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UNIVERSITY OF CALIFORNIA SAN DIEGO

The Effect of Urbanicity and Region on Trends in Adolescent Suicide From 2007-2018.

A thesis submitted in partial satisfaction of the requirements for the Master's degree

in

Public Health

by

Devlin Kathleen Cole

Committee in charge:

Professor Richard Garfein, Chair
Professor Kimberly Brower
Professor Anita Raj

2020

The thesis of Devlin Kathleen Cole is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

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Chair

University of California San Diego

2020

DEDICATION

Twenty-six thousand nine hundred and thirty-three
adolescents committed suicide between 2007 and 2018.

This work is dedicated to every single teenager who took their own life.
You are not just a number in a database.
You are seen.
May we all work together to create a world that supports resilience in all children and adolescents, so that eventually this type of research will no longer be necessary.

EPIGRAPH

Only when we are brave enough to explore the darkness
will we discover the infinite power of our light.

Brené Brown

You may not control all the events that happen to you,
but you can decide not to be reduced by them.

Maya Angelou

As long as you are breathing there is more right with you than wrong with you,
no matter what is wrong.

Jon Kabat-Zinn

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ABSTRACT OF THE THESIS

The Effect of Urbanicity and Region on Trends in Adolescent Suicide From 2007-2018.

by

Devlin Kathleen Cole

Master's degree in Public Health

University of California San Diego, 2020

Professor Richard Garfein, chair

Background: In the United States, suicide is the second leading cause of death for adolescents ages 10-19, and adolescent suicide rates have been rising since 2007. Suicide rates in adolescents are higher in areas of lower urbanicity, but urbanicity is not evenly distributed across the U.S. Regional suicide differences have been found across the country, but no study has examined regional differences and the interaction with urbanicity. **Objective:** To compare the change in crude rates of suicide between populations of 10-19-year-old adolescents in three different levels of urbanicity with stratification by national region. **Methods:** Suicide rates were queried from the CDC WONDER database from 2007-2018 for 10-19-year-olds and stratified by collapsed urbanicity level based on the 2013 NCHS Urban-Rural Scheme for Counties. Linear regression analysis tested the impact of the interaction of region and urbanicity over time on

suicide rates and trends. **Results:** Overall, 26,933 adolescents committed suicide from 2007-2018. Suicide rates were highest in nonmetro areas, followed by medium/small metro and large metro areas respectively, and rates of rise were highest in nonmetro areas. Regional differences in suicide rates were found in each stratum of urbanicity, but trends in suicide rates did not significantly differ by region, though they did differ by urbanicity overall. **Conclusion:** A regional differences in suicide rates between metro levels and increasing suicide trends between metro areas suggests that more support is needed in nonmetro areas, especially in the West, to prevent further increase in suicide in adolescents.

Introduction

In the United States, suicide is the second leading cause of death for young people aged 10-19, and rates are currently on the rise.[1,2] Rates of suicide in the United States have historically been higher in nonmetro areas than metro areas, and rates of suicide are not equally distributed by region.[3–5] Males commit suicide at much higher rates than females, accounting for as much as 81% of the suicides in the 10- to 24-year age group.[6] Recently, in addition to increases in adolescent male suicide trends, adolescent female suicide trends have more than doubled from 2007, including the largest percentage increase in 10- to 14-year-old girls.[7]

Another risk factor that has shown to be increasingly related to the recent rise in suicide is urbanicity. The age-adjusted suicide rate in rural counties is 80% higher than that seen in urban counties, and the increase in suicides over the past two decades has been more than three times greater in rural relative to urban counties.[8] Surveillance data shows that adolescent suicide rates have been higher in areas with lower urbanicity in the United States since the 1990s.[6]

However, urbanicity is not evenly distributed across the country. Of all of the individuals living in rural areas, about 65% live east of the Mississippi River and almost half live in the South, accounting for almost 28 million people.[9] The proportion of people living in rural areas ranges by state from Maine and Vermont with 61% rural populations to California with only 5%.[9] Regional differences also exist in suicide rates across the U.S., with the West seeing the highest rates and the Northeast seeing the lowest rates.[4] However, regional differences in suicide and differences in suicide across urbanicity have not been explored together. Using CDC surveillance data from 2007-2018, this study examined effect of urbanicity, region, and the interaction between the two on the rates of suicide and suicide trends in 10-19-year-olds in the United States.[10]

Methods

Data Source

Within the CDC WONDER database, which provides public health information to health care professionals and the general public, multiple data files were queried from the "Underlying Cause of Death 1999-2018" dataset, specifically targeting youths aged 10-19 (in brackets 10-14 and 15-19).[11] Production of the dataset includes collaboration by the CDC, the U.S. Department of Health and Human Services, the National Center for Health Statistics, the Division of Vital Statistics, and the Mortality Statistics Branch.[11] These organizations gather morbidity data from Vital Statistics Cooperative, which includes 57 jurisdictions (50 states, 5 territories [Puerto Rico, U.S. Virgin Islands, Guam, American Samoa, and the Northern Mariana Islands], the District of Columbia, and New York City), based on the single cause of death and demographic information listed on death certificates.[11,12] Rates are calculated using county-level population estimates across the U.S.[11] Specifically, in the ninth editions of the International Classifications of Diseases (ICD-9, 1979-1998) suicide data is coded as E950-E959, and in the tenth editions of International Classifications of Disease (ICD-10, 1999-present) suicide data is coded as X60-X84, Y87.0 and U03, with a correlation between ICD-9 and ICD-10 of near 1.[13]

