Nocturnal Wakefulness as 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 percentage of individuals awake at each hour.

Methods: Archival analyses were conducted estimating the time of fatal injury using the National Violent Death Reporting System for 2003–2010 and the proportion of the American population awake per hour across the 24-hour day using the American Time Use Survey.

Results: The mean ± SD incident rate from 06:00–23:59 was 2.2% ± 0.7%, while the mean ± SD incident rate from 00:00–05:59 was 10.3% ± 4.9%. The maximum incident rate was from 02:00–02:59 (16.3%). Hour-by-hour observed values differed from those that would be expected by chance ($P < .001$), and when 6-hour blocks were examined, the observed frequency at night was 3.6 times higher than would be expected by chance ($P < .001$).

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

J Clin Psychiatry 2016;77(6):e726–e733
dx.doi.org/10.4088/JCP.15m10131

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Suicide is a major public health problem and the 10th leading cause of death in the United States.[1] 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 years, 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 (eg, references 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 (risk ratio = 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 (eg, reference 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, 8 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,

Clinical Points

- Little attention has been paid to the circadian patterning of suicide and the possibility that at-risk individuals are unduly vulnerable at specific times of the day or night.
- Modifying risk for the 20% of suicides that occur during the night may be as simple as ensuring that such individuals can sleep through the night and/or have increased access to supportive resources during this phase of the circadian day.

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 data set, compiled by the Centers for Disease Control and Prevention, includes details on violent deaths from 18 participating US states.[22] The data for the present study included the years 2003–2010. The 4 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 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 (00:00–00:59, 01:00–01:59, 02:00–02:59, etc) and also arrayed in 6-hour bins categorized as "night" (00:00–05:59), "morning" (06:00–11:59), "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 years).

The ATUS is a database maintained by the US Bureau of Labor Statistics 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." The percentage of the population awake per hour is represented in Figure 1A. Additional data were also gathered on age, sex, and race/ethnicity. The data for the present analysis were acquired from 2003 through 2010 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 (ie, the behavior of interest occurs with similar frequency across all time intervals) and (2) a significant finding would entail the observation that 1 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. Such equal probability 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?" When suicidal behavior is 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.

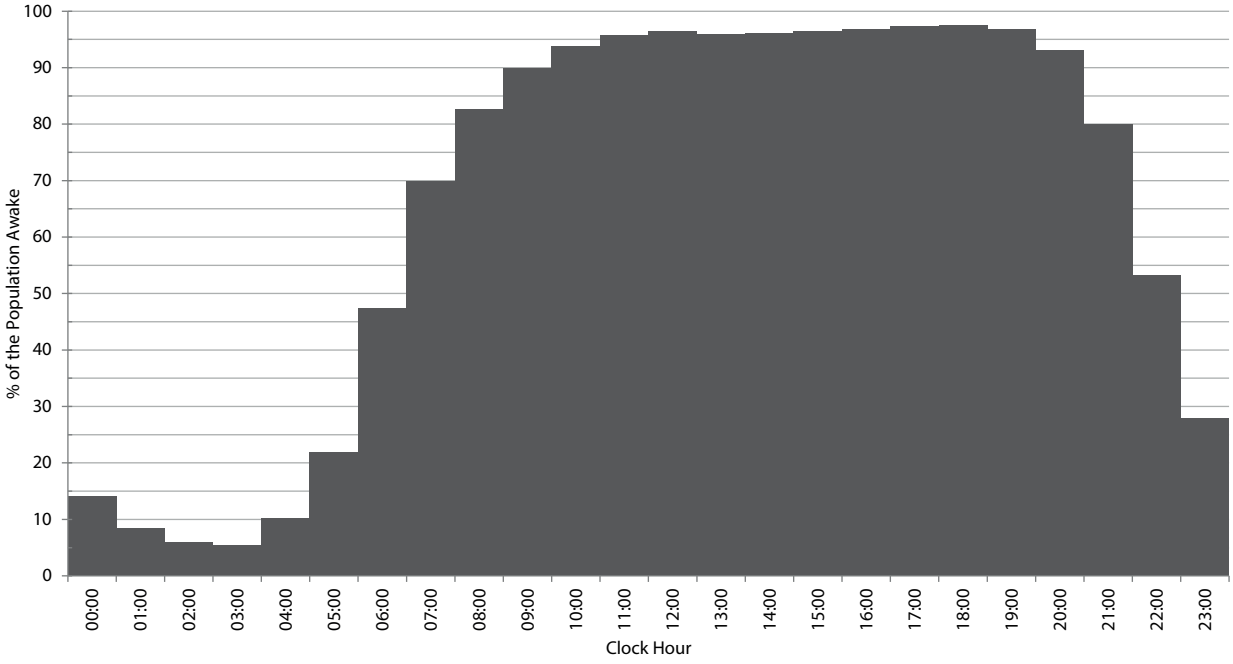
For example, a data set of 100 individuals who perform a behavior is collected, and the cumulative occurrences of the behavior are arrayed by hour for each hour of the 24-hour day. Assuming equal probability of performing the behavior for each hour (eg, 100/24 = 4.17 per hour), if it is observed that 10 individuals performed the behavior at 13:00 (1 PM) and 2 individuals performed the behavior and at 01:00 (1 AM), then it would be concluded that the behavior occurred disproportionately more frequently at 1 PM (10 vs 2). If, however, approximately 95% of the population is awake at 1 PM and only 10% of the population is awake at 1 AM, and if the behavior estimates were weighted to take this into account, then the adjusted incidents would be 10.5% at 1 PM and 20% at 1 AM (10/[100 × 0.95] and 2/[100 × 0.10]). When incidence is assessed in this manner, it would be concluded that behavior occurred disproportionately at 1:00 AM. This approach was used for the present study.

