Tibshirani (1996), is a shrinkage and selection method for linear regression. This procedure shrinks the number of covariates included in the regression model by reducing some coefficient estimates to zero. This facilitates the model selection process by determining a set of predictors that best explain the response variable. It is generally recognised that the inclusion of irrelevant variables a model results in increased variance of OLS estimators while omission of important variables from the model cause omitted variable bias. As remarked by Tibshirani (1996), techniques such as Subset Selection or Ridge regression used to improve OLS estimates have certain weaknesses. While Subset Selection allows for more interpretable models, the process can be highly variable due to its discrete nature. Ridge regression, being a continuous process, overcomes this shortcoming by shrinking coefficients. Despite exhibiting less variability (hence more stability), Ridge regression scores low on model interpretation as all predictors are retained since none of coefficients in the regression are set to zero. LASSO combines the advantages of these two processes by yielding easily interpretable models as well as greater stability.

Hence, following, Belloni et al. (2016) we consider the model:

$$y_{it} = x_{it}'\beta + \alpha_i + \varepsilon_{it} \qquad i = 1, \dots n, \qquad t = 1, \dots T, \tag{1}$$

where the dependent variable, y_{it} is measured as the rate per 100,000 population of state *i*'s age-adjusted suicide rate over annual time *t*. α_i are state specific effects, and x_{it} is covariates and ε_{it} is an idiosyncratic disturbance term which is mean zero conditional on covariates but may have dependence within an individual.

We eliminate the fixed effects parameters from our estimation (removal of the heterogeneity) before LASSO selection, where we define:

$$\tilde{y}_{it} = y_{it} - \frac{1}{T}\sum_{t=1}^{T} y_{it}$$

Control variables $\tilde{x}_{it}$ and disturbance term have similar notations. Hence our 'within' model can be defined as

$$\tilde{y}_{it} = \beta \tilde{x}'_{it} + \tilde{\varepsilon}_{it}$$

The Cluster-LASSO estimator with data-driven penalty loadings that estimates $\hat{\beta}$ is defined by solving the following penalised minimisation problem on the within model:

$$\hat{\beta} = \arg\min_{b} \frac{1}{nT}\sum_{i=1}^{n}\sum_{t=1}^{T}(\tilde{y}_{it} - b\tilde{x}'_{it})^2 + \frac{\lambda}{nT}\sum_{j=1}^{p}\hat{\phi}_j|b_j|$$

where λ is ther main tuning parameter that dictates the amount of regularisation in the LASSO procedure and serves to balance overfitting and bias concerns. $\{\hat{\phi}_j\}_{j=1}^{p}$ is the covariate specific penalty loading which allows us to handle data which may be dependent within state, heteroscedastic and non-Gaussian (see Belloni et al. (2016) for detail discussion). To find the natural rate of the suicides, we use the Least Squares Dummy Variable (LSDV) estimator:

$$y_{it} = \alpha + \beta x'_{it} + \mu_i + \varepsilon_{it}\ ; i = 1,2,\dots N; t = 1,2,\dots T \qquad (2)$$

where α is the constant term of interest, y_{it} are observations of the response variable, x_{it} are covariates which have selected by the LASSO approach, μ_i is the latent state effect and $\varepsilon_{it}$is the disturbance.

5. Results and Discussion

Predictors selected by the Cluster-LASSO procedure are summarised in Table 2. Obesity is found to have the biggest influence on overall suicide rate and a 1% increase in obesity would lead to 0.416% increase in suicide. Extant literature presents mixed evidence on the obesity-suicide mortality relationship. While several epidemiological and ecological studies find that an increase in the body mass index (BMI) is associated with a drop in completed suicides compared to control groups (see Klinitzke et al. 2013 and Zhang et al. 2013 for a review), other investigators found no association. Following a comprehensive review of published work, Heneghan et al. (2012) nonetheless conclude that the bulk of studies show more evidence of a positive relationship between obesity and suicide than a negative or no association.

Table 2: Cluster-LASSO Predictors Selection

Rank	Variable	Coefficient
1	Obesity	0.416***
2	Smoke	-0.197***
3	Education	-0.190***
4	Divorce rate	0.007***
5	Poverty line	0.004

Note to table: *** denotes significance at the 1% level.

