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Timing of suicide in people with epilepsy: A population-based study from 18 states of the United States, 2003–2014☆

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ABSTRACT

Suicide timing varies across several psychiatric disorders, which may share common underlying pathophysiological mechanisms with epilepsy. We investigated suicide timing in people with epilepsy.
Using cross-sectional, population-based U.S. National Violent Death Reporting System data from 2003 through 2014 in 18 States, we identified 1310 suicides with epilepsy and 102,582 suicides without epilepsy among those 10 years and older. We compared patterns of suicide mortality ratios between those with and without epilepsy by month of year, week of month, day of week, time of day, and overall by age, sex, and race/ethnicity. As the suicide patterns seen among persons without epilepsy, suicides in persons with epilepsy occurred significantly more often during the morning, afternoon, and evening hours than at night in all subgroups except females. Compared to Sundays, suicides in persons with epilepsy were only significantly increased on Mondays and Tuesdays in those aged ≥45 years and only on Mondays in men. This pattern differs from persons without epilepsy whose suicides significantly increased on Mondays and significantly decreased on Saturdays in nearly all study subgroups. Suicides in persons with epilepsy did not exhibit the timing patterns of persons without epilepsy by week of month (significant decreases from the third to fifth weeks compared to the first week among those aged ≥45 years, males, and Non-Hispanic whites) and month of year (significant increases from January to November peaking from June to September compared to December in all study groups). Compared to the general population or people without epilepsy, previous and current studies suggest that in people with epilepsy, suicide timing differs from and suicide rates significantly exceed those in people without epilepsy. Preventing suicide in people with epilepsy should focus not only on the peak times of occurrence but also across all time periods.

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1. Introduction

In 2017, more than 47,000 suicides occurred in the United States [1]. Large population-based studies from both U.S. [2] and Europe [3,4] show that people with epilepsy have a higher risk for suicide than those in the general population. Because about 3.4 million people in the U.S. have active epilepsy [5], suicide in people with epilepsy is a public health concern in the U.S. population.

In general, suicide prevention relies on understanding and changing where possible risk factors, such as substance use; mental health conditions; family history of suicide; life stressors, such as physical health, job, financial, and relationship problems; and the periods when people are most at risk/or suicides most often occur [6]. A meta-analysis of 50 years of research found that no single risk factor accurately predicts suicide [7].

Epidemiological study of suicide timing is an important research target for suicide prevention because it may identify vulnerable periods and immediate factors that increase suicide risk. Numerous studies on suicide timing have been conducted in the general population and limited other specific populations such as military personnel [8] or youth [9]. Among patients, suicide timing mainly focuses on those with psychiatric illness or mental health problems (e.g., mood disorder [10], major depressive disorder [11,12], schizophrenia [11], or alcoholism [13]). A more prominent seasonal suicide pattern occurs in those with psychiatric disorders (e.g., depression) than in those without such a diagnosis [10]. Evidence of bidirectional relationships between epilepsy and psychiatric disorders (depression, anxiety, psychosis, and suicide) also suggests that epilepsy and psychiatric disorders may share common underlying pathophysiological mechanisms [14]. Nevertheless, no study has explored suicide timing among people with epilepsy. Most previous studies on suicide timing in those with psychiatric disorders considered

Abbreviations: NCDR-CRS, National Child Death Review Case Reporting System.

☆ **Disclaimer:** The findings and conclusions of this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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only some time categories or specified subpopulations. Therefore, we used suicide data from 2003 through 2014 in the 18 states that participated in the U.S. National Violent Death Reporting System (NVDRS) to compare suicide timing patterns among persons with and without epilepsy by time of day, day of week, week of month, month of year, and overall by age group, sex, and race/ethnicity. This study aimed 1) to distinguish suicide timing patterns in those with and without epilepsy; 2) to discuss possible reasons for specific suicide timing patterns; and 3) to propose prevention measures based on these patterns for suicide among people with epilepsy.

2. Methods

2.1. Data source

Study cases come from the NVDRS, a U.S. population-based, active surveillance system that collects data on all violent deaths in participating states [15]. The NVDRS provides participating states and communities with comprehensive, accurate, and timely information about violent deaths to aid in their prevention. The NVDRS compiles hundreds of characteristics about violence-related deaths from death certificates, medical examiner/coroner reports, and law enforcement records. Trained state data abstractors summarize text narratives describing further details about the death and take into account information from all source documents and the circumstances surrounding the death. These abstractors determine the final classification of manner of death including suicide in NVDRS after reviewing all available case materials and being consistent with the manner of death on at least one primary data source. Estimated time of occurrence of injury for suicides including year, month, week day, and hour was determined according to standardized coding guidance developed by U.S. Centers for Disease Control and Prevention (CDC). At the time of data analysis, data from eighteen states from 2003 through 2014, including about one-third of the U.S. population were available. Suicide data were collected from 2003 to 2014 in seven States (Alaska, Maryland, Massachusetts, New Jersey, Oregon, South Carolina, and Virginia), from 2004 to 2014 in six states (Colorado, Georgia, North Carolina, Oklahoma, Rhode Island, and Wisconsin), from 2005 to 2014 in three states (Kentucky, New Mexico, and Utah), from 2011 to 2014 in Ohio, and from 2014 in Michigan.