Statistical Analyses

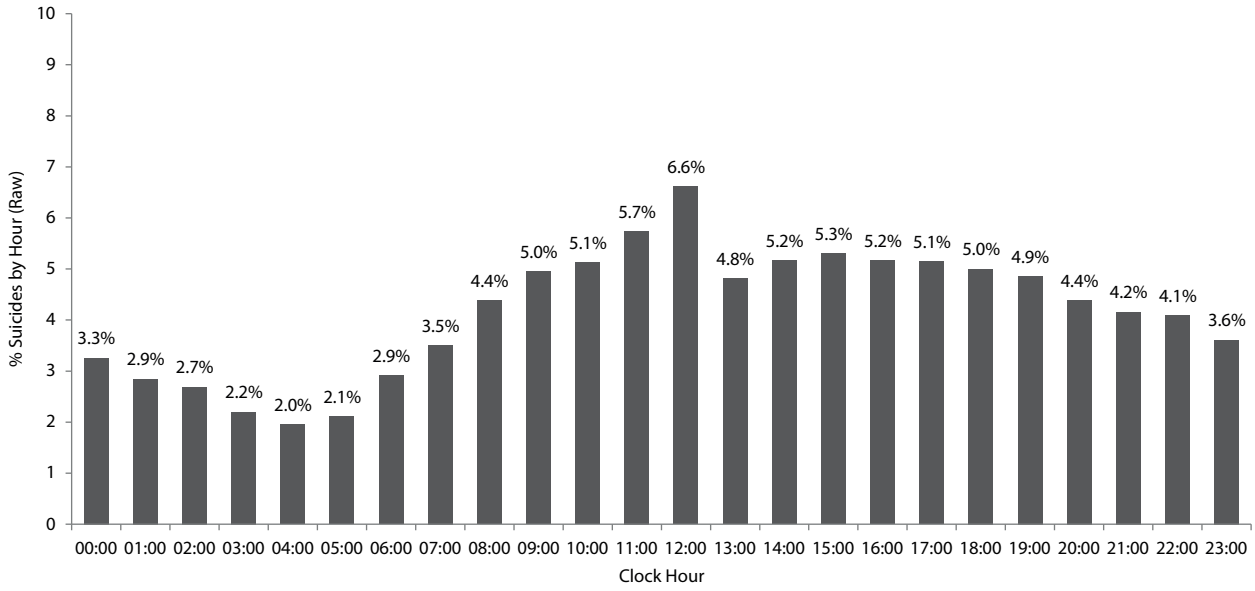
Time of fatal injury was categorized by hour (24 bins, 1 hour per bin) or by general time of day (4 bins, 6 hours per bin). The proportion of the population awake by hour was determined using ATUS. These proportions were used to compute the expected number of suicides per hour to compare to observed values. These computations resulted

