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Nocturnal Wakefulness: A Previously Unrecognized Risk Factor for Suicide

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Abstract

OBJECTIVE: Suicide is a major public health problem and the 10th leading cause of death in the United States. The identification of modifiable risk factors is essential for reducing the prevalence of suicide. Recently, it has been shown that insomnia and nightmares significantly increase the risk for suicidal ideation, attempted suicide, and death by suicide. While both forms of sleep disturbance may independently confer risk, and potentially be modifiable risk factors, it is also possible that simply being awake at night represents a specific vulnerability for suicide. The present analysis evaluates the frequency of completed suicide per hour while taking into account the percent of individuals awake at each hour.

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METHODS: Archival analyses were conducted estimating the time of fatal injury using the National Violent Death Reporting System (NVDRS) and the proportion of the American population awake per hour across the 24 hour day using the American Time Use Survey (ATUS). The initial evaluation of the data took place from September 2013 to December 2014.

RESULTS: The mean incident rate from 06:00-23:59 was 2.2% +/−0.7%, while the mean incident rate from 24:00-05:59 was 10.3% +/− 4.9%. The maximum incident rate was at 2:00-2:59 (16.3%). Hour-by-hour observed values differed from those that would be expected by chance ($p<0.001$), and when 6-hour blocks were examined, the observed frequency at night was 3.6 times higher than would be expected by chance ($p<0.001$).

CONCLUSIONS: Being awake at night confers greater risk for suicide than being awake at other times of the day, suggesting disturbances of sleep or circadian neurobiology may potentiate suicide risk.

INTRODUCTION

Suicide occurs in both men and women, in most age groups, and in all socioeconomic groups and races[1]. The population trends suggest that completed suicide occurs most often in Non-Hispanic White men and among those aged 45-64, with an annual population prevalence of approximately 12 per 100,000 individuals[1]. The effort to understand why people die by suicide, and why so many others attempt suicide, requires the identification of risk factors that are associated with such behaviors. Recently, sleep disturbance has been identified as an indicator of risk for suicidal ideation, suicide attempts, and suicide. To date, there have been at least 40 studies that have evaluated the association of sleep disturbance and suicide[(e.g., 2-12)]. Pigeon et al.[5] recently conducted a meta-analysis of these studies and found that sleep disturbance was associated with an overall increased risk across suicide outcomes (RR=2.79, 95% CI=2.44-3.19). Insomnia, nightmares, and “other sleep disturbances” were found to have comparable risk ratios, overall (2.84, 2.61, and 2.72 respectively). Several recent epidemiologic studies add to the existing evidence base by providing information about how the specific subtypes of insomnia and sleep duration are associated with suicide. For example, Wojnar et al.[11] found that difficulty initiating sleep and difficulty maintaining sleep predicted suicidal ideation and planning, and difficulty maintaining sleep was associated with suicide attempts. Short sleep duration, while not an insomnia subtype per se, has also been found to be associated with suicidal ideation across several studies[(e.g., 13)].

It is possible that the association between sleep disturbance and suicide can be explained by factors independent of sleep. For example, variance accounted for by sleep disturbance may simply represent the effects of physiological, psychological, and/or social stressors that may not otherwise be adequately captured[5]. Yet another possibility is that sleep disturbance results in being awake at night, and it is the fact of being awake at night itself that confers risk. If this is the case, it would be expected that the incidence of suicide attempts and/or completed suicides should be elevated at night (during the circadian phase for sleep). To date, eight studies[14-21] have investigated the temporal patterning of suicide across the 24 hour day and found that the peak frequency for completed suicide occurs during the day. Although seminal, the above studies did not adjust for the proportion of the population

awake at each time interval. Since suicide represents an intentional behavior that can only be performed when awake, the population that is at risk of suicide varies by time of day. The present analysis evaluates the incidence of suicide by clock time while accounting for the proportion of the population that is likely awake at each given hour. The hypothesis for the present analysis is that, after accounting for the proportion of the population likely to be awake, suicide disproportionately occurs at night.

