

The Effects of Internet Interactions on National Suicides in The United States

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Abstract

Suicide rates have been increasing throughout 21st century America. In this study, I used empirical analysis to test whether or not internet usage, implied as any individual who has a web access point and uses the technology at least occasionally, affects the total number of suicides in the United States. In my analysis, I utilized CDC national suicide totals coupled with internet usage data and multiple other variables such as GDP per capita, poverty, income, and race to test my hypothesis that internet exposure increases suicides. The initial empirical model suggested that internet usage was insignificant ($p\text{-value} < 0.10$) in dictating the number of suicides in the United States from 1999-2018, concluding that the hypothesis that internet usage increases suicides was incorrect. Further testing and allowing suicide to be unitized in millions of individuals while also computing the percent makeup of both white and black ethnic populations, I found that internet usage had a negative coefficient and was statistically significant. This implied that increasing internet exposure decreased suicides in the United States which was contradictory to my original claim. Following these results and performing various diagnostic tests, we can conclude that policymakers should explore internet exposure in affected people groups for suicidal ideation to slow to spread of self-inflicted harm.

Introduction

In a constantly evolving world, one factor which has plagued humanity throughout generations is self-inflicted mortalities. In this study, I plan to use statistical analysis on time-series data to evaluate variables that may affect suicide totals in the United States; most notably, my variable of interest will be Internet usage and its effects, if any, on suicide totals.

Americans have faced a growing national suicide rate from the start of the 2000s. For example, as to a report from the American Foundation for Suicide Prevention, the suicide rate

per 100,000 individuals have grown from 11.75 in 2009 to 14.21 in 2018 (NIH 2020). Suicide is ranked the 10th leading cause of death in the U.S. curated from data in 2018; moreover, the rate of national suicide only seems to be accelerating indicated by CDC data revealing that self-inflicted mortality increased 1% per year from 1999 to 2006 and 2% from 2006 through 2018 (CDC 2020). The total attempt of suicides in 2018 touched 1.4 million with 48,344 of those being successful (AFSP). In this past year, 0.6% of adults age 18 and older reported an attempt of suicide. The most prevalent age group to have attempted suicide in 2019 were young adults ranging from 18-25 years old, 1.8% of these individuals reported an attempt of suicide (NIH 2020). Interestingly, males have had a historically larger national suicide rate than women from 1999 to 2018; males rose from 17.8 to 22.8 in 2018 while women rose from 10.5 in 1999 to 14.2 in 2018 out of 100,000 individuals (NIH 2020). However, data accumulated from SAMHSA indicated that females were more prevalent to have suicidal thoughts (5.1%) than men (4.5%) in 2019 (NIH 2020). In 2019, data revealed that while 1.4 million adults attempted suicide, 3.5 million adults made suicide plans and 12.0 million adults “had serious thoughts of suicide” (NIH 2020).

This trend is worrisome for multiple reasons: First and foremost, suicide takes a tremendous toll on family members and close companions to the individual, unsuccessful attempts of suicide can lead to negative emotional externalities such as stigma, shame, and isolation (HARVARD 2019). Suicide is usually profiled with mental illness and can cause the survivor a great amount of mental pain and isolation due to the stigma of suicide. Along with emotional externalities, suicide has been verified to cause financial implications along with emotional burdens. A study review from the Suicide Prevention Resource Center revealed that the average cost of a self-induced death totals \$1,329,553 (SPRC). This is both implied by wage

loss costs (indirect) and medical expenses (direct). The national cost of reported suicides in 2013 was \$58.4 billion, while after adjusting for under-reporting the total moved to \$93.5 billion or \$298 per capita (SHEPARD). The growing rate of Suicide raises the question of what variables, if any, contribute to the rise of self-inflicted death? A possible contributing factor, and the variable I plan to test in this study, is the effects of internet usage focused on social media and web applications on national suicide rates. Social media and various communicative applications have been linked to negative implications such as cyber-bullying and a phenomenon called media contagion (GOULD). The vast distribution of self-inflicted harm images and suicidal information distributed on the web could induce a modern-day Werther effect. Some studies suggest that suicide clustering could support Social learning theory, which states most human behavior is learned via observation. Clustering has been a suggestion to evaluate suicide contagion, that of which multiple suicides occur in close proximity and in a relatively short period; this method however has been difficult to evaluate due to unreported attempts of suicide (GOULD). In this documentation, I plan to evaluate suicide based on newly generated national data regarding suicide rates and internet usage. My goal is to use this data to supplement how modern-day digital information interactions affects suicide rates and further identify policy implications supported by my findings.

