Time Zone Lines and Suicides: West Side Story

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Abstract: Suicide is a major cause of death in the USA and worldwide. There is a puzzle over the influence of sunlight on suicides that dates back to 1897: On the one hand, lack of sunlight is linked to seasonal affective disorder, and thereby more suicides. And yet curiously, the suicide rate peaks in spring/summer and midday. This paper sheds light on this debate, identifying the separate role of sunlight, as opposed to cultural influences on suicides.

I compare the suicide rates of counties along the three major time zone lines in the USA. Using a random effects panel regression, I show that a short move to the west side of any time zone line significantly inflates the suicide rate by about 10%. Beyond the scientific value for epidemiology, these results have economic ramifications for location choices, and raise questions about current time zone placements.

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1. Introduction

Suicide is a major cause of death in the USA and worldwide, and affects adult of all ages, and so is obviously of enormous economic importance (see Hamermesh (1974)). There is a longstanding puzzle in the psychiatric and epidemiological literature over the influence of sunlight on suicides, dating far back to Durkheim (1897):[2] On the one hand, lack of sunlight may lead to seasonal affective disorder and thereby more suicides, perhaps by way of a biochemical avenue, such as depressing serotonin hormonal levels.[3] On the other hand, the suicide rate peaks in spring and summer, and midday rather than nighttime.

But these observations cannot resolve the debate about the role of sunlight. For there is a myriad of differences – physical, cultural or emotional – between the seasons of the year, or the times of the day. For instance, spring and summer mark the end of school, or a time to relax after a winter of hard work, and ponder or experience vacation idleness. More practically, there are simply far more people awake, and thus even able to commit suicide, in day-time than night-time. Such seasonal or diurnal associations may drive the suicide rate, swamping the independent effect of sunlight. Disentangling them seems impossible. In this paper, I offer a way to identify the separate role of sunlight, as opposed to other confounding influences on suicides. I exploit a long-standing natural experiment in how we measure time: the existence of time zone boundaries.

I explore the suicide rates by white males among the north-south ribbon of counties adjacent to the three time zone lines within the USA. I calculate the suicide rate along each time zone line over the years 1979-2006. I find that living on the west side of any such boundary significantly raises one's suicide rate by about 8-10%. I deduce this first in a linear regression over counties and years, and then in a random effects panel of the counties. The cumulative effect of this suicide rate shift in my twenty-eight year data set is quite substantial: about 1500 excess suicides with the current time zone placement, as opposed to shifting each line one county to the west. This ignores lives saved from more radical movements of these lines.

There is reason to believe that the shifts across time zone boundaries should affect the amount of sunlight experienced. Those living west of any time zone line receive one less hour of light at night, compensated by an extra hour of light in the morning. This tradeoff is *not* neutral. For most people typically rise very soon after sunrise, but go to sleep long after sunset. This asymmetry suggests that a shift of one hour of light from morning to night should *not* be neutral. Consider the following data from the American Time Use

[2] Later on, see Lester and Funk (1988) and Dublin (1963).

[3] Serotonin is linked to good mental health. See Lambert et al., (2002).

Survey[4] for the fraction of adults asleep at various times of the day, in 2005-2009.

12 AM	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM
82.5	90.2	93.5	94.7	91.7	85.3	65.4	41.4	24.1	13.5	7.6	4.9
12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM
3.6	4.2	4.3	4.1	3.7	3.0	2.6	2.8	5.0	14.2	36.7	64.8

Next, consider the sunrise and sunset times at the time shift days in Chicago – a city on a time zone boundary. Sunrise on March 13, the day before DST, was at 6:06AM, a time when 65% of the population was still asleep. Sunset occurred at 5:55PM, or about four hours before a comparable percentage of Americans would be asleep. Crossing just to the east side of the time zone line would raise the nighttime sunlight hours of 97.5% of Chicago adults, but lessen the morning hours of only 25%. Thus, far more people are awake and thus darkened by the nighttime one-hour light reduction moving west of a time zone line than are helped by the equivalent morning increment.