METHODS

Data Source

Two databases were used to evaluate the study hypothesis. The National Violent Death Reporting System (NVDRS, www.cdc.gov/violenceprevention/nvdrs/)[22] was used to investigate deaths by suicide by clock hour. The American Time Use Survey (ATUS, www.bls.gov/tus/data.htm)[23] was used to assess the proportion of the population that is awake by clock hour. Both databases are available to public access. The archival analysis project conducted here was reviewed by the University of Pennsylvania's Internal Review Board (IRB 815690).

The NVDRS dataset, compiled by the Centers for Disease Control and Prevention (CDC), includes details on violent deaths from 18 participating US states[22]. The data for the present study included the years 2003-2010. The four major sources of data include death certificates, reports from the coroner and/or medical examiner, reports from law enforcement agencies, and reports from crime laboratories. For the present analyses, all the available data regarding estimated time of fatal injury data were obtained from the database, regardless of method or situational factors. In addition to estimated time of fatal injury, several other variables were extracted from the NVDRS database including: estimated time of fatal injury, age, sex, race/ethnicity (Non-Hispanic White, Black/African-American, Hispanic/Latino, Asian, and Other), and mood status ("current depressed mood")[22]. Estimated time of fatal injury was binned in 1-hour segments (0:00-0:59, 1:00-1:59, 2:00-2:59, etc.) and also arrayed in six hour bins categorized as "night" (0:00-5:59), "morning" (6:00-11:59), "afternoon" (12:00-17:59), and "evening" (18:00-23:59). Age was categorized by 10-year groupings (15-24, 25-34, 35-44, 45-54, 55-64, 65-74, and ≥75).

The ATUS is a database maintained by the US Bureau of Labor Statistics (BLS) and is an annual survey that assesses a range of activities across the 24-hour day in a representative sample of Americans[23]. The survey is conducted by phone and requires respondents to retrospectively profile their activities hour by hour for the last 24 hours. Responses are coded into standardized categories. The primary variable of interest was the report of "sleep." Percent of the population asleep per hour is represented in Figure 1, panel A. Additional data were also gathered on age, sex, and race/ethnicity. The data for the present analysis were acquired from 2003-2011, and represent population-weighted values for the weekdays (vs. weekends). In supplementary analyses stratified by age, sex, and race/ethnicity, weighted population estimates were separately computed for each category.

Conceptual Approach

If an analysis aims to discern the temporal patterning of a behavior by hour over the 24-hour day, it follows that: (1) the null hypothesis would be that $time_1$=$time_2$=$time_3$ and so on (i.e., the behavior of interest occurs with similar frequency across all time intervals) and (2) a significant finding would entail the observation that one or more time points would be associated with more or less occurrences of the behavior than expected based on the null hypothesis. In both cases, the underlying assumption is that there is an equal probability of the suicidal behavior occurring across all time intervals. This is not, however, likely to be the case. Since the behavior of interest is volitional and requires wakefulness, the calculation must take into account the probability of being awake across the 24-hour day. Put differently, the question may be better phrased as, "How common is suicide at each hour of the day, given how many people tend to be awake at that hour?" Asked and operationalized in this manner, it may be possible to observe an effect that has been previously masked: That suicide occurs disproportionately at night.

For example, a data set of 100 individuals who perform a behavior is collected, and the cumulative occurrences of the behavior are arrayed by hour for each hour of the 24-hour day. Assuming equal probability of performing the behavior for each hour (e.g., 100/24 = 4.17 per hour), if it is observed that 10 individuals performed the behavior at 13:00 (1pm) and 2 individuals performed the behavior and at 1:00 (1am), then it would be concluded that the behavior occurred disproportionately more frequently higher at 1pm (10 vs. 2). If, however, approximately 95% of the population is awake at 1pm and only 10% of the population is awake at 1am, and if the behavior estimates were weighted to take this into account, then the adjusted incidents would be 10.5% at 1pm and 20% at 1am (10/[100*0.95] and 2/[100*0.10]). Assessed in this manner, it would be concluded that behavior occurred disproportionately at 1:00am. This approach was used for the present study.