Smoking is the next strongest determinant of suicide and 1% increase in smoking will reduce suicide rate by 0.197%. The literature generally points to a positive link between smoking and suicide. In a meta-analysis Poorolajal and Darvishi (2016), find evidence of increased risk of suicidal behaviours, prompting them to conclude that smoking is a contributing factor to suicide but not causal. Smokers are predisposed to many other suicide risk factors such as depression, aggressiveness, alcohol consumption, poor physical health and disabilities (Lucas et al., 2013), making it unclear whether smoking is a true risk factor. On the other hand, it is widely recognised that antidepressant properties of smoking help to relieve negative emotions (see Kassel et al. 2013 for a review) and stress (Dozois et al., 1995; Nichter et al., 1997) and as such, are the prime motives of tobacco consumption (Warburton et al., 1991). A negative relationship between smoking and suicide, as shown by our results, may be possible. According to participants' subjective ratings (see foe example Nesbitt, 1973; Pomerleau and Pomerleau, 1987; Perkins et al., 1992; Parrott, 1995), the level of anxiety and stress were lower with smoking. These findings are echoed in Choi et al.'s (2015) study of event-related potential, where cigarettes are found to reduce anxiety both in neutral and unpleasant states. However, the psychological 'benefits' conferred by cigarettes may hold in the short to medium term, but not necessarily in the longer term where adverse effects may outweigh short term benefits.

In line with previous studies (for example Abel and Kruger, 2005; Phillips and Hempstead, 2017), education (highest grade of school completed is college and above) is negatively associated with the suicide rate and a 1% increase in school completion would reduce suicide rate by 0.19%. Such result indicates more educated individuals are less likely to commit to suicide due to higher levels of satisfaction in life (e.g. better jobs and higher income). Similarly, the divorce rate is positively related to suicide with a 1% increase in divorce rate leading to a 0.7% increase in the suicide rate.

Least Squares Dummy Variable (LSDV) estimates of natural suicide rates for each State derived using the LASSO predictor selection along with actual average suicide rate over 2005-2017 are shown in Table 3. The estimated natural rates are lower than the actual average rate and the differences are ranged between 9.36% (DC) and 46.34% (Mississippi).

Table 3: Actual average and Natural rate of suicide by US State, 2005-2017.

Ranking	State	Natural rate (per 100,000 population)	Actual average rate (per 100,000)	% DIFF
1	Montana	18.739	22.862	21.998
2	Wyoming	17.647	22.977	30.204
3	Alaska	17.609	22.877	29.916
4	Colorado	16.083	18.208	13.210
5	New Mexico	15.818	20.585	30.131
6	Nevada	14.668	19.246	31.208
7	Idaho	13.760	18.938	37.631
8	Utah	13.655	19.115	39.984
9	Arizona	13.045	17.162	31.553
10	South Dakota	12.900	17.238	33.634
11	Oregon	12.775	16.746	31.082
12	Vermont	12.475	15.231	22.090
13	Oklahoma	12.348	17.292	40.047
14	North Dakota	11.901	15.815	32.891
15	Arkansas	11.490	16.331	42.125
16	Maine	11.346	14.762	30.101
17	New Hampshire	11.316	14.192	25.414
18	Missouri	11.277	15.138	34.238
19	Kansas	11.221	15.031	33.946
20	Wisconsin	11.166	16.085	44.050
21	Kentucky	11.142	15.269	37.045
22	Washington	10.693	14.138	32.222
23	Tennessee	10.672	14.900	39.619
24	Florida	10.510	13.738	30.723
25	Indiana	10.191	13.692	34.359
26	South Carolina	9.908	13.615	37.424
27	West Virginia	9.883	13.262	34.192
28	Alabama	9.733	13.892	42.737
29	Virginia	9.704	12.192	25.646
30	Pennsylvania	9.667	12.685	31.210
31	Hawaii	9.625	12.015	24.829
32	Iowa	9.395	12.854	36.815
33	North Carolina	9.374	12.554	33.923
34	Minnesota	9.368	11.854	26.533
35	Ohio	9.302	12.462	33.960
36	Michigan	9.147	12.392	35.472
37	Mississippi	9.041	13.231	46.336
38	Delaware	9.036	11.623	28.630
39	Louisiana	9.023	12.762	41.436
40	Georgia	8.780	11.800	34.392
41	Nebraska	8.601	11.538	34.158
42	Texas	8.296	11.662	40.567