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

A. Proportion of the Population Awake by Clock Hour, Estimated by the American Time Use Survey



B. Raw Proportion of Completed Suicides by Clock Hour, Not Accounting for the Proportion of the Population Awake



(continued)

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 $time_1 = time_2 = time_3$, etc, was tested (taking into account appropriate weighting) using a χ^2 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

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

C. Scaled Proportion of Completed Suicides by Clock Hour, Accounting for the Proportion of the Population Awake at That Hour

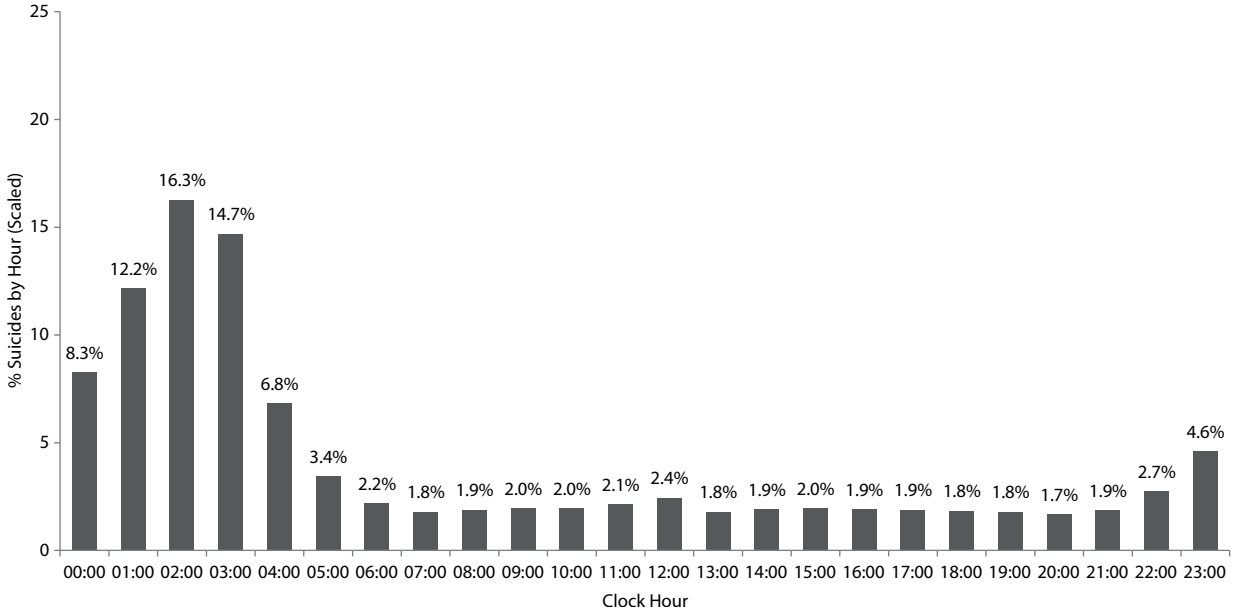


Table 1. Characteristics of the Overall Sample

	Time of Fatal Injury Data	
Variable	No	Yes
N	35,998	35,332
Age, mean ± SD, y	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, %	39.20	36.56

effect size. Phi is roughly equivalent to the commonly used Cohen *d* statistic, modified for use with χ^2. Phi is calculated by taking the square root of the result of dividing the χ^2 statistic by the sample size. As with Cohen *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, χ^2 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 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 2 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 1B), the majority of suicides were committed during the day with a peak frequency at noon (6.6%) and a trough frequency at 4 AM (2.0%). The overall distribution was roughly sinusoidal with suicide at night (midnight to 6 AM) 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 and 9 and Figure 1C), the majority of suicides were

