Unintentional injury fatalities in the context of rising U.S. suicide rates: A five-year review of the web-based injury statistics query and reporting system

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ARTICLE INFO	ABSTRACT
	This archival study focuses specifically on suicide fatalities in relation to unintentional and undetermined injury fatalities in an effort to determine whether or not these rates are rising consistently. This question may serve to inform whether or not suicides are being accurately reported and documented. Data from all 50 states from the years 2012–2016 were obtained from the Web-based Injury Statistics Query and Reporting System (WISQARS) developed by the Centers for Disease Control and Prevention. A total of 213,726 suicide fatalities, 702,176 unintentional injury fatalities, and 24,533 undetermined injury fatalities comprised the dataset. Injury fatality rates depicted annual increases in both suicide and unintentional injury fatalities but variability in undetermined injury fatalities. Bivariate analyses discovered a statistically significant association between annual suicide fatality rates and unintentional (nonsuicidal) injury fatality rates. It would be suspected, ceteris paribus, that calculated rate changes over these years would follow suit. However, this was not observed. Given the trends and increasing stigma surrounding suicide, it is worth considering the degree to which suicides may be under-reported or -documented and the epidemiological and translational ramifications of these trends as they pertain to future suicide research.

1. Introduction

Suicide is often broadly defined as intentional self-harm intended to and resulting in death. The United States (U.S.) alone has observed consistent annual increases in suicide rates, with the current rate being the highest it has been in 50 years (Drapeau and McIntosh, 2020). Further, the rate of suicide attempts has increased by 250% in global conflict zones over the past 18 years (Shoib and Kim, 2019). However, there are clear issues with this broad definition due to suicide attempts (SAs) during which the individual's life does not end, which may be due to nonlethal means or rapid medical intervention. Intentionality is a key philosophical and psychological component but cannot always be determined by outside investigators or even consciously by the suicidal individual (Münster and Broz, 2016). Impulsivity is also a heterogeneous concept that harbors inaccurate implications as it relates to suicide (Cole et al. 2019). Suicidal thoughts and behaviors (STBs) come in many forms, including not only SAs but nonsuicidal self-injury (NSSI) and other risk-taking behaviors such as drug and alcohol use

(Ammerman et al. 2016), reckless driving (Start et al. 2018), and hostile behavior (McKinney et al. 2017). These behaviors are provoked by psychosocial stressors and associated with suicide deaths (Athey et al., 2018).

Suicide rates are known to peak in the summer months and drop in winter months (Kim et al., 2004; Sawa et al., 2016). Interestingly, the effects of sunshine are thought to implicate the serotonergic system, though one study found that the relationship between suicide and sunshine became non-significant when controlling for season. This relationship became significant among individuals undergoing selective serotonin reuptake inhibitor treatment (Makris et al., 2016). College students experience more suicidal ideation in the summer and attempts in late spring and early summer. Perceived belongingness was a factor that seemed to contribute to this seasonal association (Van Orden et al., 2008). In terms of fatal injuries, approximately one-third of motor vehicle-related deaths in Iran occur in the summer months (Khorshidi et al., 2016). Traffic-related traumatic brain injuries in the Slovak Republic have also been noted to be highest in the summer

months (Taylor et al., 2020). The U.S. follows this trend, such that motor vehicle accidents peak in the summer rather than the winter (Rau et al., 2018). In fact, one study found that warm temperatures that extend beyond the norm are associated with increased injury fatalities (Parks et al., 2020), such that summer appears to be a consistently risky time of year for both suicide deaths and injury fatalities.

Noteworthy are the complex, bidirectional associations between biological and psychological components on suicide risk. Changes in these risk factors both impact and are impacted by the external environment, which is often comprised of recursive events that have variable impacts across individuals. In fact, one study found that those who experience the death of loved ones by suicide experience long-term emotional turmoil, presenting as its own risk factor for their own suicides (Pompili et al., 2013). This is important because it is estimated that 135 people are exposed to each suicide death, resulting in roughly 6.9 million exposed survivors each year (Cerel et al., 2018). From a neurobiological perspective, serotonergic system alterations is one of the most common findings in suicide research, including expression of 5-hydroxytryptamine (5-HT) receptor subtypes, downregulation of brain-derived neurotrophic factor (BDNF), and epigenetic alterations such as histone and deoxyribonucleic acid (DNA) methylation modifications (Gould et al., 2017). These findings suggest that depressed individuals, suicide attempters, and those who die by suicide may exhibit distinct biomarkers. These serotonergic disturbances are thought to be met with compensatory mechanisms involving thyroid and hormones and prolactin (Pompili et al., 2012). For example, free triiodothyronine (FT3) tests, which assess thyroid function, have been found to distinguish between suicide attempters and non-attempters, such that attempters are 2.27 times less likely to have higher FT3 values than non-attempters (Pompili et al., 2012). Further, sex, suicidal status, and their interaction were found to have statistically significant effects on prolactin levels independent of FT3 values, suggesting that biological mechanisms extend beyond 5-HT and BDNF. Thus, vast extant literature suggests that a complex interplay of recursive biological mechanisms may indicate suicide risk and eventually predict this behavior in those at risk.