Variables

Initial information was stratified by year and U.S. Census region (Northeast, Midwest, South, and West), and three iterative queries produced data for each of the three metro strata. These metro levels were a consolidation of the 2013 NCHS Urban-Rural Scheme for Counties. This NCHS Urban-Rural Scheme was derived from definitions of metropolitan and micropolitan statistical areas produced by the Office of Management and Budget, based off of census data and

specifically engineered to aid studies of health disparities between metro areas.[14,15] "Large Central Metro" and "Large Fringe Metro" areas both have over 1 million people, with distinctions to separate inner city areas with surrounding areas,[14] and were collapsed together to create the large metro area dataset. "Medium Metro" areas, which have populations between 250,000 to 999,999 people, and "Small Metro" areas, which have populations less than 250,000 but above 50,000 people, created the medium/small metro area dataset. Lastly, "Micropolitan (non-metro)" and "NonCore (non-metro)" areas, the remaining counties with populations below 50,000 people, created the nonmetro dataset. All of the data was restricted to the years 2007-2018. Each query produced the number of suicides within the stratum, with an estimate of the population of that stratum based off of the U.S. Census Bureau estimates of resident populations at the county, state and national level, with most years being estimates of the July 1 resident population from previous census data and subsequent birthrates, and 2010 being April 1 modified census counts, with bridged-race categories.[14,16]

Analysis

Initially, three individual linear regression models were fit to each of the three metro level strata of the dataset without stratification by region to estimate the change in the suicide trend over time (Figure 1). Next, linear models were fit to each of the three metro strata of the dataset with additional stratification by region, for a total of 12 models estimating the suicide trends over time (Figures 2-6). In order to test for differences between slopes, a linear regression model was computed to estimate the effect of metro level, region, and any potential interaction on both the rate of suicide and the change in the trend of suicide rates, with 95% confidence intervals (95% CI). Terms included metro level, year with 2007 normalized to year 0, census

regions labeled 1-4, and an interaction term between metro level, region, and year. This analysis did not include stratification by gender or race because these categories produced suppressed data from the CDC WONDER database when queried simultaneously with other variables. An ANOVA was performed on this model, and a separate ANOVA was performed comparing this model to one without the interaction term to confirm the significance of the interaction term. All analyses were conducted using R (Version 3.6.2, 2019-12-12).

Results

Between 2007 and 2018, 26,933 adolescents aged 10-19 committed suicide (Table 1). Over the 12-year period, the number of suicides ranged from 2,873 in nonmetro areas to 6,271 suicides in large metro areas (Table 1). After accounting for population differences between metro areas, large metro areas had the lowest rate of suicides, and nonmetro areas had the highest rates (Figure 1). Differences in suicide rates in three metro levels were statistically significant (large metro vs. medium/small metro $p=0.01$; large metro vs. nonmetro $p<0.001$; medium/small metro – nonmetro $p<0.001$). In 2007, the rate of suicide for adolescents in nonmetro areas was already over 60% higher than in large metro areas and over 20% higher than rates in medium/small metro areas (Table 2). When further stratified by region, this pattern was preserved in 2007, with nonmetro areas seeing the highest rates of suicide and large metro areas seeing the lowest rates of suicide in all four regions (Figures 3-6). The difference between suicide rates in each metro level was most distinct in the West (Figure 6).

Over the 12-year time period, rates of suicide increased linearly for all three metro levels and within all four regions (Table 3). An ANOVA comparing interactions between year, metro level and region found interactions between year and metro level ($p<0.001$). Interaction between year and region was not quite significant ($p=0.06$). The model produced an R-squared value of 0.9264 (F-statistic = 65.69).

Both in nonmetro and in medium/small metro areas, the West had the highest rates of suicide. In large metro areas, the highest rates of suicide were in the Midwest. However, the distinction between regional rates was more marked in nonmetro areas, with the West statistically different than all other regions ($p<0.001$). Nonmetro areas had strong regional distinction, seeing even the second highest rates in the Midwest significantly higher than the two

lower levels, the South (p=0.02) and the Northeast (p=0.004). In the medium/small metro areas, the West was significantly higher than the two areas with the lowest rates, the South (p=0.05) and the Northeast (p=0.02). In large metro areas, the highest rates in the Midwest were only statistically different from the lowest rates of suicide in the Northeast (p=0.03).

When comparing all three metro levels within a single region, the West and Midwest again showed significant differentiation, with the nonmetro areas seeing the highest rate of suicide and the large metro areas seeing the lowest rates of suicide in these regions and all three levels with significant differences (Table 3). The northeast also had a significant distinction between the highest rates of suicide in the nonmetro areas and the lowest rates in the large metro areas (p=0.02).