Statistical Analyses

Time of fatal injury was categorized by hour (24 bins, one hour per bin) or by general time of day (4 bins, 6 hours per bin). The proportion of the population awake by hour was determined using ATUS. These proportions were used to compute the expected number of suicides per hour to compare to observed values. These computations resulted in raw and adjusted percentages of suicides by clock hour, relative to the complete sample, as well as relative to the proportion of the population awake at each hour. In addition, these computations resulted in observed and expected frequencies for each clock hour.

Based on these values, the null hypothesis that time1=time2=time3 etc. was tested (taking into account appropriate weighting) using a chi square goodness-of-fit test. This test served as an omnibus evaluation of whether there are differences in the observed versus expected percentages across clock hours. A significant result would indicate that at least 1 hour was different from the rest. To evaluate the degree to which the prevalence at each hour deviated from what would be expected, a series of standardized incidence ratios (SIRs) were computed by dividing the number of observed suicides per hour by the number of suicides expected based on ATUS estimates. By taking this approach, a 95% confidence interval around the SIR was obtained. Because of the large sample size and high statistical power for

detecting very small effects, a phi statistic was calculated to estimate effect size. Phi is roughly equivalent to the commonly-used Cohen's d statistic, modified for use with chi square. Phi is calculated by taking the square root of the result of dividing the chi square statistic by the sample size. As with Cohen's d, typical rules of thumb suggest that effects of 0.2 are small, effects of 0.5 are medium, and effects of 0.8 are large. Post-hoc hour-by-hour pairwise comparisons were not performed. A similar process was followed to obtain weighted percentages and both observed and expected values for the 4 time of day categories. Similarly, chi-square goodness of fit tests were used to detect whether there were differences among the times of day and phi statistics were computed to estimate effect size. Finally, post-hoc pairwise tests compared night-morning, night-afternoon, night-evening, morning-afternoon, morning-evening, and afternoon-evening periods. To evaluate whether this pattern was consistent across demographic groups, this analytic approach was repeated in analyses stratified by sex, race/ethnicity, and 10-year age groups. Separate ATUS values were extracted for each group. Also, separate analyses were performed for individuals with or without known depression (collected by NVDRS), using the overall sample values from ATUS.

RESULTS

Characteristics of the Overall Sample (Unadjusted Data).

A total of n=35,332 records out of the 71,282 documented suicides had time of fatal injury data and were included in analyses. The first evaluation was undertaken without any adjustment for the proportion of the population that is likely awake at each given hour. As can be seen in Table 1, the two subsets of data (records with and without time of fatal injury) did not differ with respect to demographics, education, or mood status (depression). In the unadjusted data (see Table 2, Column 7 and Figure 1, Panel B.), the majority of suicides were committed during the day with a peak frequency at noon (6.6%) and a trough frequency at 4am (2.0%). The overall distribution was roughly sinusoidal with suicide at night (midnight to 6am) occurring in 18.1% of the sample.

Characteristics of the Overall Sample (Adjusted Data).

When accounting for the proportion of the population that is likely awake at each given hour (see Table 2, Columns 2 & 9 and Figure 1, Panel C), the majority of suicides were committed at night with a peak frequency at 2am (16.3%) and a mean incident rate from 24:00-05:59 of 10.3% +/− 4.9%. In this model, 63.9% of the suicides occurred between midnight and 6am. The overall distribution, apart from midnight to 6am, was flat with an average incidence of suicide across the remaining 18 hours (6am-midnight) of 2.2% +/ −0.7%, per hour. This 24-hour pattern of time of fatal self-injury (hour by hour) deviated from that which would be expected by chance (See Table 2, Columns 12). When the data were categorized in 6-hour bins (night, morning, afternoon, or evening), post-hoc pairwise chi-square tests (See Table 3) showed that the rate of suicide at night was significantly greater than the rate of occurrence during the morning, afternoon, and evening. Further, the differences between morning, afternoon, and evening were nominal.

Stratified Analyses.