There are injurious causes of death noted on WISQARS such as poisoning (general), suffocation, and drowning that may be misrepresented due to an inability for a medical examiner to determine the decedents' intentions. Further, a study of veterans found that approximately one-third of suicide attempters had no mental health diagnoses (Ursano et al. 2018). Approximately 50% of older individuals who die by suicide are believed to have had physical health problems that precipitated the act, resulting in controversy in cause of death if suicide is unclear or ambiguous (Choi et al. 2019). Overdoses may be included in poisonings and the other causes of death are also known to be ranked in the top five of suicide methods. However, the most common cause of reported suicide deaths is firearms, which is arguably easier to determine intention – or the individual who used the firearm – for both law enforcement investigators and medical examiners.

Ward and colleagues (2011) discovered significant differences between the circumstances reported in medical examiner and police reports, including alcohol or drug dependence, financial considerations, and recent familial deaths, suggesting that this lack of continuity and integration serves to reduce overall reporting statistics that could improve prevention tactics. Other evidence supports that death certificates are inconsistent with Centers for Disease Control and Prevention (CDC) Guidelines between 20% and 85% of the time across U.S. hospitals (Lloyd et al., 2017), which is no different than the suicide classification difficulties published by the CDC over three decades ago (CDC, 1988). Other studies, however, have found concordance between classifications and vital statistics (Gatov et al., 2018).

The National Violent Death Reporting System (NVDRS) is one such effort utilized to compile data on specific causes of death with the use of such variables as whether or not a suicide note was left by the decedent (Karch et al., 2009). However, Ward et al. (2011) reported that validity and reliability issues remained questionable, as suicide notes are one of very few pieces of evidence that can truly verify a suicide decedent's intentions prior to the act. In highly vulnerable populations, such as the military, self-reports and open communication regarding ideation is often limited if not absent, such that limited evidence may exist to suggest intent to die even if they would be predicted to be ideators (Anestis et al. 2017; Vannoy et al. 2016).

With the incessantly rising suicide rates in the U.S. remaining at a relatively steady percentage of total deaths across all causes, it is worth considering where other increases are located (Drapeau and McIntosh, 2016; Web-Based Injury Statistics Query and Reporting System [WISQARS], 2018). Furthermore, it is a warranted speculation that suicide rates are likely higher than those reported due to a multitude of factors. This article focuses specifically on suicide fatalities as they relate to unintentional and undetermined injury fatalities deemed nonsuicidal in an effort to determine whether or not these rates are rising consistently with those attributed to suicide. It is hypothesized that, if associations between suicide and undetermined injury fatalities exist and suicides are being reported appropriately, these rates will also be associated. However, with a rise in concern related to suicide and substantial growth in extant literature on the subject, this may not be the case.

2. Methods

Data for the current retrospective study were obtained from the CDC Web-Based Injury Statistics Query and Reporting System (WISQARS, 2018) for years 2012-2016. Data from all 50 states were included in the data set. Statistics pertaining specifically to suicide deaths were corroborated with data disseminated by the American Association of Suicidology (AAS; Drapeau and McIntosh, 2015a, 2015b, 2015c, 2016, 2017), also obtained directly from the CDC's WISQARS and NVSR, at which time small discrepancies were located in regards to number of suicide deaths but these differences did not alter the suicide rates as a measure of deaths per 100,000 individuals. In any situation in which differences were found, WISQARS data was utilized rather than those reported in a secondary fashion by AAS.