The ANOVA did not show a significant interaction between year, metro level and region together, though there were some individual differences found between trends in suicide rates between specific metro levels and regional combinations. The nonmetro Western area, which already had the highest rate of suicide in 2007, saw the fastest rate of rise over the 12-year period (Figure 2), significantly faster than the slowest rates of rise in nonmetro areas in the South (Table 5). And in the medium/small metro area, the Midwest saw the fastest rate of rise in suicide, significantly different than the slowest rate of rise in the Northeast (Table 4). Comparing trends in suicide rates between metro levels within regions, both the West (Figure 6) and the Northeast (Figure 3) had the highest rates of rise in the nonmetro areas (Table 5).

Discussion

Suicide rates among 10- to 19-year-olds in the United States between 2007 and 2018 were consistently higher in nonmetro areas compared to large metro and medium/small metro areas. Medium/small metro areas also experienced consistently higher rates of adolescent suicide between 2007 and 2018 compared to large metro areas. In addition to the baseline difference, suicide rates rose fastest in nonmetro areas, suggesting a continuing exaggeration of the disparity. In addition to these nationwide urbanicity trends, exploring the effect of urbanicity within each region can help to expose at-risk populations that may not have been identified in analysis of urbanicity-based or regional suicide variation alone.[4] The Midwest saw the highest rates of suicide among the large metro areas, which was unexpected based on previous observations of regional suicide rates. The West experienced higher rates of suicide in nonmetro and medium/small metro areas than all other regions.[17]

Trends in changes in rates of suicide were relatively stable across the various urbanicities and regions, which was supported by a lack of significant interaction term in the ANOVA. However, trends like the high rate of rise in Northeastern nonmetro areas are nevertheless concerning, especially considering the high proportion of rural populations in some Northeastern states.[9] And again, trends in suicide rates in the nonmetro West were highest of the all of the nonmetro regions, compounding a baseline disparity.

Urban-rural disparities potentially increase risk of suicide through multifactorial means. Though healthcare coverage in nonmetro areas has increased to rates much closer to metro areas in the past decade, there are huge shortages of providers in nonmetro counties, especially mental health providers, with 65% of nonmetro counties without a psychiatrist in 2018 compared to 27% of metro counties.[18] Changing economic environments could also contribute to suicide

disparities in different metro areas. After the great recession in 2008, nonmetro employment has continued to increase more slowly than in metro areas, potentially contributing to more stress at home and less available resources.[19] Lack of nonmetro area jobs could also impact social isolation, which is associated with increased risk of suicide.[20] Increased mobility in modern times has encouraged adolescents to move to metro areas for employment, potentially further isolating peers, and even siblings, left behind.[21]

Geographic isolation may also compound social isolation. Nonmetro counties account for 69% of all counties in the West, second only to the 71% of counties in the Midwest, both higher than the national average of 63%.[17] Adolescents in these areas face transportation challenges,[6] and may utilize smart devices and social media more heavily, which has been shown to be associated with rising adolescent rates of suicide, even when compared to economic markers.[22] Worldwide, the number of internet users has been positively correlated with higher rates of suicide, with potential risks of increasing suicide ranging from information on methods of suicide, cyberbullying and support from other suicidal individuals, even leading to suicide pacts.[23,24]

While lack of mental health providers and geographic isolation potentially contribute to increased suicide risk for adolescents, those factors can also pose challenges to delivering preventive interventions to this population. School-based programs offer a structure that provides easy access to adolescents and frequent contact for implementation, observation and follow up. Schools give the widest access to this population, especially in rural areas where there is limited access to mental health resources and there may not be as many structured community activities outside of school.

Programming at schools are easily gender inclusive, and provide skill sets like resilience that are beneficial regardless of traditional suicide risk factors like self-harm and previous attempts,[25] alcohol and drug use which have recently been declining,[26–28] and gender-divided factors like externally-focused conduct disorders and deviant behavior in males and internally-focused PTSD, eating disorders, and depressive symptoms in females.[29,30] Potential interventions need to focus on specific internal and external protective factors, especially ones demonstrated by literature to help decrease suicidality, like self-esteem, self-efficacy, connectedness, physical activity, and mindfulness.[31–35] Physicans and school officials are poised to make a tanglible difference in the lives of students as school returns to in-person learning after the Sars-CoV-2 pandemic, in particular in nonmetro counties across the United States and especially in the West.

Limitations

Major limitations exist when studying suicide rates, most importantly the dependence on coroner reports to correctly identify suicidal intent, which may lead to underreporting. This can be difficult, especially in an impulsive age group like adolescents, where unintentional injury is the leading cause of death.[1] It is also limiting to only use death records when estimating suicide risk, since some studies estimate suicide attempts to completions in populations to be as high as 20:1.[36]Further limiting analysis, the CDC WONDER database suppresses results when the number of suicides in a stratum falls below 10 in order to keep the data deidentified. This limits the number of factors that can be assessed at one time in a linear model before data imputation is required to correct for the missing small cells. This study could not additionally stratify by gender, age group (10-14 vs. 15-19) or race because of limitations in analysis due to suppressed data.

Conclusion

Rates of suicide in adolescent populations are rising, and nonmetro areas are seeing higher rates and a faster rate of rise than metro areas. The West already has the highest nonmetro rates, and rates are rising most steeply there. The Midwest had the highest rates of suicide among large metro areas, and nonmetro areas of the Northeast had significantly higher trends compared to large and medium/small metro areas, which potentially could have been overlooked by more general regional studies without combined region and urbanicity analysis. These disparities need to be addressed immediately, especially given the likelihood that the Sars-2-CoV pandemic in 2020 will exacerbate factors contributing to increases in suicide, like isolation and social media use. More focused studies, especially in these areas, are needed to better understand risk factors and inform interventions.