Literature Review

Literature regarding suicide rates and internet exposure is highly debated and ambiguous. Studies such as “Social Media, internet use and suicide attempts in adolescents” written by Rosemary Sedgwick suggests that current evidence signifying excessive use of social media/internet does indeed impact suicide risk; however, the study implies longitudinal data may be useful in establishing “the direction of potential association.” In contrast, a study from José

Luis which conducted questionnaires given to a sample of 374 college students concluded that addictive social media behavior was not related to suicidal ideation. In an alternative lens, certain exterior implications of suicide suggest a high economic cost mentioned in Donald S. Shepard's analysis. Shepard found that the average cost per suicide from an individual 15-24 years of age is \$2,012,476; the paper suggests a multifactorial approach of prevention "involving communities, workplaces, schools, and the health sector." This issue also can be taken to a global scale, particularly in Japan where digital information and social media platforms may be as influential such as in the U.S. Akihito Hagihara fitted a linear model using time series data from January 1987 to March 2005; Hagihara's analysis concluded that internet use and newspaper articles about suicide was a predictor among both male and females. During the study period, "the monthly number of suicides increased by approximately 200% for males (888 to 2434) and 100% for females (479 to 1062). These rates of internet use and social media interaction "is expected to increase in Japan until internet use becomes saturated" similarly to the United States, indicating that internet use is a good predictor of self-induced mortality due to its positive association. Limits of this study include the lack of information regarding gender and age. My analysis will stay strictly domestic within the United States and will measure national suicide rates on national internet usage.

Empirical Model

I employed linear regression to evaluate the relationship between national internet usage and suicides in the United States from 1999 to 2018. In this paper, I estimated the following regression model:

$$\log(\text{suicide}) = \alpha + \beta_1 \text{internet} + \beta_2 \text{educ} + \beta_3 \text{blackpop} + \beta_4 \text{whitepop} + \beta_5 \text{poverty} + \beta_6 \text{income} \\ + \beta_7 \text{GDPpercapita} + \beta_8 \text{poverty} * \text{white} + \beta_9 \text{poverty} * \text{black} + \beta_{10} \text{time} + u$$

In the model above, *log(suicide)* measures the total reported self-inflicted mortalities in the United States for the corresponding year in logarithmic form. The independent variable of interest, *internet*, calculates the total number of individuals who access the internet at least occasionally throughout the United States from 1999-2018.

Educ records the percent of individuals 25 years or older who have completed at least 4-years or more of high school education during that year. Other variables such as *blackpop* and *whitepop* measure the total demographic population in the United States of white and black ethnic groups for the respected year. *Poverty* represents the percentage of financially impoverished individuals residing in the nation. Two interaction terms are included listed as *whitepop* poverty* and *blackpop * poverty*, these variables serve to measure the relationship of poverty on race and the impacts these relationships have on suicide. Lastly, *income* records the mean annual income per household in the United States, *GDPpercapita* measures the growth rate per year of American GDP per capita, and *time* is included in standard year format from 1999 - 2018 due to the time-series nature of the data.

Data

Suicide data was gathered via the CDC utilizing CDC Wonder with UCD - ICD-10 Codes: X60-X84 (Intentional self-harm), covering all self-inflicted mortalities in the United States from 1999 to 2018. This data is available at <https://wonder.cdc.gov/mcd-icd10.html>.

Internet usage information was gathered from Statista, which was sourced from Internet World Stats. The data records the total individuals with access to the internet who utilize the web or applications at least occasionally. Internet World Stats was updated on April 30, 2019; usage statistics stemmed from published data from Nielsen Online, ITU, Facebook, and other local sources. A defined internet user is an individual with available access to a web connection point

and the person must have basic knowledge required to use internet technology. Population data was extracted from the [United Nations – Population Division](#).

National characteristics considered include national racial populations in the United States such as black and white unitized in millions of people characterized as that ethnic group living in the United States; this data was sourced from the [US Census Bureau](#) with a survey period from July 2000 – July 2019 and [Population Profile of the United States](#). Other variables include education (percent of U.S. population 25 years of age or older who have completed 4 or more years of high school education), poverty (percent of financially impoverished individuals), income (mean household income recorded in thousands of dollars), GDP Per Capita (annual rate of change), and time (spanning from 1999 to 2018).