The temporal pattern effect of suicide was evaluated by age, sex, and race (See Table 4). When the sample was stratified by sex, the overall pattern of incidence of suicide over time, adjusting for likelihood of being awake, was maintained, with significant differences when examining hour-by-hour data and data by 6-hour categories. When examining effect sizes, there was a clear gender difference: the temporal effects for men were larger than for women. When the sample was stratified by race/ethnicity, the same temporal pattern emerged with nominal differences among groups. The largest effect sizes were seen among Hispanic/Latinos and the smallest effect sizes were seen among Black/African-Americans. When the sample was divided into 10-year age groups, the pattern remained, with significant omnibus effects for all groups. It should be noted, however, that effects were largest among the 15-24 and 25-34 age groups, and, to a lesser degree, the 35-44 age group. Analyses stratified by depression also show this pattern, with both depressed and non-depressed individuals showing increased prevalence of suicides at night ($p < 0.0001$ for both models).

DISCUSSION

Summary of Main Results.

Only a few studies have examined the temporal patterning of suicide across the 24-hour day. The results of all the prior investigations indicated a higher prevalence of suicides during the day than at night. These findings were, however, are based on the assumption that the probability for suicide is equal during each hour of the 24 hour day. This is unlikely because the at-risk population (i.e., the denominator for the suicide rate) changes with time-of-day. In the present analysis, when accounting for the proportion of the population that is awake at each given hour, it was found that suicide is more likely to occur at night then during the morning, afternoon or evening hours. This finding was consistent across age groups, sex, race/ethnicity groups, and for depressed and non-depressed individuals. The effect sizes for the finding was nominally greater for younger individuals, males, and those identified as Hispanic/Latino.

Implications.

If suicide occurs disproportionately at night (as compared to other times during the 24 hour day), the emergent question is, “What about being awake at night confers risk?” One possibility is that being awake may be associated with reduced social support and increased utilization of alcohol and other substances which promote cognitive and behavioral disinhibition [**e.g.,**24,25]. These factors alone, or in combination with other known and unknown factors, may confer increased risk for suicide. Another possibility, in line with current findings, is that insomnia and/or nightmares contribute to suicidal ideation and behavior by making it more likely that an afflicted individual will be awake at night; intensifying the individual’s sense of hopelessness, isolation, and distress relative to inability to sleep. Being awake at night (when one is not biologically predisposed to be awake) also likely results in a decrease in frontal lobe function (i.e., hypo-activation of the frontal lobes due to circadian effects, sleep loss /sleep deprivation, and/or sleep inertia) [**e.g.,**26]. Hypofrontality, in turn, may result in diminished problem solving abilities and increased impulsive behavior, both of which may be expected to increase the risk for suicide. This

possibility suggests that one way to reduce the risk of suicide is to ensure that individuals are not awake when they are disproportionately vulnerable. Conceptualized this way, it follows that 1) targeted treatment for insomnia and nightmares and 2) the increased allocation / utilization of psycho-social resources at night (e.g., increased availability of peer and professional support) should have substantial value as preventive strategies for suicide.

Limitations.

The NVDRS data set does not contain data regarding why individuals that die by suicide at night were awake from midnight to 06:00. Although insomnia and awakenings from nightmares seem like reasonable explanations, it is also possible that the individuals who die by suicide at night did so deliberately; that is, they simply stayed awake until a chosen hour. Further, while the given data make it clear that being awake at night is a risk, there are no data to allow for an assessment of which factors (e.g., social isolation, access to weapons, alcohol and substance use, or decreased executive functioning) alone or in combination, undergird the observed finding. Finally, the use of the ATUS data set to estimate proportion of the population awake at each across the 24 hour day may systematically under represent the segment of the population of depressed and/or suicidal individuals that are awake during the traditional sleep period and asleep during the day.

Future Directions.

Several directions seem possible. First, a large scale psychological autopsy study could be undertaken to assess the relative contribution of insomnia and/or nightmares, social isolation, access to substances to the observed finding. Second, within-subject circadian experimental paradigms (with or without QEEG measures of frontal lobe activity) could be used to assess how executive function, suicidal ideation, and/or impulsive behavior vary as a function of time of day, especially in at-risk subjects. Third, large scale studies of circadian effects on decision making and/or impulsive behavior could be conducted in other populations that are more easily tracked (e.g., data sets that have hour by hour data related to on-line gambling, shopping, or social networking). Finally, as suggested above, an indirect assessment of the association, and the importance of, being awake during the normal sleep period (circadian night) could be accomplished by assessing whether treatment for insomnia and/or nightmares or increased nighttime psychosocial support in at risk populations diminishes suicidal ideation and behavior. This last possibility appears to particularly viable given the results from a recent study by Manber and colleagues (2015) which provides the first evidence that Cognitive Behavioral Therapy for Insomnia (CBT-I) can significantly reduce suicidal ideation[27].