2.2. Identification of suicide

Suicide in the NVDRS is defined as a death resulting from the use of force against oneself when a preponderance of the evidence indicates that the use of force was intentional. This definition also includes deaths of persons who intended only to injure rather than to kill themselves, deaths associated with risk-taking behavior without clear intent to inflict fatal injury but associated with a high risk for death (e.g., "Russian roulette"), and deaths involving others' passive assistance to the decedent (e.g., supplying the means or information needed to complete the act). This definition excludes deaths caused by chronic or acute substance abuse without the intent of dying and deaths attributed to autoerotic behavior (i.e., self-strangulation during sexual activity). The NVDRS uses the following International Classification of Diseases, 10th edition (ICD-10) diagnostic codes from death certificates for suicide identification: X60–X84 and Y87.0 [16]. This analysis includes suicides among those 10 years or older because determining suicidal intent in younger children can be difficult [17].

2.3. Identification of suicides in persons with epilepsy

To identify epilepsy among suicide decedents in NVDRS, we searched text fields that originated from death certificates, medical examiner/coroner records, law enforcement reports, and abstractors' narratives/descriptors using the following keywords and phrases: "epilepsy", "seizure", "convulsion", "drop attack", "falling out spell", and "staring spell". These keywords and phrases have been validated as ways to identify those with possible epilepsy in different kinds of population-based surveys [18–20]. We also identified suicide decedents with epilepsy by searching for the following epilepsy/seizure-related ICD-10 codes: G40 (epilepsy), G41 (status epilepticus), and R56 (convulsions, not elsewhere classified) in both the underlying cause of death and the first ten multiple cause of death conditions recoded on the death certificate. Finally, we read abstractors' narratives/descriptors among those initially identified as having epilepsy who died by suicide from overdose/poisoning and were able to exclude 45 suicide decedents whose seizures were not associated with epilepsy but with drugs or other poisons that cause seizures (i.e., drug-induced seizures).

2.4. Classification of the time categories

We examined the time of suicide for the following calendar periods: month of year, week of month, day of week, and time of day. Suicides were counted each month to investigate the timing of suicide during the months of year; each week of the month (grouping the days into seven-day periods within a month) to learn the timing of suicide during days of the month; each day of the week to distinguish suicides during weekdays and on weekends; and four equal periods during a day to investigate suicide's daily cycle: night (midnight–05:59 am); morning (6:00 am–11:59 am); afternoon (noon–5:59 pm); and evening (6:00 pm–11:59 pm).

2.5. Calculation of suicide rates in the study populations

We calculated suicide rates and rate ratios by calendar periods in persons with and without epilepsy and by age, sex, and race/ethnicity. To estimate suicide rates in the overall population, we counted numerators as the total number of suicide in 18 states that were part of NVDRS from 2003 to 2014 by each calendar period. We used data collected by the U.S. Census Bureau and tabulated in the CDC Wide-ranging Online

Table 1
Distribution of selected demographic characteristics of suicide decedents aged 10 years and older by epilepsy status from the U.S. National Violent Death Reporting System,[a,b] 18 States, 2003–2014.

	Suicide decedents with epilepsy			Suicide decedents without epilepsy		
	N	%	95% CI	N	%	95% CI
Age (years)						
10–17	33	2.5	1.8–3.4	3306	3.2	3.1–3.3
18–29	213	16.3	14.4–18.3	19,247	18.9	18.5–19.0*
30–44	437	33.4	30.9–36.0	26,792	26.1	25.9–26.4*
45–64	511	39.1	36.5–41.7	37,128	36.2	35.9–36.5*
≥65	114	8.3	7.3–10.3	16,010	15.6	15.4–15.9*
Sex						
Males	825	63.0	60.4–65.5	80,880	78.8	78.6–79.1
Females	485	37.0	34.5–39.6	21,702	21.2	20.9–21.4*
Race/ethnicity						
Non-Hispanic White	1103	84.3	82.3–86.2	86,174	84.1	83.9–84.3
Non-Hispanic Black	64	4.9	3.9–6.1	6886	6.7	6.6–6.9*
Other race/ethnicity[c]	141	10.8	9.2–12.5	9428	9.2	9.0–9.4

[a] Suicide data were collected from 2003 to 2014 in seven States (Alaska, Maryland, Massachusetts, New Jersey, Oregon, South Carolina, and Virginia); from 2004 to 2014 in six states (Colorado, Georgia, North Carolina, Oklahoma, Rhode Island, and Wisconsin); from 2005 to 2014 in three states (Kentucky, New Mexico, and Utah); from 2011 to 2014 in Ohio; and from 2014 in Michigan.

[b] The different case totals by age, sex, and race-ethnicity are because of missing values in some groups.