Table 2. Calculating Expected Frequencies by Clock Hour

1	2	3	4	5	6	7	8	9	10	11	12
Hour	ATUS % Awake[a]	Scaled % Awake[b]	Expected No. Awake[c]	Scaled Expected Awake[d]	Observed Frequency[e]	Observed %[f]	Adjusted %[g]	Scaled %[h]	SIR[i]	95% CI for SIR	*P* Value
00:00	14.07	0.89	4,971.79	316.22	1,153	3.26	23.19	8.27	3.65	(3.43–3.86)	<.001
01:00	8.36	0.53	2,954.17	187.89	1,007	2.85	34.09	12.16	5.36	(5.03–5.70)	<.001
02:00	5.89	0.37	2,080.76	132.34	949	2.69	45.61	16.27	7.17	(6.72–7.64)	<.001
03:00	5.34	0.34	1,886.76	120.00	777	2.20	41.18	14.69	6.47	(6.02–6.94)	<.001
04:00	10.19	0.65	3,600.73	229.02	690	1.95	19.16	6.83	3.01	(2.79–3.24)	<.001
05:00	21.89	1.39	7,735.18	491.98	746	2.11	9.64	3.44	1.52	(1.40–1.62)	<.001
06:00	47.40	3.01	16,746.51	1,065.13	1,030	2.92	6.15	2.19	0.97	(0.90–1.02)	.2918
07:00	69.92	4.45	24,704.73	1,571.29	1,241	3.51	5.02	1.79	0.79	(0.74–0.83)	<.001
08:00	82.66	5.26	29,206.87	1,857.64	1,548	4.38	5.30	1.89	0.83	(0.79–0.87)	<.001
09:00	89.80	5.71	31,728.35	2,018.01	1,748	4.95	5.51	1.96	0.87	(0.82–0.90)	<.001
10:00	93.82	5.97	33,149.08	2,108.38	1,814	5.13	5.47	1.95	0.86	(0.82–0.90)	<.001
11:00	95.63	6.08	33,787.45	2,148.98	2,027	5.74	6.00	2.14	0.94	(0.90–0.98)	.0081
12:00	96.34	6.13	34,039.95	2,165.04	2,334	6.61	6.86	2.45	1.08	(1.03–1.12)	.0004
13:00	95.92	6.10	33,891.12	2,155.57	1,701	4.81	5.02	1.79	0.79	(0.75–0.82)	<.001
14:00	96.01	6.11	33,922.25	2,157.55	1,825	5.17	5.38	1.92	0.85	(0.80–0.88)	<.001
15:00	96.46	6.13	34,079.52	2,167.55	1,871	5.30	5.49	1.96	0.86	(0.82–0.90)	<.001
16:00	96.81	6.16	34,204.99	2,175.53	1,828	5.17	5.34	1.91	0.84	(0.80–0.87)	<.001
17:00	97.26	6.19	34,365.28	2,185.73	1,816	5.14	5.28	1.88	0.83	(0.79–0.86)	<.001
18:00	97.43	6.20	34,424.29	2,189.48	1,768	5.00	5.14	1.83	0.81	(0.77–0.84)	<.001
19:00	96.80	6.16	34,200.01	2,175.22	1,718	4.86	5.02	1.79	0.79	(0.75–0.82)	<.001
20:00	93.09	5.92	32,891.02	2,091.96	1,551	4.39	4.72	1.68	0.74	(0.70–0.77)	<.001
21:00	79.91	5.08	28,234.86	1,795.82	1,469	4.16	5.20	1.86	0.82	(0.77–0.86)	<.001
22:00	53.28	3.39	18,824.30	1,197.28	1,444	4.09	7.67	2.74	1.21	(1.14–1.26)	<.001
23:00	27.96	1.78	9,879.86	628.39	1,277	3.61	12.93	4.61	2.03	(1.92–2.14)	<.001
Sum	1,572.24	100.00	555,509.83	35,332	35,332	100.00	280.37	100.00			

[a]The proportion of the population awake at each hour based on the ATUS.
[b]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%.
[c]Values from column 2, multiplied by the total N = 35,332. This represents the number of individuals from the sample expected to be awake at each hour.
[d]Values from column 4, divided by the total of column 4. This normalizes all values to a 100% scale.
[e]The observed number of suicides at each clock hour, from the National Violent Death Reporting Scale.
[f]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 = 35,332).
[g]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 number awake in column 4).
[h]Values from column 8, divided by the sum of all values from column 8. This normalizes proportions so they all add up to 100.
[i]SIR computed by dividing the observed frequency from column 6 (ie, observed) by the scaled number expected awake from column 5 (ie, expected).
[j]95% confidence interval (95% CI) computed around the SIR.
[k]*P* value for SIR.
Abbreviations: ATUS = American Time Use Survey, SIR = standardized incidence ratio.