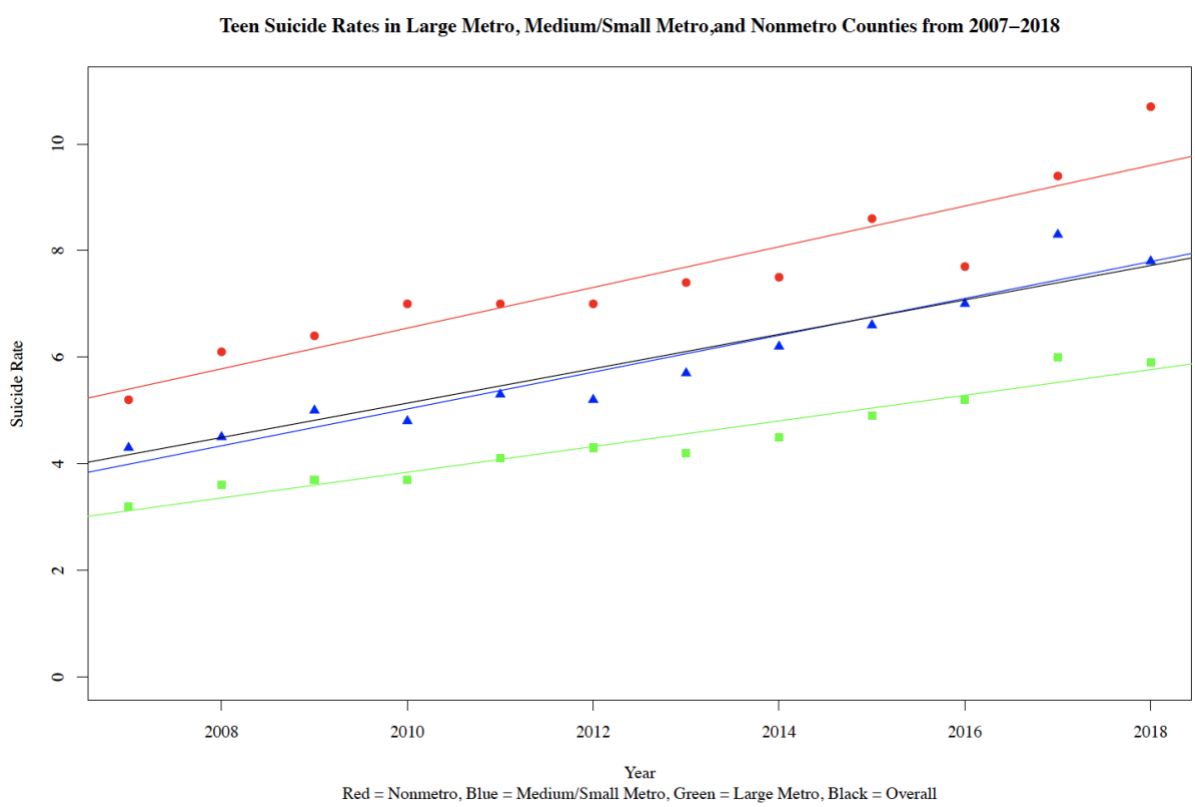

Figure 1. Teen Suicide Rates in Large Metro, Medium/Small Metro, and Nonmetro Counties from 2007 to 2018. Each line represents a separate linear model based on one metro-level stratum of the dataset.