[c] The other race/ethnicity category includes Hispanics and other non-Hispanic groups (American Indians, Alaskan Natives, Asians, Pacific Islanders, other races, and multiracial groups).

* The corresponding comparison groups between people with and without epilepsy whose 95% confidence intervals did not overlap were considered as statistically significant.

Data for Epidemiologic Research (WONDER) to obtain counts of the population aged 10 years and older [21]. The denominators were overall person-years of the population at risk from all participating states and all participating years. In addition, the denominators of population size were adjusted after subtracting half of the number of suicide, assuming that persons who died from suicide during a specific year contributed only 0.5 person-year to that year. Since there are unequal numbers of days in each month of the year and in the fifth week of the month, we used person-days of the population at risk as the denominator in calculating the suicide rate for each calendar period.

2.6. Statistical analysis

Suicide mortality rates for each calendar period were compared to the rate in the corresponding reference group to estimate relative mortality rate ratios. Reference groups included the last calendar periods for each time category (except for week of month as only 0–3 days occur in the last week of some months, and the sample size in this period is relatively small). The relevant groups included the following: December (last month of the year); the first week of the month; Sunday (last day of the week); and night (last six-hour period of a day). Mortality rate ratios with 95% Poisson confidence intervals excluding 1.00 were considered statistically significant.

3. Results

CDC Human Subjects (IRB) review was not required for NVDRS because it received a non-research determination and data comes from deceased persons.

3.1. Sample characteristics

From 2003 through 2014, NVDRS identified 103,892 suicides decedents in 18 states among those 10 years of age or older. Among them, 1310 met epilepsy criteria ("persons with epilepsy") and 102,582 did not ("persons without epilepsy"). Suicide decedents with reported epilepsy compared with those without epilepsy were more often females (37% vs. 21%) or 30–64 years old (33–39% vs. 26–36%) but were less often younger (aged <18–29 years; 16% vs. 19%) or older (≥65 years old; 8% vs. 16%) or non-Hispanic black (5% vs. 7%) (all $p < 0.05$) (Table 1).

3.2. Suicide timing patterns among persons with or without epilepsy in selected subgroups by age, sex, and race

3.2.1. By time of day

Compared to the night, suicide mortality ratios among persons with epilepsy were significantly higher (10% to 91%) from most subgroups except females during the morning (except for those aged 10–44 years), afternoon (peaking in the afternoon), or evening hours (Fig. 1). This timing pattern is similar to that among persons without epilepsy; compared to the night, suicide mortality ratios were significantly higher (20% to 120%) in all subgroups during the morning (except for those aged 10–44 years), afternoon (peaking in the afternoon), or evening hours. ($p < 0.05$) (Fig. 1).

3.2.2. By day of the week

Compared to Sundays, suicide mortality ratios among persons with epilepsy were significantly higher by 34–58% on Mondays and Tuesdays only among those ≥45 years old and on Monday only in males ($p < 0.05$) (Fig. 2). However, compared to Sundays, suicide mortality ratios in persons without epilepsy were significantly higher by 7–24% on Monday and/or Tuesday in all subgroups but those of 10–44 years old, and were significantly lower by 5–7% on Saturday in all subgroups ($p < 0.05$) (Fig. 2).