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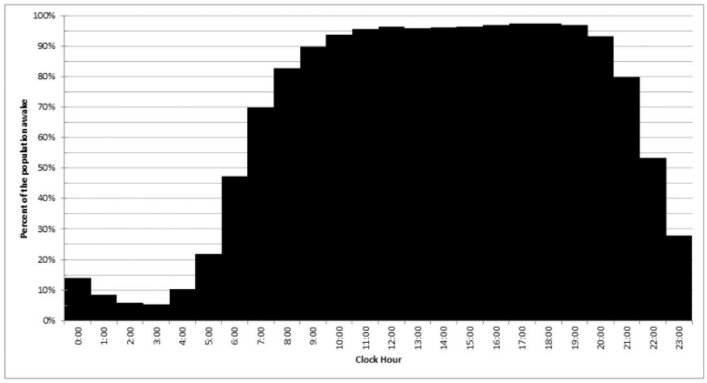
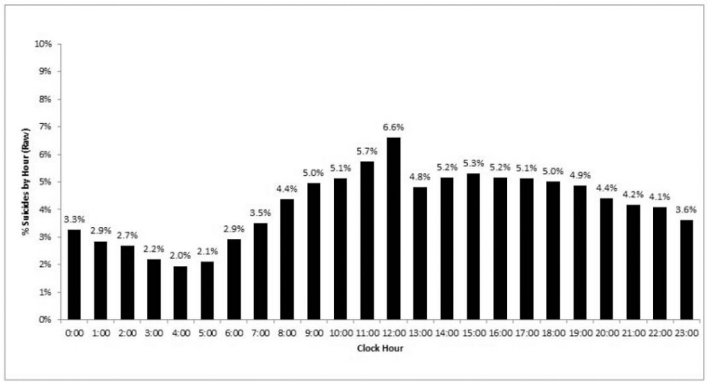
A. Proportion of the population awake by clock hour, estimated by ATUS



B. Proportion of Suicides by Clock Hour (Not Accounting for the Proportion of the Population Awake)



C. Scaled Proportion of Suicides by Clock Hour Accounting for the Proportion of the Population Awake at that Hour

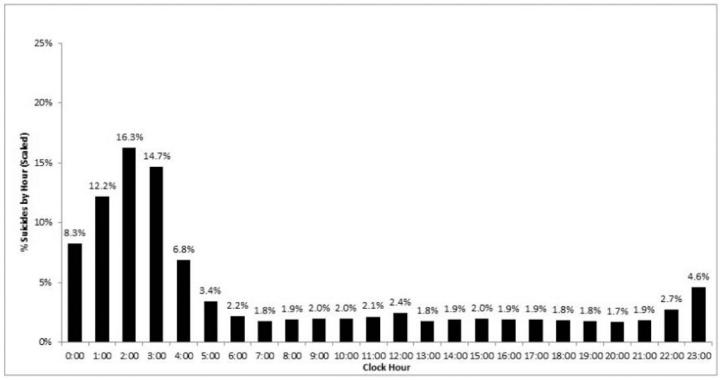


Figure 1.
Proportion of the Population Awake and Completed Suicides by Clock Hour

Table 1.