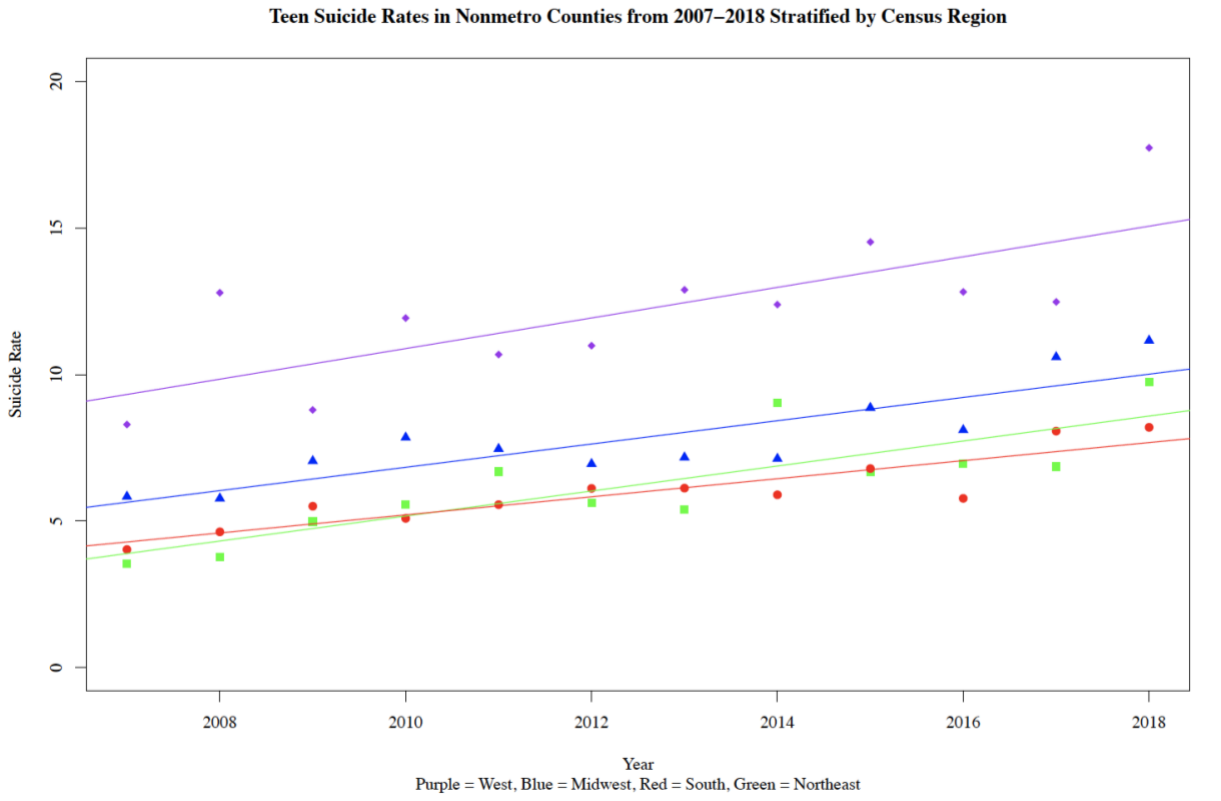

Figure 2. Teen Suicide Rates in Nonmetro Counties stratified by the four US Census Regions from 2007 to 2018. Each line represents a separate linear model based on one metro-level stratum of the dataset.

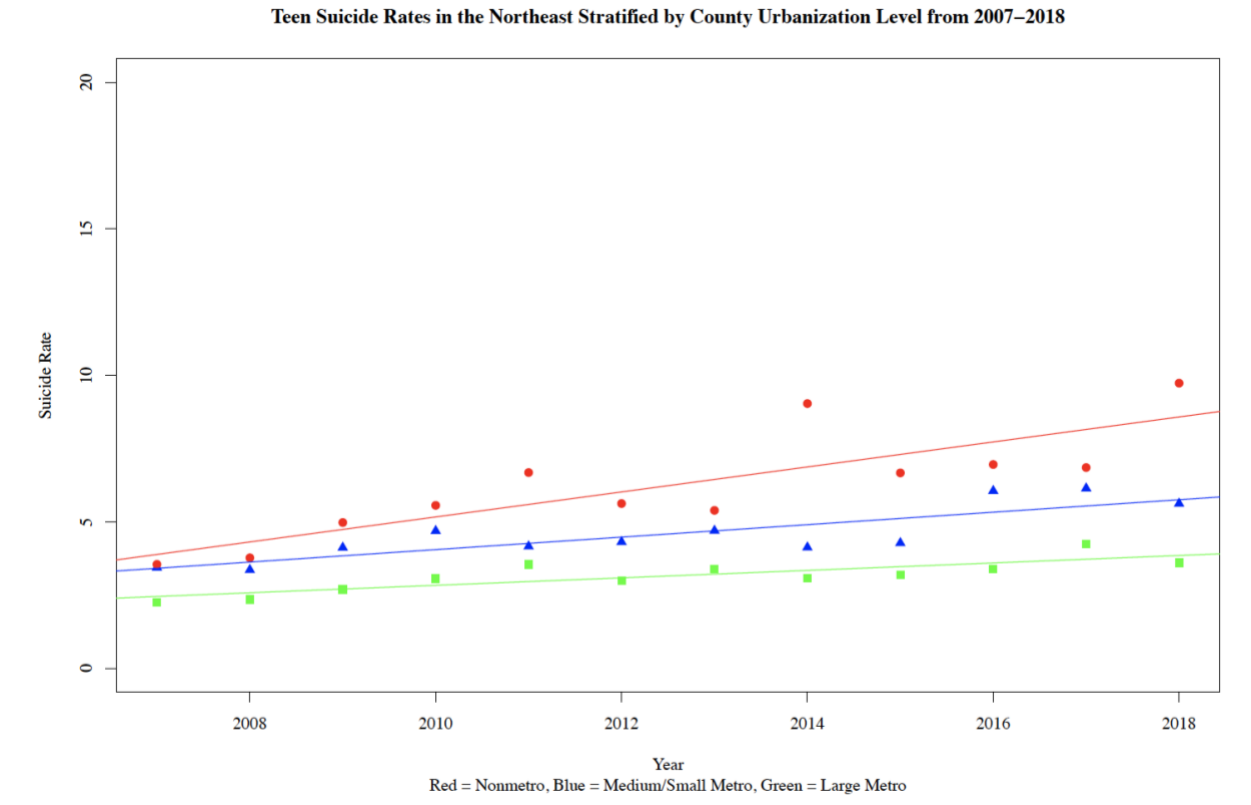

Figure 3. Teen Suicide Rates in the Northeast Stratified by Large Metro, Medium/Small Metro, and Nonmetro Counties from 2007 to 2018. Each line represents a separate linear model based on one metro-level stratum of the dataset.