The influence of sunlight on the suicide rate continues to be the subject of much work. Gallerania et al (1996) find a significant peak in the late morning to early afternoon hours, and several other papers have since agreed, with qualification controlling for the mode of suicide.[5] On the seasonal front, revisiting earlier work by Lester (1971), Lambert (2003) found a clear summer suicide peak in Australia, when sunlight clearly also peaks. Petridou et al (2002) ambitiously survey the twenty-nine OECD countries, and find that the maximal suicide rate occurs near the maximum monthly sunshine levels. They conclude that: "These findings indicate that sunshine may have a triggering effect on suicide, and suggests further research in the field of sunshine-regulated hormones, particularly melatonin." But is this sunlight "trigger" conclusion fully justified?[6] This paper suggests that the sunlight per se might not be causal. For the cultural and emotional associations of summer are arguably similar throughout the OECD countries, and thus a cross-sectional survey cannot control for this. Could such other factors that are co-present with the sunshine peaks actually be the "triggerman" in this suicide link?

[4] The source is the BLS web site www.bls.gov/tus/tables/a3_0509.htm

[5] See Williams and Tansella (1987) and Preti and Miotto (2001).

[6] Preti and Miotto (1998),

2. Research methodology

A. Data

I have gathered county-level data from the *compressed mortality files* accessed via the CDC WONDER website. This includes age-adjusted suicide rates for 1979-2006 disaggregated by, eg., place of residence, "age group" (twelve in total), race, gender, and underlying cause of death. Beginning in 1989, major additional confidentiality restrictions apply to the compressed mortality files: If a county's population falls below 100,000 (in the last decadal census), then death counts of five or less are not shown unless three or more years of data are combined, or counties are merged.

Suicide rates vary significantly by age, gender and race. For instance, the CDC *Fact Sheet* reveals that males commit suicide almost four times as often as females. Also, adult suicide rates generally rise by age. I therefore restrict focus to the largest class of suicides, namely, white males. And, as noted, the CDC suicide rates are age-adjusted.

I restrict focus to the 177 counties adjacent to the three major north-south time zone boundaries strictly inside the contiguous 48 states – namely, the Pacific-Mountain time zone boundary (denoted PT/MN), Mountain-Central time zone boundary (MN/CT), and Central-Eastern time zone boundary (CT/ET). This No counties in the data set were sliced by either time zone line. All told, the included counties had an average population of 30,861 in the time-span, totaling approximately 5.5 million people. So this amounts to a little over 5% of the counties nation-wise, with almost 2% of the population. The average age-adjusted suicide rate for these counties was 30.11 per 100,000 from 1979 to 2006. In this time span, there were a total of 14,816 suicides.

B. Weighted Least Squares

For a first pass-through, I explore the effect of living on the west side of a time zone boundary using a benchmark (weighted) ordinary least squares linear regression (WLS). Indeed, since realized suicide rates in larger counties are more reliable indicators of an underlying rate, each observation must be weighted by the square root of the population of the county in question. When the CDC suppressed suicide data for a county, I merged that county with an adjacent one, or possibly two counties, such that data for that possibly merged "county unit'' was not suppressed for any of the years 1979-2006.[7] There are 82 county units observed over twenty-seven years, for a total of 28×82=2296 observations.

[7] The CDC released death counts of less than five with merged counties. The suppression rule was unclear, and sometimes counties with a unique suicide were not suppressed.

I regress the age-adjusted suicide rates for all observations against a 0-1 indicator variable for whether the county lies on the west-side of that boundary, and a control indicator variable for the time zone. I also tested the major other intuitive explanatory variables discussed in the suicide literature, such as percent of "households living alone" (known as HHD), gun ownership rates, percent attending church, or percent living with kids.[8] Only the first variable HHD was significant in the WLS regression, and so is included in results below.[9] For the WLS regression, I estimated

$$Y_i = a + cW_i + b'Z_i + dH_i + e_i/\sqrt{N_i}$$

Here $W_i = 1$ indicates being just west of the time zone line; $Z_i' = (Z_i(1), Z_i(2))$ is a 0-1 vector, where $Z_i(1)=1$ indicates the CT/ET boundary, $Z_i(2)=1$ indicates the MT/CT boundary, and otherwise, the county unit lies along the PT/MN time zone boundary; H_i is the percent living alone in county unit i; N_i is the population of county unit i. In this regression, I found that HHD is barely not significant, with a t-statistic t=1.88. So I then re-ran the regression without including HHD, and found that all coefficients remained extremely close with almost unchanged significance. Table 1 summarizes the findings.

Table 1: Weighted Least Squares Linear Regression. Suicide rates are per 100,000.