committed at night with a peak frequency from 02:00–02:59 (16.3%) and a mean ± SD incident rate from 00:00–05:59 of 10.3% ± 4.9%. In this model, 63.9% of the suicides occurred between midnight and 6 AM. The overall distribution, apart from midnight to 6 AM, was flat with a mean incidence of suicide across the remaining 18 hours (6 AM–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, column 12). When the data were categorized in 6-hour bins (night, morning, afternoon, or evening), post hoc pairwise χ^2 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 (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 Hispanics/Latinos and the smallest effect sizes were seen among blacks/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- to 24-year and 25- to 34-year age groups and, to a lesser degree, the 35- to 44-year age group. Analyses stratified by depression also show this pattern, with both depressed and nondepressed individuals showing increased prevalence of suicides at night ($P < .0001$ 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

Table 3. Pairwise χ^2 Comparisons Among Rates of Night, Morning, Afternoon, and Evening, Accounting for the Proportion of the Population Awake

	Pairwise: Night vs Morning			Pairwise: Night vs Afternoon			Pairwise: Night vs Evening		
Variable	χ^2	Phi	*P* Value	χ^2	Phi	*P* Value	χ^2	Phi	*P* Value
Overall	10,176.143	0.831	<.00001	10,208.801	0.782	<.00001	10,075.921	0.832	<.00001
Men	11,145.151	0.960	<.00001	11,244.438	0.913	<.00001	11,077.243	0.964	<.00001
Women	1,200.119	0.676	<.00001	1,159.119	0.600	<.00001	1,168.269	0.667	<.00001
White	8,087.796	0.812	<.00001	8,071.199	0.759	<.00001	8,009.944	0.817	<.00001
Black	736.885	0.813	<.00001	747.075	0.766	<.00001	717.511	0.766	<.00001
Hispanic	1,080.621	1.201	<.00001	1,114.552	1.204	<.00001	1,071.075	1.197	<.00001
Asian	200.592	0.984	<.00001	195.600	0.866	<.00001	196.832	0.942	<.00001
Others	498.880	1.141	<.00001	517.721	1.169	<.00001	507.568	1.201	<.00001
Age, y									
15–24	3,892.223	1.365	<.00001	3,886.953	1.228	<.00001	3,794.864	1.214	<.00001
25–34	3,704.741	1.240	<.00001	3,677.520	1.148	<.00001	3,568.352	1.121	<.00001
35–44	1,965.562	0.857	<.00001	1,888.846	0.768	<.00001	1,856.621	0.797	<.00001
45–54	856.924	0.550	<.00001	809.084	0.490	<.00001	805.599	0.537	<.00001
55–64	490.596	0.501	<.00001	492.973	0.480	<.00001	523.869	0.574	<.00001
65–74	424.102	0.597	<.00001	422.634	0.598	<.00001	458.297	0.734	<.00001
75+	729.042	0.700	<.00001	665.054	0.727	<.00001	786.720	0.990	<.00001

	Pairwise: Morning vs Afternoon			Pairwise: Morning vs Evening			Pairwise: Afternoon vs Evening		
Overall	376.868	0.135	<.00001	243.988	0.114	<.00001	276.646	0.116	<.00001
Men	362.364	0.147	<.00001	195.169	0.113	<.00001	294.456	0.133	<.00001
Women	54.033	0.116	.00002	63.182	0.136	<.00001	22.183	0.074	.509
White	270.718	0.123	<.00001	209.462	0.115	<.00001	192.865	0.105	<.00001
Black	50.731	0.187	.00007	21.167	0.123	.571	31.358	0.142	.114
Hispanic	55.434	0.253	.00002	11.956	0.119	.971	45.887	0.230	.00031
Asian	7.300	0.157	.999	8.532	0.182	.997	3.540	0.107	1.000
Others	21.722	0.232	.537	11.570	0.175	.977	30.410	0.286	.138
Age, y									
15–24	202.718	0.289	<.00001	110.630	0.214	<.00001	105.360	0.190	<.00001
25–34	246.009	0.295	<.00001	136.841	0.218	<.00001	109.621	0.184	<.00001
35–44	142.180	0.193	<.00001	109.955	0.176	<.00001	33.239	0.090	.770
45–54	58.541	0.115	<.00001	55.056	0.119	.00002	7.217	0.040	.999
55–64	3.423	0.033	.999	34.320	0.116	.061	36.697	0.116	.035
65–74	17.600	0.098	.779	53.263	0.188	.00003	51.796	0.186	.00005
75+	107.674	0.225	<.00001	229.340	0.369	<.00001	165.352	0.337	<.00001