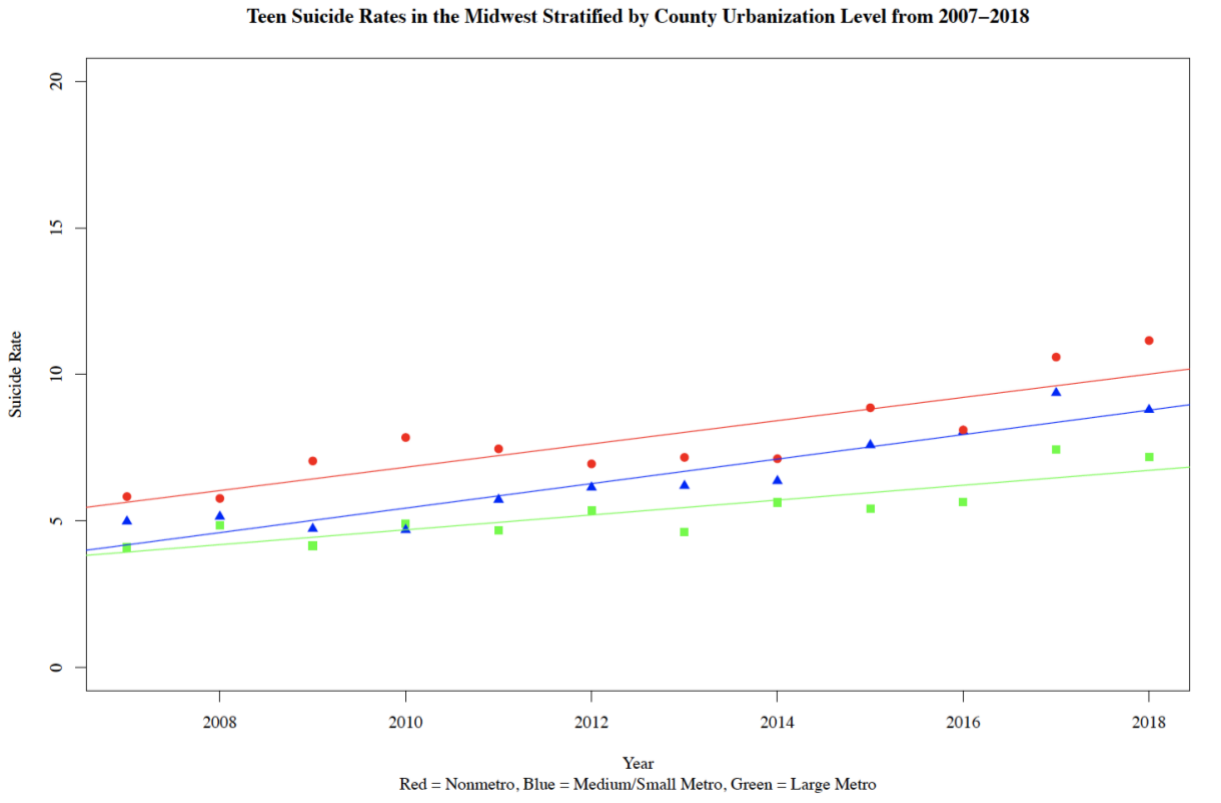

Figure 4. Teen Suicide Rates in the Midwest Stratified by Large Metro, Medium/Small Metro, and Nonmetro Counties from 2007 to 2018. Each line represents a separate linear model based on one metro-level stratum of the dataset.