Characteristics of the Overall Sample

		Time of Fatal Injury Data	
Variable	**Category**	**No**	**Yes**
N		35998	35284
Age		46.029 ± 16.940	45.359 ± 18.280
Sex	Female	24.77%	18.76%
Race/Ethnicity	White	86.47%	84.26%
	Black/African-American	5.80%	7.56%
	Hispanic/Latino	4.06%	4.57%
	Asian/Pacific Islander	1.85%	1.47%
	Native American	1.56%	1.91%
	Other	0.27%	0.24%
Education	Less than High School	20.86%	27.18%
	High School	39.64%	39.53%
	Some College	15.63%	13.56%
	College	18.36%	14.94%
	Postgraduate	5.51%	4.80%
Known Depression	Yes	39.20%	36.56%

Table 2

Calculating Expected Frequenices Per Clock Hour

1	2	3	4	5	6	7	8	9	10	11	12
Hour	ATUS % Awake[1]	Scaled % Awake[2]	Expected # Awake[3]	Scaled Expected Awake[4]	Observed Frequency[5]	Observed %[6]	Adjusted %[7]	Scaled %[8]	Standardized Incidence Ratio (SIR)[9]	95% CI for SIR	P value
0:00	14.47%	0.89%	4971.74	316.22	1153	3.26%	23.19%	8.27%	3.65	(3.43, 3.86)	<0.001
1:00	8.36%	0.53%	2954.17	187.89	1007	2.85%	34.09%	12.16%	5.36	(5.03, 5.70)	<0.001
2:00	5.89%	0.37%	2080.76	132.34	949	2.69%	45.61%	16.27%	7.17	(6.72, 7.64)	<0.001
3:00	5.34%	0.34%	1886.76	120.00	777	2.20%	41.18%	14.69%	6.47	(6.02, 6.94)	<0.001
4:00	10.19%	0.65%	3600.73	229.02	690	1.95%	19.16%	6.83%	3.01	(2.79, 3.24)	<0.001
5:00	21.89%	1.39%	7735.18	491.98	746	2.11%	9.64%	3.44%	1.52	(1.40, 1.62)	<0.001
6:00	47.40%	3.01%	16746.51	1065.13	1030	2.92%	6.15%	2.19%	0.97	0.90, 1.02)	0.2918
7:00	69.92%	4.45%	24704.73	1571.29	1241	3.51%	5.02%	1.79%	0.79	(0.74, 0.83)	<0.001
8:00	82.66%	5.26%	29206.87	1857.64	1548	4.38%	5.30%	1.89%	0.83	(0.79, 0.87)	<0.001
9:00	89.80%	5.71%	31728.35	2018.01	1748	4.95%	5.51%	1.96%	0.87	(0.82, 0.90)	<0.001
10:00	93.82%	5.97%	33149.08	2108.38	1814	5.13%	5.47%	1.95%	0.86	(0.82, 0.90)	<0.001
11:00	95.63%	6.08%	33787.45	2148.98	2027	5.74%	6.00%	2.14%	0.94	(0.90, 0.98)	0.0081
12:00	96.34%	6.13%	34039.95	2165.04	2334	6.61%	6.86%	2.45%	1.08	(1.03, 1.12)	0.001
13:00	95.92%	6.10%	33891.12	2155.57	1701	4.81%	5.02%	1.79%	0.79	(0.75, 0.82)	<0.001
14:00	96.01%	6.11%	33922.25	2157.55	1825	5.17%	5.38%	1.92%	0.85	(0.80, 0.88)	<0.001
15:00	96.46%	6.13%	34079.52	2167.55	1871	5.30%	5.49%	1.96%	0.86	(0.82, 0.90)	<0.001
16:00	96.81%	6.16%	34204.99	2175.53	1828	5.17%	5.34%	1.91%	0.84	(0.80, 0.87)	<0.001
17:00	97.26%	6.19%	34365.28	2185.73	1816	5.14%	5.28%	1.88%	0.83	(0.79, 0.86)	<0.001
18:00	97.43%	6.20%	34424.29	2189.48	1768	5.00%	5.14%	1.83%	0.81	(0.77, 0.84)	<0.001
19:00	96.80%	6.16%	34200.01	2175.22	1718	4.86%	5.02%	1.79%	0.79	(0.75, 0.82)	<0.001
20:00	93.09%	5.92%	32891.02	2091.96	1551	4.39%	4.72%	1.68%	0.74	(0.70, 0.77)	<0.001
21:00	79.91%	5.08%	28234.86	1795.82	1469	4.16%	5.20%	1.86%	0.82	(0.77, 0.86)	<0.001
22:00	53.28%	3.39%	18824.30	1197.28	1444	4.09%	7.67%	2.74%	1.21	(1.14, 1.26)	<0.001
23:00	27.96%	1.78%	9879.86	628.39	1277	3.61%	12.93%	4.61%	2.03	(1.92, 2.14)	<0.001
SUM:	1572.24%	100.00%	555509.83	35332	35332	100.00%	280.37%	100.00%			

[1]The proportion of the population awake at each hour based on ATUS.