Table 4. χ^2 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	χ^2	Phi	*P* Value	χ^2	Phi	*P* Value
Overall	17,102.757	0.696	<.00001	10,452.789	0.544	<.00001
Depressed	4,633.666	0.599	<.00001	2,735.311	0.460	<.00001
Men	18,282.137	0.798	<.00001	11,439.607	0.631	<.00001
Women	2,138.292	0.568	<.00001	1,222.302	0.430	<.00001
White	13,999.033	0.686	<.00001	8,280.661	0.527	<.00001
Black	1,126.573	0.649	<.00001	768.242	0.536	<.00001
Hispanic	2,023.212	1.119	<.00001	1,126.508	0.835	<.00001
Asian	241.145	0.682	<.00001	204.132	0.628	<.00001
Others	983.282	1.140	<.00001	529.291	0.837	<.00001
Age, y						
15–24	5,460.433	1.046	<.00001	3,997.583	0.895	<.00001
25–34	5,797.393	1.012	<.00001	3,814.361	0.821	<.00001
35–44	3,960.947	0.766	<.00001	1,998.801	0.544	<.00001
45–54	2,061.963	0.533	<.00001	864.141	0.345	<.00001
55–64	1,174.229	0.501	<.00001	527.292	0.336	<.00001
65–74	703.552	0.512	<.00001	475.897	0.421	<.00001
75+	1,123.741	0.618	<.00001	894.394	0.552	<.00001

prior investigations[14–21] indicated a higher prevalence of suicides during the day than at night. These findings were, however, 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 (ie, 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, sex, and race/ethnicity groups and for depressed and nondepressed individuals. The effect sizes for the finding were 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 at night may be associated with reduced social support and increased utilization of alcohol and other substances

that promote cognitive and behavioral disinhibition (eg, references 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 quite likely results in a decrease in frontal lobe function (ie, hypoactivation of the frontal lobes due to circadian effects, sleep loss/sleep deprivation, and/or sleep inertia) (eg, reference 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 psychosocial resources at night (eg, 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 who 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 (eg, 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 time interval across the 24-hour day may systematically underrepresent the segment of the population of depressed and/or suicidal individuals who are awake during the traditional sleep period and asleep during the day.

Future Directions

Several directions for further research seem possible. First, a large-scale psychological autopsy study could be undertaken to assess the relative contribution of insomnia and/or nightmares, social isolation, and access to substances to the observed finding. Second, within-subject circadian experimental paradigms (with or without quantitative electroencephalography 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 (eg, data sets that have hour by hour data related to online 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 be particularly viable given the results from a recent study by Trockel and colleagues that provides the first evidence that cognitive behavioral therapy for insomnia can significantly reduce suicidal ideation.[27]

Submitted: May 25, 2015; accepted October 26, 2015.

Potential conflicts of interest: The authors certify that they have no actual or potential conflicts of interest in relation to this article.

Funding/support: The study had no direct support by grant funding. Partial salary support was provided by the National Institute on Aging grant R01AG041783 (Drs Perlis and Morales); National Center for Complementary and Alternative Medicine grant R01AT003332 (Drs Perlis and Morales); National Institute of Mental Health grant R01MH077900 (Drs Perlis and Morales), R01MH086572 (Dr Brown), R21MH103963 (Dr Gehrman), and R01MH082794 (Dr Thase); National Institute of Environmental Health Services grant R21ES022931 (Dr Grandner); National Heart, Lung, and Blood Institute grant K23HL110216 (Dr Grandner); National Institute of Nursing Research grant R01NR004281 (Dr Dinges); National Space Biomedical Research Institute grant NCC 9-58 through the National Aeronautics and Space Administration (Dr Basner); and US Department of Veterans Affairs grant IK2CX000855 (Dr Chakravorty).

Role of the sponsor: None.

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