Table 1. Descriptive Statistics

Variable	Observations	Mean	St. Deviation	Minimum	Maximum
Suicide	20	37203.65	6056.004	29199	48312
Internet	20	216.411	61.03141	63.7	292.89
% Education	20	86.545	1.990894	83.4	89.8
Black pop.	20	39.5805	2.69237	34.9	43.73
White pop.	20	239.483	7.504523	224.6	249.96
% Poverty	20	13.115	1.271665	11.3	15.1
Income	20	43010.35	6483.223	32359	55619
GDP Per Cap.	20	3.3255	1.926779	-2.65	5.76
White * Pov	20	3145.495	364.3543	2582.389	3665.25
Black * Pov	20	520.6452	73.2894	404.653	622.932

Time	20	2008.5	5.91608	1999	2018
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Shown in Table 1, we see that the distribution of suicides is rather large ranging from the minimum of 29,199 in 1999 up until 48,312 in 2018. Internet usage grew significantly in the later 21st century resulting in the mean of 216 million users in the United States. The percent of education remained rather constant over the 21st century, with a minimum of 83.4%, maximum of 89.8%, and average of 86.5%. The black population in the United States grew from a minimum of 34.9 million in 1999 to 43.73 million in 2018. White populations remained significantly larger than any other racial group in the United States with an average count of 239 million individuals. The poverty level, much like education, remained relatively constant in the time series data, showing an average of 13% with a minimum of 11.3% and a maximum of 15.1%. Income saw a gradual increase from 1999 with the average earning being \$32,359 and \$55,619 in 2018. Finally, GDP Per Capita from 1999-2018 averaged a growth rate of 3.32%.

Empirical Results

Regression results displayed in Table 2 show internet usage has a negative effect on suicides in the United States, concluding that with 100 new internet users this decreases national suicides by 5.8% $((-.0005849*100)*100)$. However, the data revealed that *internet* is insignificant at all tested significance levels (p-value > 0.1, 0.05, 0.01).

Table 2. Regression Results

```
. reg logsuicide internet educ blackpop whitepop white_pov black_pov poverty income
gdppercapita time
```

Source | SS df MS Number of obs = 20

Model	.491836741	10	.049183674	F(10, 9)	=	651.12
Residual	.000679836	9	.000075537	Prob > F	=	0.0000
				R-squared	=	0.9986
				Adj R-squared	=	0.9971
Total	.492516577	19	.025921925	Root MSE	=	.00869

logsuicide	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
internet	-.0005849	.0005226	-1.12	0.292	-.0017671	.0005973
educ	-.0119997	.0214146	-0.56	0.589	-.0604429	.0364435
blackpop	-.159399	.3472388	-0.46	0.657	-.9449078	.6261099
whitepop	.2031925	.1446588	1.40	0.194	-.1240483	.5304334
white_pov	-.0210954	.0118229	-1.78	0.108	-.0478407	.00565
black_pov	.0473912	.0303963	1.56	0.153	-.02137	.1161524
poverty	3.201594	1.645101	1.95	0.083	-.5198843	6.923072
income	2.35e-06	.0000149	0.16	0.878	-.0000313	.000036
gdppercapita	.0025883	.002626	0.99	0.350	-.0033521	.0085286
time	-.0895092	.0279551	-3.20	0.011	-.1527479	-.0262704
_cons	148.6867	44.77717	3.32	0.009	47.39366	249.9797

The coefficients on education, black population, income, time, and the interaction term between poverty and white population are all negative; however, these terms are all insignificant for every tested level (p-value > 0.1, 0.05, 0.01). The percentage of impoverished is reported to have a large positive effect on suicide rates, reporting that a 1% increase in poverty increases suicide rates by 3.2%; although a large effect, poverty is insignificant at all tested levels in the regression. Other positive coefficient variables are white population and GDP Per Capita. The intercept term is significant at 10% (p-value < 0.1) but does not conclude viable evidence for factors affecting suicide in the United States.

Empirical Diagnostic Tests

To test the viability of my regression, multiple Diagnostic Test was applied to bolster its validity. The tests utilized were: Heteroskedasticity, Normality, Multicollinearity, Ramsey, and autocorrelation due to the time-series nature of the data.