	Coefficient	Standard deviation	t-statistic
Intercept	a=30.6	S = 0.59	t = 51.23
West Side of a Time Zone Line	c=2.28	s = 0.49	t = 4.66
CT/ET	b_1=-7.9	s = 0.59	t = -12.16
MT/CT	b_2=-8.5	s = 0.94	t = -9.04

The controls for the time zones incorporate an unknown assortment of cultural, sociological, geographical and other factors unique to that region that may influence suicide. Manifestly, the suicide rates along the eastern two time zone boundaries is lower

[8] The U.S. Census has data for HHD as well as percent of families with kids for the 1990 and 2000 decadal censuses. I found church attendance rates in the Association of Religion Data Archives at www.thearda.com. I found gun ownership rates only by state in

[9] Specifically, HHD by county was only available for the 1990 and 2000 decadal censuses. Thus, I used the 1990 numbers for pre-1990 years, the 2000 numbers for post-2000 years, and used the linearly interpolated the HHD percentages for the years 1990-2000.

by about 25% than along the Pacific/Mountain border. This is consistent with the national suicide rate maps[10] showing elevated suicide rates in the Western desert and plains states.

On the other hand, moving from the east to the west side of the time zone is extremely significant (t=4.66). The regression coefficient suggests that shifting residence one county west reduces the suicide rate by 2.28 per 100,000, or by about 9%. Cumulatively, such a change would add up. In the twenty-seven year data set, the regression suggests a saving of nearly 1500 lives from a one-county westward shift of the three time zone lines.

C. Panel Data Analysis

The above WLS regression analysis ignores the possibility of unobserved fixed effects specific to each county-unit over the twenty-seven years. It is therefore natural to question whether the previous linear regression possibly overstated the significance of West, since it treats possibly correlated county observations in separate years as independent. To account for the "unobserved" heterogeneity of each county, I now re-run the regression as a panel with observations from the 82 merged county units.

Because the key explanatory variables – namely, the indicator dummies for the time zone and the "west" parameter are time invariant – I must employ the random effects model; as is well-known, this is like a regression with a random constant term. As in the linear regression benchmark, I first included HHD; this time, it is even less significant (the t-statistic is t=1.3). I then re-run the panel regression, suppressing the HHD variable.

$$Y_i = a_i + cW_i + b'Z_i + e_{it} + v_i$$

I use in particular, a maximum likelihood estimation, with all variables weighted by the square root of county population, as in WLS. I find that the earlier regression results based on WLS are robust here. Naturally, the significance of west side drops, but it is still extremely significant (t=3.07), with an extremely small p-value of about 0.0015.

Table 2: Panel Regression. Suicide rates are per 100,000.

	Coefficient	Standard deviation	t-statistic
Intercept	a=30.4	s= 0.97	t = 31.32
West Side of a Time Zone Line	c=2.43	s = 0.79	t = 3.07
CT/ET	b_1=-7.68	s = 1	t = -7.26
MT/CT	b_2=-8.4	s = 1.5	t = -5.45

[10] See www.cdc.gov/violenceprevention/suicide/statistics/suicide_map.html and Figure 1 later.

3. Discussion of Results

In this paper, I have shown that evidence of suicide rates from counties lying adjacent to time zone lines strongly suggests that we rethink the role of sunshine. To my knowledge, no one has previously thought of using the discontinuities of time zone boundaries to separately identify this suicide link. Since the finding is so significant (to 99.85%), it is natural to look for differences aside from daylight that might be driving the importance of time zone lines. But a priori, no other case is obvious: For the three north-south time zone lines separate immediately adjacent counties with arguably similar suicide causes: urbanization, religiosity, attitudes to guns, etc. All these controls were insignificant. Still, since this paper stands against a large literature, I hope that more research can better elucidate this debate.

Overall, I argue that sunlight does not indeed *by itself* reduce the suicide rate. This means, for instance, that searching for a melatonin-suicide link is not a fruitful course of action. Still, since it is obviously infeasible to change the seasons or times when sunlight peaks, one may still view my finding of purely theoretical *economic* interest. But I argue more strongly that this is of real *economic* import too. For since the time zone control instrument is itself man-made, its choice has major policy ramifications. For these results suggest that suicide reduction is a real and currently ignored consideration in the time zone choices.[11] Adjusting the boundaries could constitute a major life-saving policy change. [12]

[11] For instance, William Willett, who originally pushed for British Summer Time in a 1907 pamphlet, proposed 20 minute changes to move toward daylight saving time (see en.wikipedia.org/wiki/William_Willett).

[12] In the closest parallel that I have found, Kellogg and Wolff (2008), and Kotchen and Grant (2010) use Daylight Saving Time as a control, and argue that inflates electrical usages.