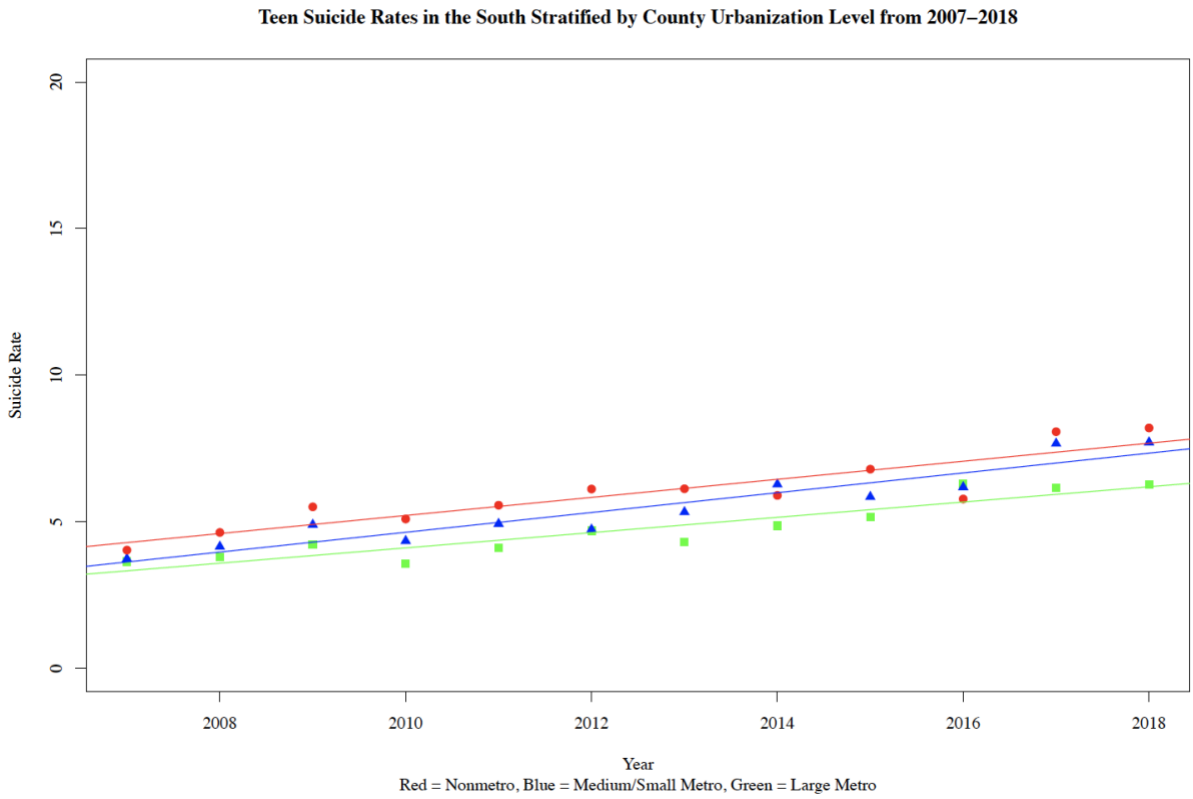

Figure 5. Teen Suicide Rates in the South Stratified by Large Metro, Medium/Small Metro, and Nonmetro Counties from 2007 to 2018. Each line represents a separate linear model based on one metro-level stratum of the dataset.

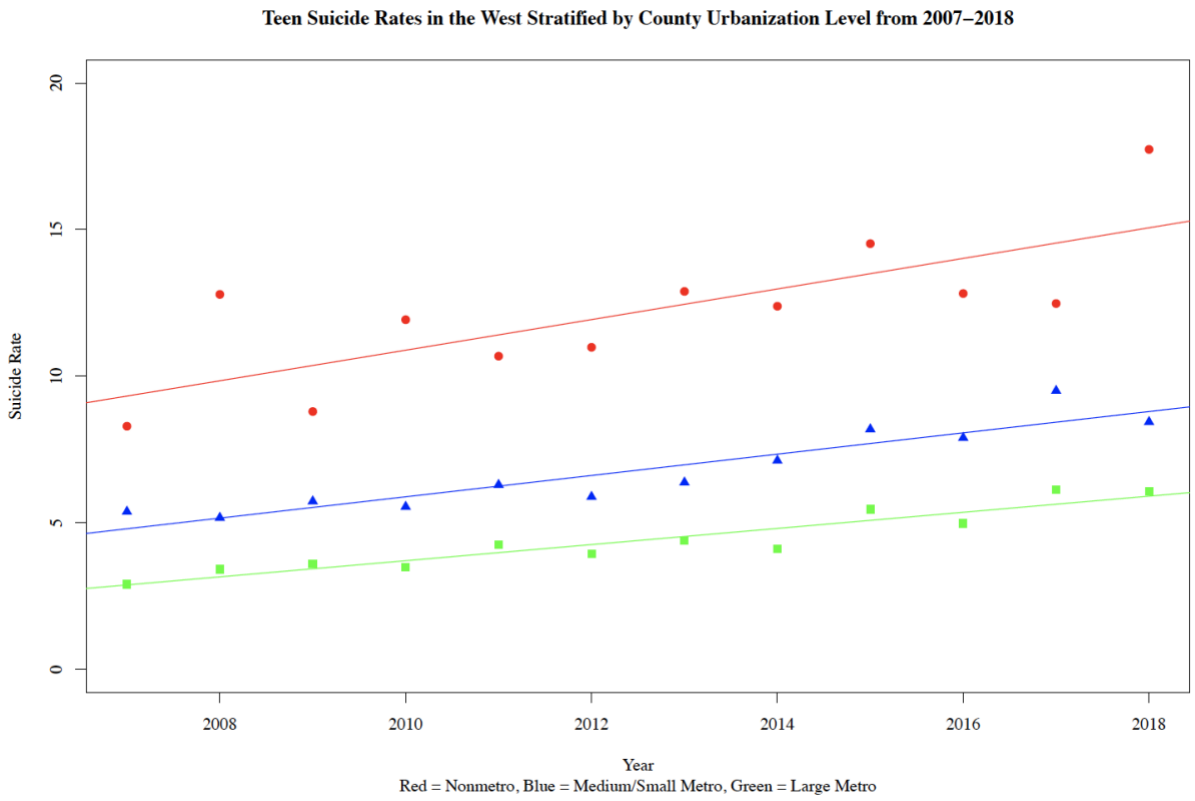

Figure 6. Teen Suicide Rates in the West Stratified by Large Metro, Medium/Small Metro, and Nonmetro Counties from 2007 to 2018. Each line represents a separate linear model based on one metro-level stratum of the dataset.

Table 1. Populations of 10-19-year-old adolescents living in Large Metro, Medium/Small Metro and Nonmetro counties in the US from 2007-2018 and the crude number of suicides in this population during that time period.