1. Heteroskedasticity

```
. reg s1s internet educ blackpop whitepop white_pov black_pov poverty income gdppercapita time
```


Source	SS	df	MS	Number of obs	=	20
Model	2.6530e-08	10	2.6530e-09	F(10, 9)	=	1.00
Residual	2.3868e-08	9	2.6520e-09	Prob > F	=	0.5044
				R-squared	=	0.5264
				Adj R-squared	=	0.0002
Total	5.0398e-08	19	2.6525e-09	Root MSE	=	5.1e-05

s1s	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
internet	-9.73e-07	3.10e-06	-0.31	0.761	-7.98e-06	6.03e-06
educ	-.0000516	.0001269	-0.41	0.694	-.0003386	.0002355
blackpop	-.0017546	.0020575	-0.85	0.416	-.006409	.0028997
whitepop	.001045	.0008571	1.22	0.254	-.000894	.002984
white_pov	-.000093	.0000701	-1.33	0.217	-.0002515	.0000654
black_pov	.0002216	.0001801	1.23	0.250	-.0001858	.000629
poverty	.013529	.0097477	1.39	0.199	-.0085218	.0355798
income	-4.41e-08	8.82e-08	-0.50	0.629	-2.44e-07	1.56e-07
gdppercapita	3.06e-06	.0000156	0.20	0.849	-.0000321	.0000383
time	-.0002431	.0001656	-1.47	0.176	-.0006178	.0001316
_cons	.3139353	.2653171	1.18	0.267	-.2862538	.9141244

Looking at the regression above, we test the null hypothesis that Homoskedasticity exists in our data against the alternative of Homoskedasticity is absent from our data. Drawing our attention to our F-statistic, we find that we can fail to reject the null hypothesis concluding that we do not suffer from Heteroskedasticity.

2. Normality

Skewness and kurtosis tests for normality

Variable	Obs	Pr(skewness)	Pr(kurtosis)	----- Joint test -----	
				Adj chi2(2)	Prob>chi2
s1	20	0.7525	0.4158	0.82	0.6650

Observing the skewness test listed above, we tested that the null hypothesis of normality in our residuals exists in our data while the alternative hypothesis states that normality does not exist. From our results, we can conclude that the residuals exhibit normality by being unable to reject the null hypothesis.

3. Multicollinearity

. vif

Variable	VIF	1/VIF
time	12.45	0.080321
white_pov	11.34	0.088183

black_pov		9.56	0.104603
poverty		9.33	0.107181
whitepop		8.78	0.113895
blackpop		8.55	0.116959
income		4.32	0.231481
educ		4.11	0.243309
internet		3.98	0.251256
gdppercapita		3.44	0.290698
-----+-----			
Mean VIF		7.59	

To test multicollinearity, which shows perfect relationships between more than two variables tested, I used the VIF function STATA provides to examine the tolerance rates of each variable. As seen above, for most of the variables we conclude that multicollinearity does not exist. *Time* and the interaction variable between *whitepop* and *poverty* are seen to have slight multicollinearity issues in the model; however, seeing that the tolerance level is not significantly less than 0.1, we can move forward with our analysis with little alterations.

4. Ramsey Test

The Ramsey Equation Specification Error Test (RESET) tests whether non-linear combinations of the fitted values help explain the dependent variable. If we find that non-linear combinations of our independent variables help explain the response variable, we can conclude that our data observes misspecification.

```
. ovtest
```

```
Ramsey RESET test using powers of the fitted values of logsuicide
Ho: model has no omitted variables
      F(3, 6) =      0.47
      Prob > F =      0.7117
```

As seen above, we can conclude that the model used in our regression is adequate regarding to the RESET diagnostic (p-value > 0.10).

5. Autocorrelation

Because the data utilized in our model is time-series, we tested for autocorrelation to find any omitted variable bias, misspecification, or systematic error in our measurements. To test this, I utilized the Durban – Watson Test.

```
. tsset time
      time variable: time, 1999 to 2018
            delta: 1 unit

. reg logsuicide internet educ blackpop whitepop white_pov black_pov poverty income
gdppercapita time
```

Source	SS	df	MS	Number of obs	=	20
Model	.491836741	10	.049183674	F(10, 9)	=	651.12
Residual	.000679836	9	.000075537	Prob > F	=	0.0000
				R-squared	=	0.9986
				Adj R-squared	=	0.9971
Total	.492516577	19	.025921925	Root MSE	=	.00869

logsuicide	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
internet	-.0005849	.0005226	-1.12	0.292	-.0017671	.0005973
educ	-.0119997	.0214146	-0.56	0.589	-.0604429	.0364435
blackpop	-.159399	.3472388	-0.46	0.657	-.9449078	.6261099
whitepop	.2031925	.1446588	1.40	0.194	-.1240483	.5304334
white_pov	-.0210954	.0118229	-1.78	0.108	-.0478407	.00565
black_pov	.0473912	.0303963	1.56	0.153	-.02137	.1161524
poverty	3.201594	1.645101	1.95	0.083	-.5198843	6.923072
income	2.35e-06	.0000149	0.16	0.878	-.0000313	.000036
gdppercapita	.0025883	.002626	0.99	0.350	-.0033521	.0085286
time	-.0895092	.0279551	-3.20	0.011	-.1527479	-.0262704
_cons	148.6867	44.77717	3.32	0.009	47.39366	249.9797

```
. dwstat
```

```
Durbin-Watson d-statistic( 11, 20) = 3.272159
```

Despite the limitations of this test, with a d-statistic interval of (11, 20) and a critical range of 0.178 – 2.914, we were able to fail to reject the null hypothesis that autocorrelation was present in our model.