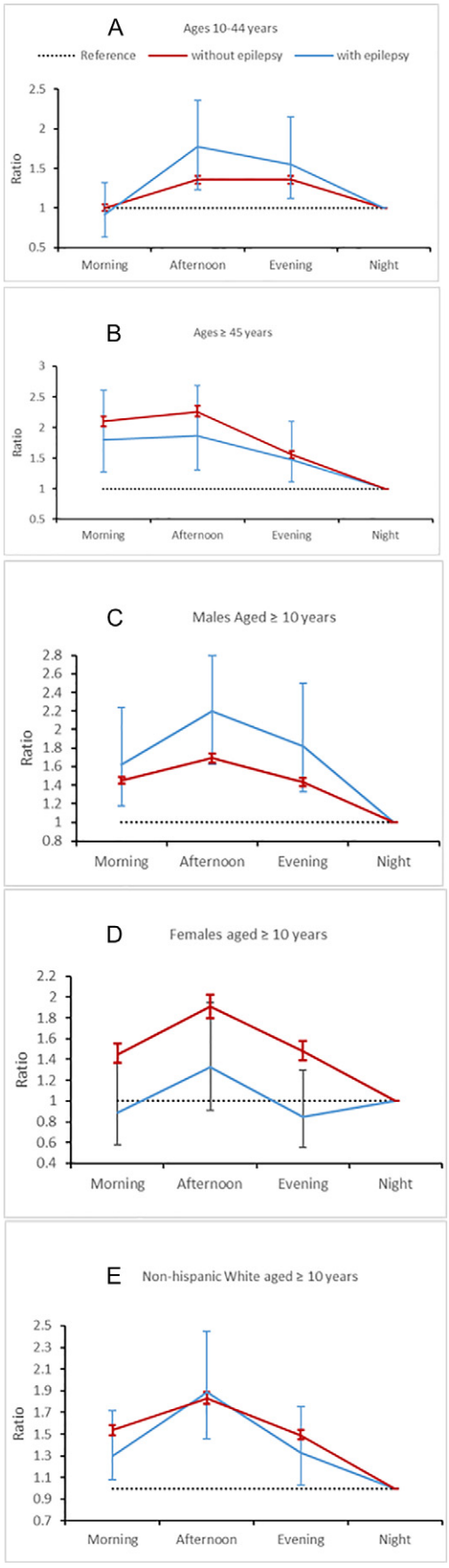
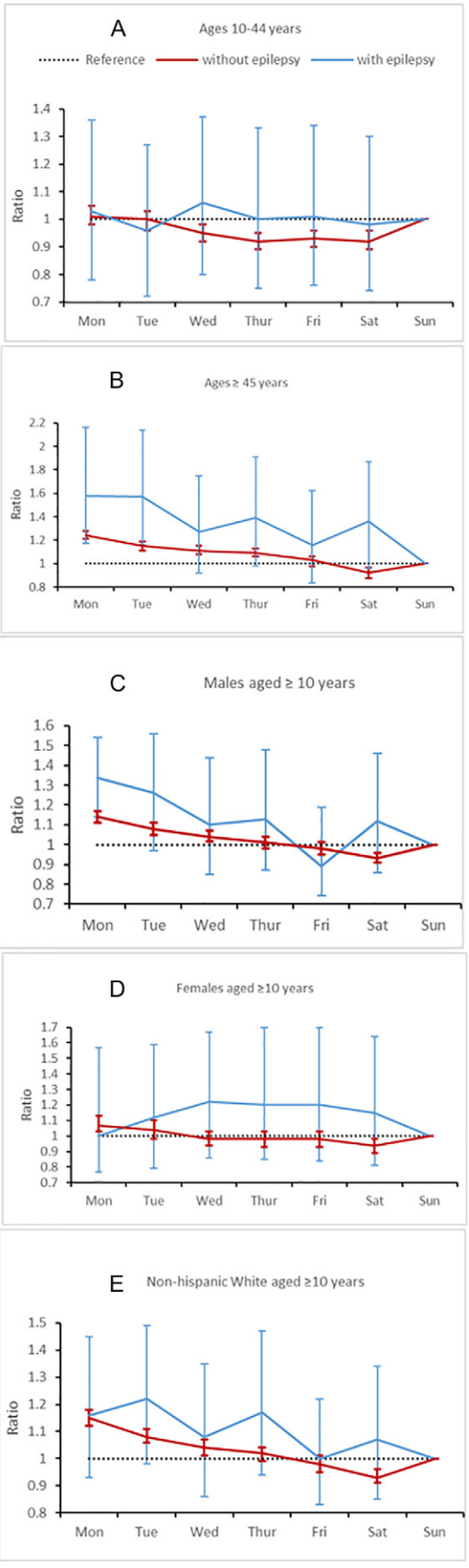


Fig. 1. Suicide mortality ratios associated with time of day among groups with selected characteristics by epilepsy status: U.S. National Violent Death Reporting System, 18 states, 2003–2014.



3.2.3. By week of the month

Compared to the first week of the month, suicide mortality ratios from the second to the fifth week among persons with epilepsy did not differ statistically significant among all subgroups (Fig. 3). However, compared to the first week of the month, suicide mortality ratios among persons without epilepsy were significantly lower by 3–8% from the third to the fifth weeks ($p < 0.05$) among those ≥45 years old, males, and Non-Hispanic whites (Fig. 3).

3.2.4. Monthly during the year

Compared to December, suicide mortality ratios among persons with epilepsy from January to November did not differ statistically significantly in all subgroups (Fig. 4). However, compared to December, suicide mortality ratios among persons without epilepsy were significantly higher from January to November by 6–21% ($p < 0.05$), peaking from June to September before falling in all subgroups (Fig. 4).