43	Rhode Island	8.001	10.092	26.144
44	California	7.569	10.115	33.640
45	Connecticut	7.533	9.115	21.005
46	Illinois	7.342	9.554	30.124
47	Maryland	7.095	9.077	27.931
48	Massachusetts	6.997	8.185	16.974
49	New York	6.094	7.562	24.083
50	New Jersey	5.896	7.300	23.812
51	DC	5.388	5.892	9.365

6. **Summary and Concluding Remarks**

The US state level societal suicide rate is determined by the factors selected using Cluster-LASSO, namely obesity, smoking, education and divorce rate. All estimates of the natural rate were non-zero and positive, ranging from 5.4 to 18.7 per 100,000 per year and well below the actual rates.

Our results suggest the ten states having the highest rates are Montana (18.739), Wyoming (17.647), Alaska (17.610), Colorado (16.083), New Mexico (15.818), Nevada (14.668), Idaho (13.760), Utah (13.655), Arizona(13.045) and South Dakota (12.900), all measured as per 100,000 population. The states with highest differences between the natural and average state rate are Mississippi, Wisconsin, Alabama, Arkansas, Louisiana, Texas, Oklahoma, Utah, Tennessee and Idaho.

In all USA states the natural rate is not only non-zero and positive but also higher than the average state suicide rate. Some USA states (e.g. Montana and Colorado) that have relatively high rankings in terms of suicide rates do not necessarily have greater differences between the natural and actual suicide rates. Mississippi, Louisiana and Texas, however, feature large differences between the natural and actual suicide rates. In terms of mental health and suicide prevention resource allocation, the results of this study provide an evidence base suggesting that policy focus and greater resources could rationally be directed to those states with the greatest positive difference between the actual and natural suicide rates. Overall, the approach suggested in this study offers one pragmatic macro-level pathway towards identifying and achieving a zero suicide target.

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Appendix

Table A1. Variable definitions and sources

Variable	Definition	Source
Suicide Rates	**Suicide rates (deaths per 100,000 people)**	
AGESUICIDE	Age-adjusted suicide rate (all mechanisms)	Centers for Disease Control WISQARS Injury Mortality Reports
Demographic and Economic measures		
CUR	Civilian unemployment rate	Bureau of Labor Statistics
POPDEN	Population density	U.S. Census Bureau
DR	Divorce rate	U.S. Census Bureau
NONWHITE	Share of the population that is non-white (Black, American Indian, Alaska Native, Asian, Hawaiian, and other)	U.S. Census Bureau
CRISIS	Post-2007 financial crisis dummy	Authors' Created
CSI (Consumer Sentiment Index, 1996 = 100)	Quantifies consumers' perceptions of their own financial situation and of the general economy in near and long term	Thomson Reuters Datastream; University of Michigan, Surveys of Consumers
PERCENTAGRI	Total population in agriculture, forestry and fishing and hunting, and mining of population of working age (16 and over)	U.S. Census Bureau
GDP per capita	Gross domestic product per capita	Bureau of Economic Analysis
EDUCLESSHS	Highest grade of school completed is less than high school	Centers for Disease Control and Prevention
EDUCCOL	Highest grade of school completed is college and above	Centers for Disease Control and Prevention
Health and social measures		
ALCOHOL	Crude prevalence of alcohol consumption	Centers for Disease Control and Prevention
OBESITY	BMI greater than or equal to 30.0	Centers for Disease Control and Prevention
FERTILITY	Percentage of women between 15 and 50 years old who gave birth within the last 12 months	U.S. Census Bureau
HHSIZE	Average household size	U.S. Census Bureau
POVLINE	Percentage below 100 percent of the poverty line	U.S. Census Bureau

FLABOUR	Percentage of female population in labour force	U.S. Census Bureau
Geographic measures		
MSD	Mountain state dummy (indicates whether the state is located in the Rocky Mountain Census Region)	U.S. Census Bureau
SUNNY	Number of sunny days in a year	Dunn (2008)
NORTH	Northern state dummy	World Atlas (2015)
SOUTH	Southern state dummy	World Atlas (2015)

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