[2]Proportions, divided by the total of all proportions (value from column 2, divided by the sum of all values from column 2). This scales each proportion so that they all sum to 100%.

[3]Values from column 2, multiplied by the total N=35332. This represents the number of individuals from the sample expected to be awake at each hour.

[4]Values from column 4, divided by the total of column 4. This normalizes all values to a 100% scale.

[5]The observed number of suicides at each clock hour, from NVDRS.

[6]The proportion of suicides occurring at each clock hour compared to the entire sample (obtained by dividing each value from column 6 by the total N=35332.

[7] The proportion of suicides occurring at each clock hour compared to the amount of the sample that is estimated to have been awake at that time (obtained by dividing the number of observed suicides from column 6 by the expected # awake in column 4).

[8] Values from column 8, divided by the sum of all values from column 8. This normalizes proportions so they all add up to 100.

[9] SIR computed by dividing the observed frequency from column 6 (i.e., observed) by the scaled number expected awake from column 5 (i.e., expected).

[10] 95% Confidence Interval (95%CI) computed around the SIR.

[11] P value for SIR

Table 3

Pairwise Chi-Square Comparisons among Rates of Night, Morning, Afternoon and Evening, Accounting for the Proportion of the Population Awake

	Chi Square	Phi	P Value
	PAIRWISE: NIGHT VS MORNING		
Overall	10176.143	0.831	<0.001
Men	11145.151	0.960	<0.001
Women	1200.119	0.676	<0.001
White	8087.796	0.812	<0.001
Black	736.885	0.813	<0.001
Hispanic	1080.621	1.201	<0.001
Asian	200.592	0.984	<0.001
Others	498.880	1.141	<0.001
Age 15-24	3892.223	1.365	<0.001
Age 25-34	3704.741	1.240	<0.001
Age 35-44	1965.562	0.857	<0.001
Age 45-54	856.924	0.550	<0.001
Age 55-64	490.596	0.501	<0.001
Age 65-74	424.102	0.597	<0.001
Age 75+	729.042	0.700	<0.001

	Chi Square	Phi	P Value
	PAIRWISE: NIGHT VS AFTERNOON		
Overall	10208.801	0.782	<0.001
Men	11244.438	0.913	<0.001
Women	1159.119	0.600	<0.001
White	8071.199	0.759	<0.001
Black	747.075	0.766	<0.001
Hispanic	1114.552	1.204	<0.001
Asian	195.600	0.866	<0.001
Others	517.721	1.169	<0.001
Age 15-24	3886.953	1.228	<0.001
Age 25-34	3677.520	1.148	<0.001
Age 35-44	1888.846	0.768	<0.001
Age 45-54	809.084	0.490	<0.001
Age 55-64	492.973	0.480	<0.001
Age 65-74	422.634	0.598	<0.001
Age 75+	665.054	0.727	<0.001

	Chi Square	Phi	P Value
	PAIRWISE: NIGHT VS EVENING		
Overall	10075.921	0.832	<0.001
Men	11077.243	0.964	<0.001
Women	1168.269	0.667	<0.001
White	8009.944	0.817	<0.001
Black	717.511	0.766	<0.001
Hispanic	1071.075	1.197	<0.001
Asian	196.832	0.942	<0.001
Others	507.568	1.201	<0.001
Age 15-24	3794.864	1.214	<0.001
Age 25-34	3568.352	1.121	<0.001
Age 35-44	1856.621	0.797	<0.001
Age 45-54	805.599	0.537	<0.001
Age 55-64	523.869	0.574	<0.001
Age 65-74	458.297	0.734	<0.001
Age 75+	786.720	0.990	<0.001