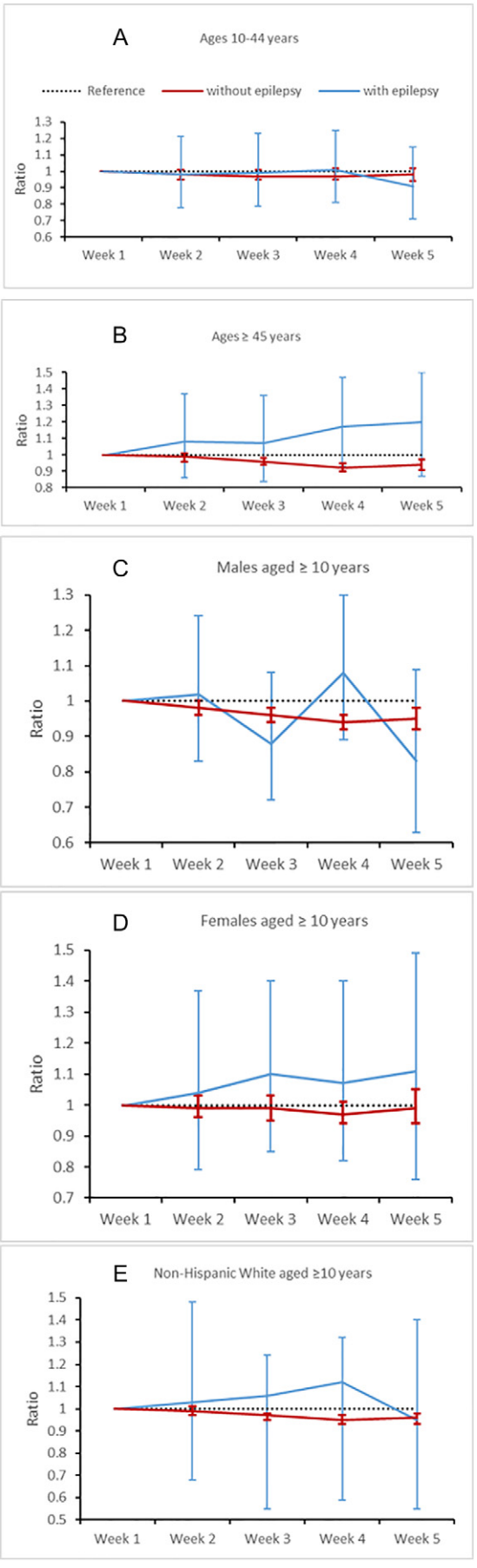
4. Discussion

This study used suicides in those without epilepsy as a comparison group for suicides in those with epilepsy, considering suicide timing patterns. Because the number of suicides in those with epilepsy (n = 1310) is only 1.3% of all suicide decedents (n = 103,892) in the current study, the suicide timing patterns among the remaining persons without epilepsy is considered to mirror suicide timing patterns in the general population [22]. Suicides in persons without epilepsy occur significantly more often during the morning, afternoon (peak), and evening hours than at night in most study groups; significantly increase on Mondays and decrease on Saturdays in nearly all study groups when compared to Sundays; significantly decrease from the third to fifth week of the month compared to the first week in most of the study groups; and significantly increase from January to November with peaks from June to September when compared to December in all study groups. These suicide timing patterns are compatible with the "broken promise" theory proposed to explain observed increased risks for suicide at the beginning of new time cycles such as season, month, week, and after holidays [23]. This theory assumes that every new cycle develops expectations for individual fulfillment, which, when unfulfilled, increases the risk for suicide. Other mechanisms, explaining the suicide timing patterns among people without epilepsy in this study such as demographic, socioeconomic, and cyclical social factors have also been described [22,24].

To the best of our knowledge, this is the first study to explore suicide timing among people with epilepsy. Except for females, persons with epilepsy had the same suicide timing pattern by time of day as persons without epilepsy. By day of the week, suicide timing patterns for persons with epilepsy partially coincided with these patterns for persons without epilepsy but only among those aged 45 years and older and males. Suicides in persons with epilepsy did not exhibit the similar monthly or the weekly suicide timing patterns as persons without epilepsy. The external risk factors described above may influence suicide timing patterns in people with epilepsy through internally unique bioclimatic or endogenous biological factors to explain varying suicide timing patterns in suicide decedents with epilepsy.

Previous studies found a more prominent seasonal suicide pattern in those with psychiatric disorders than in those without such a diagnosis [10]. Studies on specified mental disorders from Europe and North America also suggested different suicide timing patterns when compared to the general population [25–27]. On the molecular level, a seasonal variation in brain serotonin turnover with the highest values during spring and summer has been found in healthy men [28], and suicide seasonality has been correlated with the seasonality pattern of a group of mental disorders [29]. Brain serotonin transporter promoter

Fig. 2. Suicide mortality ratios associated with day of week among groups with selected characteristics by epilepsy status: U.S. National Violent Death Reporting System, 18 states, 2003–2014.



polymorphism and its triallelic genotypes differ among U.S. Whites, Black, and other races [30] and may account for the different suicide timing patterns by race/ethnicity [22]. These imply that changes in brain neurotransmitters responding to environmental and social stimulations in each mental disorder may differ [31] from those changes in the general population, which may lead to different suicide timing patterns.

In a systematic review, patients with epilepsy were comorbid with broad psychiatric disorders including depression, anxiety, bipolar disorder, psychosis, and suicide ideation and attempt [32]. Moreover, large population-based studies from national survey data found bidirectional relationships between epilepsy and psychiatric disorders (depression, anxiety, psychosis, and suicide). These findings suggest that there are common underlying pathophysiological mechanisms that both lower seizure threshold and increase risk for psychiatric disorders and suicide [14,33]. Therefore, suicide timing associated with epilepsy and variation in suicide could manifest itself differently in persons with different psychopathology and physiopathology.