Figure 1: Geographic Trends in Suicide Rates.

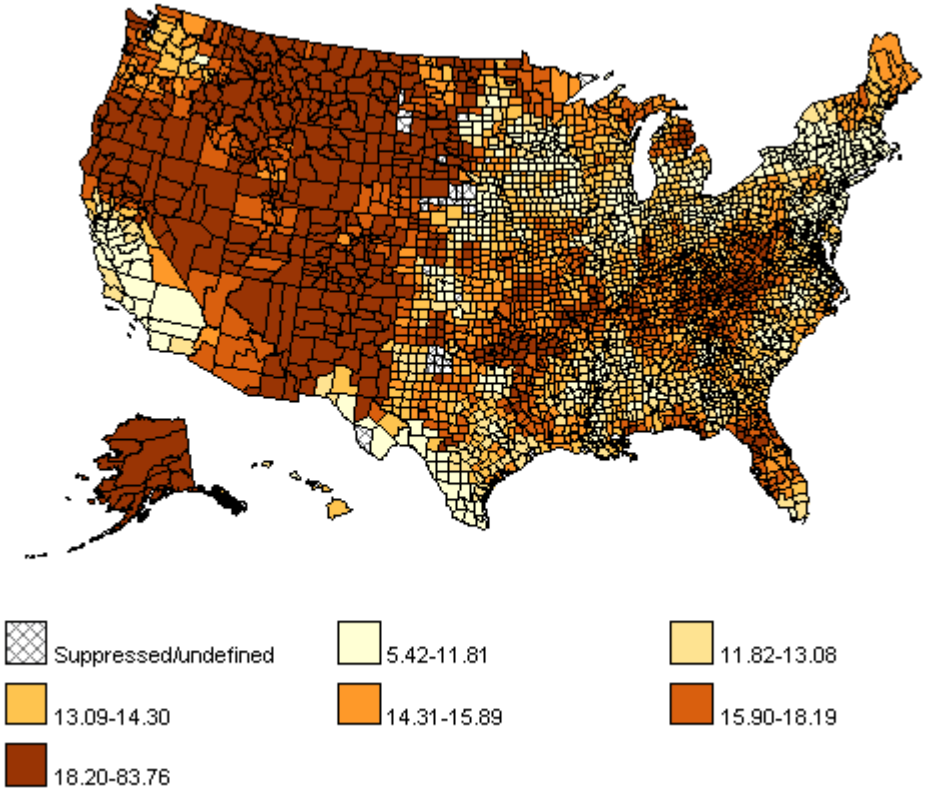
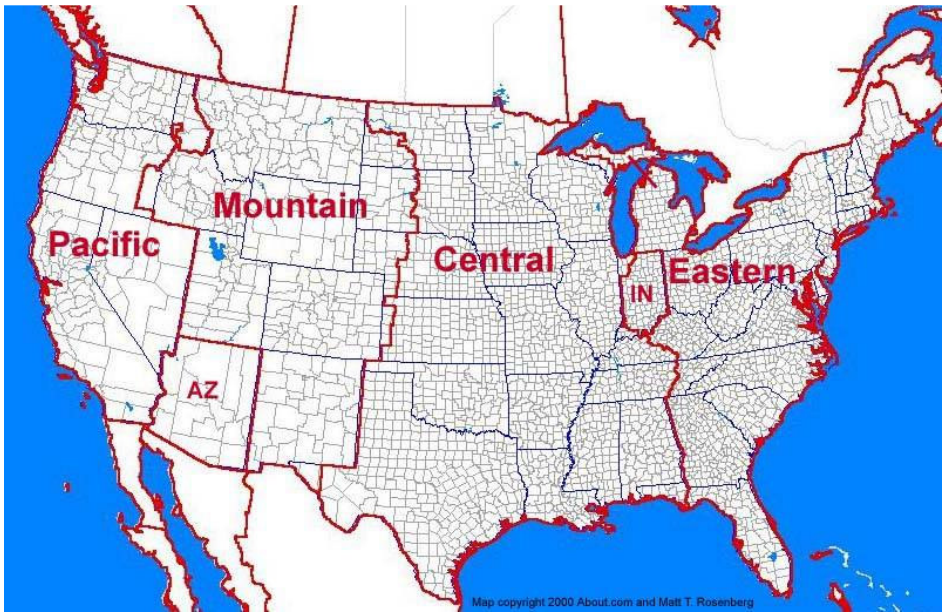


Figure 2: The Three Time Zone Lines



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