	Year	2007	2008	2009	2010	2011	2012	2013
Large Metro	Suicides	759	844	875	867	964	991	971
	Population	23,414,809	23,469,359	23,479,397	23,442,252	23,268,615	23,187,074	23,095,371
Medium/Small Metro	Suicides	567	586	646	619	686	670	722
	Population	13,039,141	13,053,610	13,046,524	13,008,030	12,907,590	12,776,338	12,727,468
Nonmetro	Suicides	335	389	407	440	434	427	441
	Population	6,454,908	6,394,566	6,327,453	6,267,255	6,172,690	6,066,508	5,986,579

	Year	2014	2015	2016	2017	2018	Total
Large Metro	Suicides	1,028	1,130	1,214	1,397	1,366	6271
	Population	23,096,196	23,115,125	23,131,632	23,235,073	23,256,706	
Medium/Small Metro	Suicides	787	834	888	1,058	1,007	4496
	Population	12,707,739	12,718,957	12,742,295	12,813,271	12,868,121	
Nonmetro	Suicides	447	506	451	553	627	2873
	Population	5,935,218	5,897,151	5,874,305	5,861,770	5,851,921	

Table 2. Suicide rates for adolescents stratified by Large Metro, Medium/Small Metro and Nonmetro counties in the US by year from 2007-2018 and the slope, 95% CI, and p-value produced by three linear regression models.

	2007	2008	2009	2010	2011	2012	2013	2014
Large Metro	3.2	3.6	3.7	3.7	4.1	4.3	4.2	4.5
Medium/Small Metro	4.3	4.5	5	4.8	5.3	5.2	5.7	6.2
Nonmetro	5.2	6.1	6.4	7	7	7	7.4	7.5

	2015	2016	2017	2018	Slope	P-value
Large Metro	4.9	5.2	6	5.9	0.241 (0.196-0.286)	<0.001
Medium/Small Metro	6.6	7	8.3	7.8	0.346 (0.274-0.418)	<0.001
Nonmetro	8.6	7.7	9.4	10.7	0.382 (0.272-0.492)	<0.001

Table 3. Slopes of the linear regression models representing the trend in suicide rates per 100,000 people per year, stratified by 4 major census regions, with 95% confidence intervals and significance testing of the fit of the individual regression models.

	Northeast		Midwest		South		West	
	Slope (95% CI)	P-value	Slope (95% CI)	P-value	Slope (95% CI)	P-value	Slope (95% CI)	P-value
Large Metro	0.127 (0.067-0.187)	<0.001	0.253 (0.148-0.359)	<0.001	0.261 (0.187-0.335)	<0.001	0.275 (0.206-0.345)	<0.001
Medium/ Small Metro	0.213 (0.114-0.311)	<0.001	0.418 (0.309-0.527)	<0.001	0.338 (0.253-0.422)	<0.001	0.364 (0.262-0.465)	<0.001
Nonmetro	0.427 (0.224-0.629)	<0.001	0.397 (0.231-0.564)	<0.001	0.308 (0.202-0.415)	<0.001	0.522 (0.204-0.840)	0.004

Table 4. Differences in suicide rates for adolescents stratified by Large Metro, Medium/Small Metro and Nonmetro counties and by four major Census regions in the US between 2007-2018. NE = Northeast, MW = Midwest, S = South, W = West, ns = not significant

Differences in Suicide Rates by US Region		Large Metro				Medium/Small Metro				Nonmetro			
		NE	MW	S	W	NE	MW	S	W	NE	MW	S	W
Large Metro	NE		p=0.01	ns	ns	ns				p=0.02			
	MW	p=0.01		ns	ns		ns				p=0.005		
	S	ns	ns		ns			ns				ns	
	W	ns	ns	ns					p=0.001				p<0.001
Medium/ Small Metro	NE	ns					ns	ns	p=0.02	ns			
	MW		ns			ns		ns	ns		p=0.01		
	S			ns		ns	ns		p=0.05			ns	
	W				p=0.001	p=0.02	ns	p=0.05					p<0.001
Nonmetro	NE	p=0.02				ns					p=0.004	ns	p<0.001
	MW		p=0.005				p=0.01			p=0.004		p=0.02	p<0.001
	S			ns				ns		ns	p=0.02		p<0.001
	W				p<0.001				p<0.001	p<0.001	p<0.001	p<0.001	

Table 5. Differences in suicide trends for adolescents stratified by Large Metro, Medium/Small Metro and Nonmetro counties and by four major Census regions in the US between 2007-2018. NE = Northeast, MW = Midwest, S = South, W = West, ns = not significant

Differences in Suicide Trends by US Region		Large Metro				Medium/Small Metro				Nonmetro			
		NE	MW	S	W	NE	MW	S	W	NE	MW	S	W
Large Metro	NE		ns	ns	ns	ns				p=0.001			
	MW	ns		ns	ns		ns				ns		
	S	ns	ns		ns			ns				ns	
	W	ns	ns	ns					ns				p=0.008
Medium/ Small Metro	NE	ns					p=0.03	ns	ns	p=0.02			
	MW		ns			p=0.03		ns	ns		ns		
	S			ns		ns	ns		ns			ns	
	W				ns	ns	ns	ns					ns
Nonmetro	NE	p=0.001				p=0.02					ns	ns	ns
	MW		ns				ns			ns		ns	ns
	S			ns				ns		ns	ns		p=0.02
	W				p=0.008				ns	ns	ns	p=0.02	

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