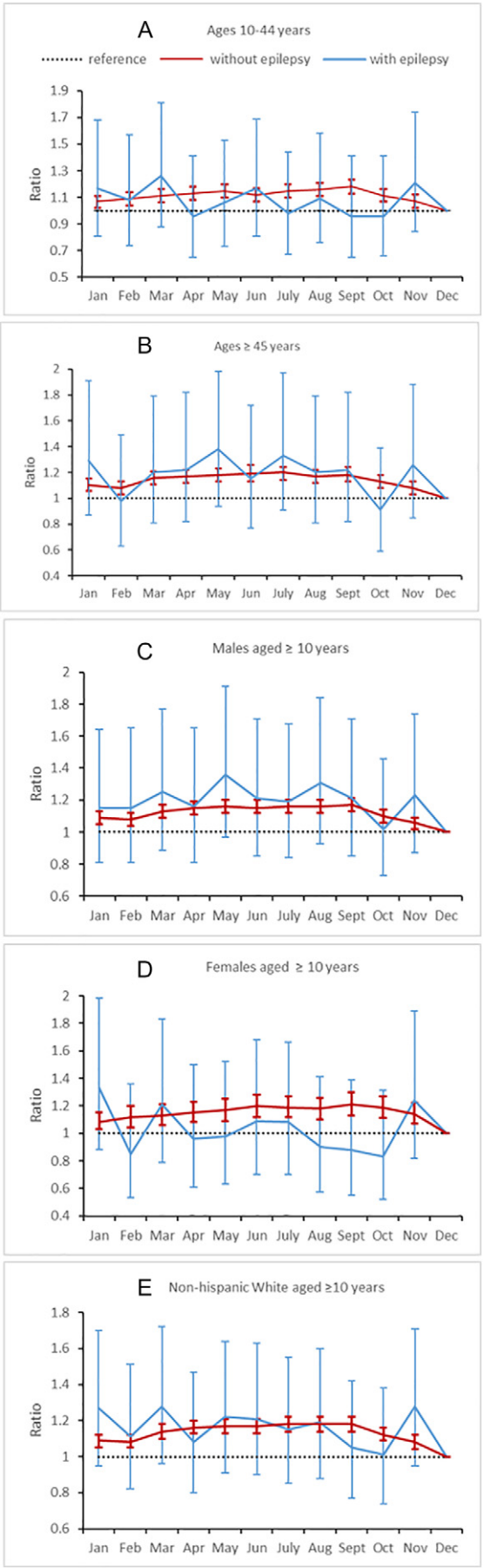
4.1. Strength and limitations

The major strength of this study is that we used the high quality and large population-based U.S. NVDRS data with different time categories and multiple sources of suicide information to study the spectrum of suicide timing among people with epilepsy. Another strength is that suicide timing patterns comparison between people with and without epilepsy were within the same general population. This study also has several limitations. One major limitation is the small number of suicide decedents in persons with epilepsy (n = 1310), reducing the statistical power to show differences in time periods among those with epilepsy. Some of the null effects observed could be because of the relatively lower power to detect differences in this group. This is particularly problematic when comparing different time periods by race-ethnicity (Supplemental Table 1). However, because non-Hispanic whites accounted for 84% of suicides in both those with and without epilepsy, the major findings were not affected, and the relative standard error of all reported relative mortality ratios was less than 30%. In addition, the sample sizes in the time category by time of day did not significantly differ from those in other time categories and still seemed to show a stable time pattern when compared to those without epilepsy. Altogether, these indicate that the overall results have an acceptable reliability. The second limitation of this study is possible misclassification of epilepsy/seizure among suicide decedents. Our searching methodology with unspecific epilepsy-related keywords could overestimate the number of epilepsy cases. However, suicide in persons with epilepsy is usually under-reported and thus, underestimated. This underestimation could balance the possible bias [2]. In fact, the selection criteria for epilepsy/seizure that we used have been validated [20] and used in large population-based studies [2,22]. Third, because our study is based on only 18 states' data, it does not reflect the whole U.S. population. Fourth, because 12 of these 18 states are located in the eastern U.S., suicide timing patterns in other parts of the U.S. may differ because suicide timing may be influenced by the weather [34,35]. Finally, only 44% of the suicides had data recorded on the time of death during the day; however, a study using NVDRS data from 2003 through 2010 in 16 U.S. states found no statistically significant differences between those with and without a reported time of death by age, sex, race/ethnicity, and education [36].

5. Conclusions and recommendations

By contrasting the suicide timing patterns among those with and without epilepsy from the same general population, we found that by

Fig. 3. Suicide mortality ratios associated with week of month among groups with selected characteristics by epilepsy status: U.S. National Violent Death Reporting System, 18 states, 2003–2014.



time of day, all but females with epilepsy had the same suicide timing patterns. By day of week, suicide timing patterns among those with epilepsy only partially match those without epilepsy. Suicides in persons with epilepsy did not exhibit the similar monthly or the weekly suicide timing patterns as persons without epilepsy. Exploration of other endogenous bioclimatic or biological mechanisms in determining suicide timing patterns among people with epilepsy may be valuable to further suicide research and prevention, especially among those with other comorbid mental disorders. Future efforts to explore endogenous factors regarding the timing of suicide in people with epilepsy should target populations with specified mental disorders.