	Chi Square	Phi	P Value
	PAIRWISE: MORNING VS AFTERNOON		
Overall	376.868	0.135	<0.001
Men	362.364	0.147	<0.001
Women	54.033	0.116	<0.001
White	270.718	0.123	<0.001
Black	50.731	0.187	<0.001
Hispanic	55.434	0.253	<0.001
Asian	7.300	0.157	0.999
Others	21.722	0.232	0.537
Age 15-24	202.718	0.289	<0.001
Age 25-34	246.009	0.295	<0.001
Age 35-44	142.180	0.193	<0.001
Age 45-54	58.541	0.115	<0.001
Age 55-64	3.423	0.033	0.999
Age 65-74	17.600	0.098	0.779
Age 75+	107.674	0.225	<0.001

	Chi Square	Phi	P Value
	PAIRWISE: MORNING VS EVENING		
Overall	243.988	0.114	<0.001
Men	195.169	0.113	<0.001
Women	63.182	0.136	<0.001
White	209.462	0.115	<0.001
Black	21.167	0.123	0.571
Hispanic	11.956	0.119	0.971
Asian	8.532	0.182	0.997
Others	11.570	0.175	0.977
Age 15-24	110.630	0.214	<0.001
Age 25-34	136.841	0.218	<0.001
Age 35-44	109.955	0.176	<0.001
Age 45-54	55.056	0.119	<0.001
Age 55-64	34.320	0.116	0.061
Age 65-74	53.263	0.188	<0.001
Age 75+	229.340	0.369	<0.001

	Chi Square	Phi	P Value
	PAIRWISE: AFTERNOON VS EVENING		
Overall	276.646	0.116	<0.001
Men	294.456	0.133	<0.001
Women	22.183	0.074	0.509
White	192.865	0.105	<0.001
Black	31.358	0.142	0.114
Hispanic	45.887	0.230	<0.001
Asian	3.540	0.107	1.000
Others	30.410	0.286	0.138
Age 15-24	105.360	0.190	<0.001
Age 25-34	109.621	0.184	<0.001
Age 35-44	33.239	0.090	0.770
Age 45-54	7.217	0.040	0.999
Age 55-64	36.697	0.116	0.035
Age 65-74	51.796	0.186	<0.001
Age 75+	165.352	0.337	<0.001

Table 4

Chi-Square and Phi Values Assessing whether the 24-Hour Distribution of Suicide Differs from Chance, Accounting for the Proportion of the Population Awake, Stratified by Age, Sex, and Ethnoracial Group

	24 HOURS			NIGHT vs MORNING vs AFTERNOON vs EVENING		
Group	**Chi Square**	**Phi**	**P Value**	**Chi Square**	**Phi**	**P Value**
Overall	**17102.757**	**0.696**	**<0.001**	**10452.789**	**0.544**	**<0.001**
Depressed	4633.666	0.599	<0.001	2735.311	0.460	<0.001
Men	18282.137	0.798	<0.001	11439.607	0.631	<0.001
Women	2138.292	0.568	<0.001	1222.302	0.430	<0.001
White	13999.033	0.686	<0.001	8280.661	0.527	<0 001
Black	1126.573	0.649	<0.001	768.242	0.536	<0.001
Hispanic	2023.212	1.119	<0.001	1126.508	0.835	<0.001
Asian	241.145	0.682	<0.001	204.132	0.628	<0.001
Others	983.282	1.140	<0.001	529.291	0.837	<0.001
Age 15-24	5460.433	1.046	<0.001	3997.583	0.895	<0.001
Age 25-34	5797.393	1.012	<0.001	3814.361	0.821	<0.001
Age 35-44	3960.947	0.766	<0.001	1998.801	0.544	<0.001
Age 45-54	2061.963	0.533	<0.001	864.141	0.345	<0.001
Age 55-64	1174.229	0.501	<0.001	527.292	0.336	<0.001
Age 65-74	703.552	0.512	<0.001	475.897	0.421	<0.001
Age 75+	1123.741	0.618	<0.001	894.394	0.552	<0.001