Alternative Specifications

When controlling for the percent makeup of the United States of black and white racial groups and allowing suicides to represent the raw number of total self-inflicted mortalities, we see that the variable *internet* becomes significant at 5% with a negative coefficient of -34.55234; this implies with a 1 unit increase of internet users (1 million individuals), decreases suicides by 34 individuals.

```
. reg suicide internet educ blackpercentage whitepercent poverty income gdppercapita time
```

Source	SS	df	MS	Number of obs	=	20
--------	----	----	----	---------------	---	----

-----+-----					F(8, 11)	=	357.41
Model		694158065	8	86769758.1	Prob > F	=	0.0000
Residual		2670490.05	11	242771.822	R-squared	=	0.9962
-----+-----					Adj R-squared	=	0.9934
Total		696828555	19	36675187.1	Root MSE	=	492.72
-----+-----							
suicide		Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
-----+-----							
internet		-34.55234	8.261281	-4.18	0.002	-52.73529	-16.36938
educ		-999.5366	696.6246	-1.43	0.179	-2532.797	533.7237
blackpercentage		26443.06	10461.39	2.53	0.028	3417.697	49468.42
whitepercent		14044.54	8097.582	1.73	0.111	-3778.115	31867.2
poverty		-733.2006	351.0249	-2.09	0.061	-1505.801	39.40007
income		-.6012508	.3805153	-1.58	0.142	-1.438759	.2362578
gdppercapita		-23.13537	68.88433	-0.34	0.743	-174.7488	128.478
time		3722.336	2066.846	1.80	0.099	-826.7622	8271.434
_cons		-8793801	4674023	-1.88	0.087	-1.91e+07	1493655
-----+-----							

Also shown in the results, growing black and white racial groups both increase number of suicides in the United States compared to other national ethnicities. A 1% increase in black population stimulates 26,443 additional suicides while a 1% increase in white populations causes an increase of 14,044 suicides. Although large effects, both white and black population percentages are insignificant at all levels of testing (p-value > 0.01, 0.05, 0.10).

Conclusion and Policy Implications

In my initial Empirical model, internet usage did not increase national suicide rates due to insignificance in the United States from 1999 – 2018. This data was inconsistent with both Hagihara and Sedgwick which presented internet usage and social media does increase suicides. However, as noted in the alternative specifications, when controlling for racial percentages including black and white populations while also allowing suicides to be regressed in millions, we see a negative and statistically significant internet effect. The data tested in my alternative specifications conflicts with both Sedgwick and Hagihara as they observed positive effects of internet usage on suicide rates; however, this data supports Luis's evidence which states addictive internet usage does not raise suicide ideation. The implications of my research imply that internet usage may or may not affect suicide rates; if interpreting my alternative

specifications, it is viable to conclude that internet exposure may cause decreases in overall suicides in the United States.

Importantly, this data does not suggest perfect conditions and has specific limitations that are significant to note. Firstly, education data was formulated from observing individuals 25 years or older, we may be missing an important population below 25 years of age which may impact regression results. Furthermore, our analysis does not record digital harassment occurrences; this would be an interesting variable to include for other studies as literature suggests harassment to be an inducing factor for suicide in adolescence. Lastly, suicide data used in this study is a conglomerated total of registered suicides for the respected year, unreported data may alter the regression results and should be recorded for future research purposes.

Policies for suicide prevention are nonetheless important for government officials. The rate of suicide is increasing as stated in the opening paragraph of this research paper and stands to be a continuous concern for families. Although insignificant, the data revealed that growing black populations increase suicides in the United States more than white populations. A suggested characteristic of a policy would be to supplement prominently black communities with further suicide preventive measures such as “safe-spaces” (localized 24/7 offices to assist mentally distressed individuals), and specialized websites with live chat functions to assist any individual procuring suicidal thoughts. As seen in my alternative specifications, internet usage may in fact reduce the cause of suicidal ideation; policy officials should explore this phenomenon and further expand internet capabilities to less fortunate families which may not have the means to afford internet connectivity. As suicide remains a continuous issue, we must continue to research suicides in the United States as to slow its growth, this issue will continue entrench families if we are not to imply policies to assist them.

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