Suicide is a significant public health problem in the general population, including people with epilepsy. Evidence-based, comprehensive strategies and approaches that focus across individual, relationship, family, community, and societal levels developed by the CDC for suicide prevention in the general population [37] are also applicable to people with epilepsy [38,39]. Because substantially more people are hospitalized as a result of nonfatal suicidal behavior (i.e., suicide attempts) than are fatally injured, and an even greater number are either treated in ambulatory settings (e.g., emergency departments) or not treated at all [40], clinicians in epilepsy clinics are encouraged to screen for existing psychiatric or mental disorders in their patients with epilepsy [41] to prevent suicide. Finally, our study reveals that the timing patterns disappeared in most categories among people with epilepsy when compared to those without epilepsy (i.e., or the mirror of general population). Together with fact that suicide rate in people with epilepsy is 3 times higher than that in the general population [2–4], prevention and intervention in people with epilepsy should focus not only on suicide peak times but on all time periods (e.g., especially in the afternoon).

Supplementary data to this article can be found online at https://doi.org/10.1016/j.yebeh.2019.07.022.

Declaration of Competing Interest

None.

Acknowledgments

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Author contributions

NT, MZ, and DH were involved in study design. MZ and NT analyzed the data. NT wrote the manuscript. All authors have critically reviewed and revised the article and approved the final version for submission.

References

[1] Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS). Mortality in the United States, 2017. Available from: https://www.cdc.gov/nchs/products/databriefs/db328.htm. [Accessed May 26, 2019].
[2] Tian N, Cui W, Zack M, Kobau R, Fowler KA, Hesdorffer DC. Suicide among people with epilepsy: a population-based analysis of data from the U.S. National Violent Death Reporting System, 17 states, 2003-2011. Epilepsy Behav 2016;61:210–7.
[3] Christensen J, Vestergaard M, Mortensen PB, Sidenius P, Agerbo E. Epilepsy and risk of suicide: a population-based case-control study. Lancet Neurol 2007;6:693–8.
[4] Bell GS, Gaitatzis A, Bell CL, Johnson AL, Sander JW. Suicide in people with epilepsy: how great is the risk? Epilepsia 2009;50:1933–42.

Fig. 4. Suicide mortality ratios associated with month of year among groups with selected characteristics by epilepsy status: U.S. National Violent Death Reporting System, 18 states, 2003–2014.

[5] Zack MM, Kobau R. National and state estimates of the numbers of adults and children with active epilepsy - United States, 2015. MMWR Morb Mortal Wkly Rep 2017;66:821–5.
[6] Stone DM, Simon TR, Fowler KA, Kegler Scott R, Yuan Keming, Holland Kristin M, et al. Vital signs: trends in state suicide rates - United States, 1999–2016 and circumstances contributing to suicide - 27 states, 2015. MMWR Morb Mortal Wkly Rep 2018;67:617–24.
[7] Franklin JC, Ribeiro JD, Fox KR, Bentley KH, Kleiman EM, Huang X, et al. Risk factors for suicidal thoughts and behaviors: a meta-analysis of 50 years of research. Psychol Bull 2017;143:187–232.
[8] Rothberg JM, Jones FD. Suicide in the U.S. Army: epidemiological and periodic aspects. Suicide Life Threat Behav 1987;17:119–32.
[9] Nakamura JW, McLeod CR, JF Jr McDermott. Temporal variation in adolescent suicide attempts. Suicide Life Threat Behav 1994;24:343–9.
[10] Postolache TT, Mortensen PB, Tonelli LH, Jiao X, Frangakis C, Soriano JJ, et al. Seasonal spring peaks of suicide in victims with and without prior history of hospitalization for mood disorders. J Affect Disord 2010;121:88–93.
[11] Kim CD, Lesage AD, Seguin M, Chawky N, Vanier C, Lipp O, et al. Seasonal differences in psychopathology of male suicide completers. Compr Psychiatry 2004;45:333–9.
[12] Zung WW, Green Jr RL. Seasonal variation of suicide and depression. Arch Gen Psychiatry 1974;30:89–91.
[13] Bradvik L, Berglund M. Seasonal distribution of suicide in alcoholism. Acta Psychiatr Scand 2002;106:299–302.
[14] Hesdorffer DC, Ishihara L, Mynepalli L, et al. Epilepsy, suicidality, and psychiatric disorders: a bidirectional association. Ann Neurol 2012;72:184–91.
[15] Blair JM, Fowler KA, Jack SP, Crosby AE. The National Violent Death Reporting System: overview and future directions. Inj Prev 2016;22(Suppl. 1):i6–11.
[16] Centers for Disease Control and Prevention. National Violent Death Reporting System (NVDRS). Coding manual revised [Online], Atlanta, GA. www.cdc.gov/injury; 2016. [Accessed May 26, 2019].
[17] Crepeau-Hobson F. The psychological autopsy and determination of child suicides: a survey of medical examiners. Arch Suicide Res 2010;14:24–34.
[18] Centers for Disease Control and Prevention. Epilepsy in adults and access to care — United States, 2010. MMWR Morb Mortal Wkly Rep 2012 Nov 16;61(45):909–13.
[19] Anderson DW, Schoenberg BS, Haerer AF. Prevalence surveys of neurologic disorders: methodologic implications of the Copiah County study. J Clin Epidemiol 1988;41:339–45.
[20] Brooks DR, Avetisyan R, Jarrett KM, Hanchate A, Shapiro GD, Pugh MJ, et al. Validation of self-reported epilepsy for purposes of community surveillance. Epilepsy Behav 2012;23:57–63.
[21] Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS). CDC wide-ranging online data for epidemiologic research (CDC WONDER). Available from: http://wonder.Cdc.Gov/bridged-race-v2014.Html. [Accessed May 26, 2019].
[22] Tian N, Zack M, Fowler KA, Hesdorffor DC. Suicide timing in 18 states of the United States from 2003–2014. Arch Suicide Res 2018:1–21.
[23] Gabennesch H. When promises fail: a theory of temporal fluctuations in suicide. Soc Forces 1988;67(1):129–45.
[24] Christodoulou C, Douzenis A, Papadopoulos FC, Papadopoulou A, Bouras G, Gournellis R, et al. Suicide and seasonality. Acta Psychiatr Scand 2012;125:127–46.
[25] Cavanagh B, Ibrahim S, Roscoe A, Bickley H, While D, Windfuhr K, et al. The timing of general population and patient suicide in England, 1997–2012. J Affect Disord 2016;197:175–81.
[26] Bradvik L. The occurrence of suicide in severe depression related to the months of the year and the days of the week. Eur Arch Psychiatry Clin Neurosci 2002;252:28–32.
[27] Bradvik L, Berglund M. A suicide peak after weekends and holidays in patients with alcohol dependence. Suicide Life Threat Behav 2003;33:186–91.
[28] Lambert G, Reid C, Kaye D, Jennings G, Esler M. Increased suicide rate in the middle-aged and its association with hours of sunlight. Am J Psychiatry 2003;160:793–5.
[29] Reutfors J, Osby U, Ekbom A, Nordström P, Jokinen J, Papadopoulos FC. Seasonality of suicide in Sweden: relationship with psychiatric disorder. J Affect Disord 2009;119:59–65.
[30] Williams RB, Bishop GD, Haberstick BC, Smolen A, Brummett BH, Siegler IC, et al. Population differences in associations of serotonin transporter promoter polymorphism (5HTTLPR) di- and triallelic genotypes with blood pressure and hypertension prevalence. Am Heart J 2017;185:110–22.
[31] Yip PS, Yang KC, Qin P. Seasonality of suicides with and without psychiatric illness in Denmark. J Affect Disord 2006;96:117–21.
[32] Titlic M, Basic S, Hajnsek S, Lusic I. Comorbidity psychiatric disorders in epilepsy: a review of literature. Bratisl Lek Listy 2009;110:105–9.
[33] Hesdorffer DC, Hauser WA, Olafsson E, Ludvigsson P, Kjartansson O. Depression and suicide attempt as risk factors for incident unprovoked seizures. Ann Neurol 2006;59:35–41.
[34] Dixon PG, Kalkstein AJ. Where are weather-suicide associations valid? An examination of nine U.S. counties with varying seasonality. Int J Biometeorol 2018;62:685–97.
[35] Hernández OH, Hernández-Sánchez JA, Flores-Gutiérrez JD. Annual fluctuations of sunlight and suicides in a region South of the Tropic of Cancer. Biol Rhythm Res 2018;49(3):405–11.
[36] Perlis ML, Grandner MA, Brown GK, Basner M, Chakravorty S, Morales KH, et al. Nocturnal wakefulness as a previously unrecognized risk factor for suicide. J Clin Psychiatry 2016;77:e726–33.
[37] Stone DM, Holland KM, Bartholow B, Crosby Alex, Davis Shane, Wilkins Natalie, et al. Preventing suicide: a technical package of policies, programs, and practices. Atlanta, GA: National Center for Injury Prevention and Control, Centers for Disease Control and Prevention. Available from: https://www.cdc.gov/violenceprevention/pdf/suicideTechnicalPackage.pdf; 2017. [Accessed May 26, 2019].
[38] U.S. Department of Health and Human Services (HHS) Office of the Surgeon General and National Action Alliance for Suicide Prevention. National strategy for suicide prevention: goals and objectives for action. Washington, D.C.: HHS; September; 2012; 2012.
[39] World Health Organization. Suicide prevention: a global imperative. Geneva, Switzerland: WHO Press; 2014.
[40] Crosby AE, Han B, Ortega LA, Parks Sharyn E, Gfroerer Joseph. Suicidal thoughts and behaviors among adults aged ≥18 years — United States, 2008–2009. MMWR CDC Surveill Summ 2011;60(13):1–22.
[41] Bell G, Sander J. Suicide and epilepsy. Curr Opin Neurol 2009;22:174–8.