2.1. Demographic Variables

Demographic variables via WISQARS are limited but include injury fatalities of individuals from all demographic categories. Homicidal injury fatalities were not included, which account for a smaller percentage of injury fatalities each year than suicide and unintentional injury fatalities deemed nonsuicidal. Data are reported in total numbers as well as by age group but this study did not look specifically at age groups when comparing the fatality groups. However, crude rates of injury fatalities from 2012–2016 by age group are illustrated in Fig. 1. Ethnicity and sex were investigated to the degree possible within the database, as ethnicity is associated with health disparities and causes of death. WISQARS data included Caucasian, African American, American Indian, and Asian/Pacific Islander ethnic groups, allowing for comparisons beyond crude numbers and rates. A specific Latinx group was not available through this database. Education was also not stratified and results in a limitation to subsequent interpretations.
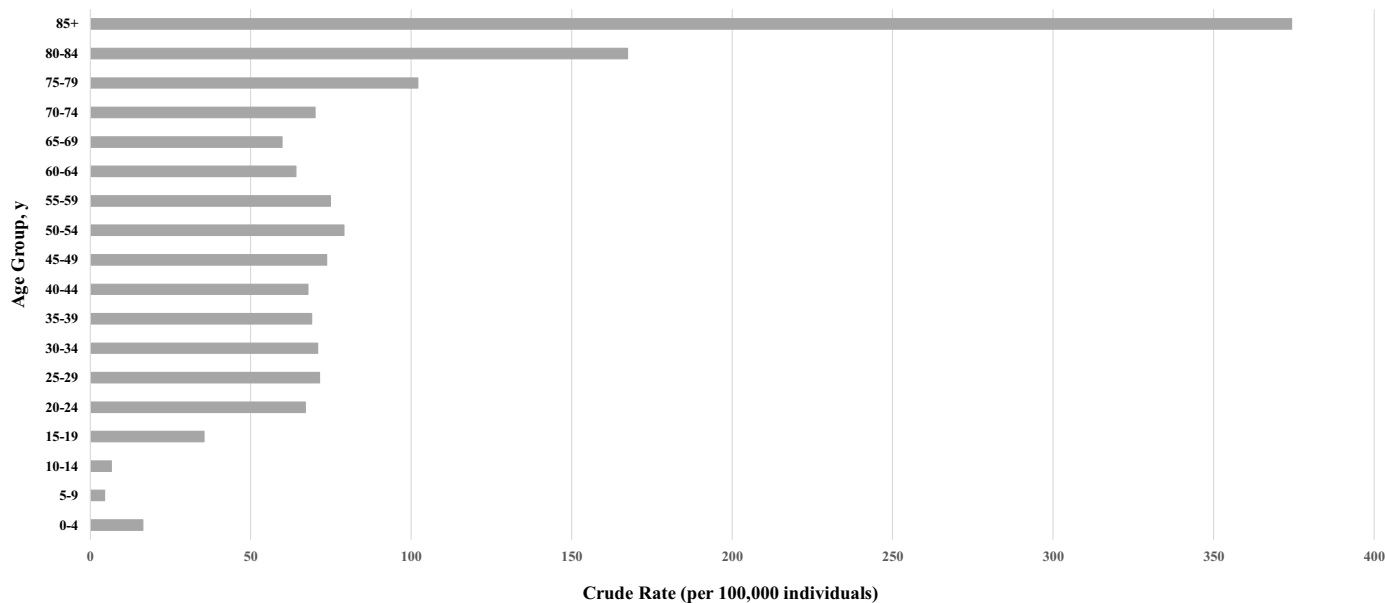
Fig. 1. Crude rates of injury fatalities from 2012–2016 by age group.

Table 1
WISQARS injury fatality count data.

Year	Total Injury Fatalities	Suicide Fatalities	Unintentional Injury Fatalities	Undetermined Injury Fatalities
2012	190,385	40,600	127,792	4,737
2013	192,945	41,149	130,557	4,584
2014	199,752	42,826	135,928	4,595
2015	213,981	44,189	146,553	4,914
2016	231,954	44,962	161,346	5,723
Totals	1,029,017	213,726	702,176	24,553

Table 2
WISQARS injury fatality rate data (per 100,000 people).

Year	Suicide Death Rate	Unintentional Injury Fatality Rate	Undetermined Injury Fatality Rate
2012	12.9	40.7	1.5
2013	13.0	41.3	1.4
2014	13.4	42.7	1.4
2015	13.8	45.7	1.5
2016	13.9	49.9	1.8

3. Results

3.1. Descriptive Statistics

This data set, over the five-year span of 2012–2016, included 213,726 deaths attributed to suicide, 702,176 deaths attributed to unintentional injuries (i.e., motor vehicle accidents, assault, falls, poisoning), and 24,533 deaths attributed to undetermined injuries – each group being mutually exclusive and falling under the CDC's broader spectrum of fatal injuries. Also included was the total injury fatality count for each year, which would include the noted causes as well as homicide and other causes (Table 1). The fatality rates per 100,000 individuals for each year were also organized, illustrating annual

increases in both suicide and unintentional injury fatalities but variability in undetermined injury fatalities (Table 2).

3.2. Bivariate Analysis

There was a mean rate change of 0.25% in suicide fatalities and unintentional injury fatalities exhibited a mean rate change of 2.30%. There existed a mean rate change of undetermined injury fatalities of 0.125%. Therefore, the average rate change was nine-fold greater for unintentional injury fatalities than suicide fatalities. To corroborate this by comparing rates from 2012 and 2016 alone, the suicide fatality rate rose by 1.0% while the unintentional injury fatality rate rose by 9.2%.

Pearson correlations suggested a statistically significant association between the average rates of suicide fatalities and unintentional injury fatalities from 2012-2016 ($p = .024$) but neither group was associated with average rates of undetermined fatalities (Table 3). When reviewing crude death counts across all five years, the association remained significant between these two groups ($p = .015$) and became significant between unintentional injury fatalities and undetermined injury fatalities ($p = .028$). Interestingly, comparison of rate changes from 2012 to 2016 did not reveal statistically significant associations between groups, not even between suicide rate change and unintentional injury rate change ($p = .089$).

Table 3
Pearson correlations for relevant variables from 2012–2016.

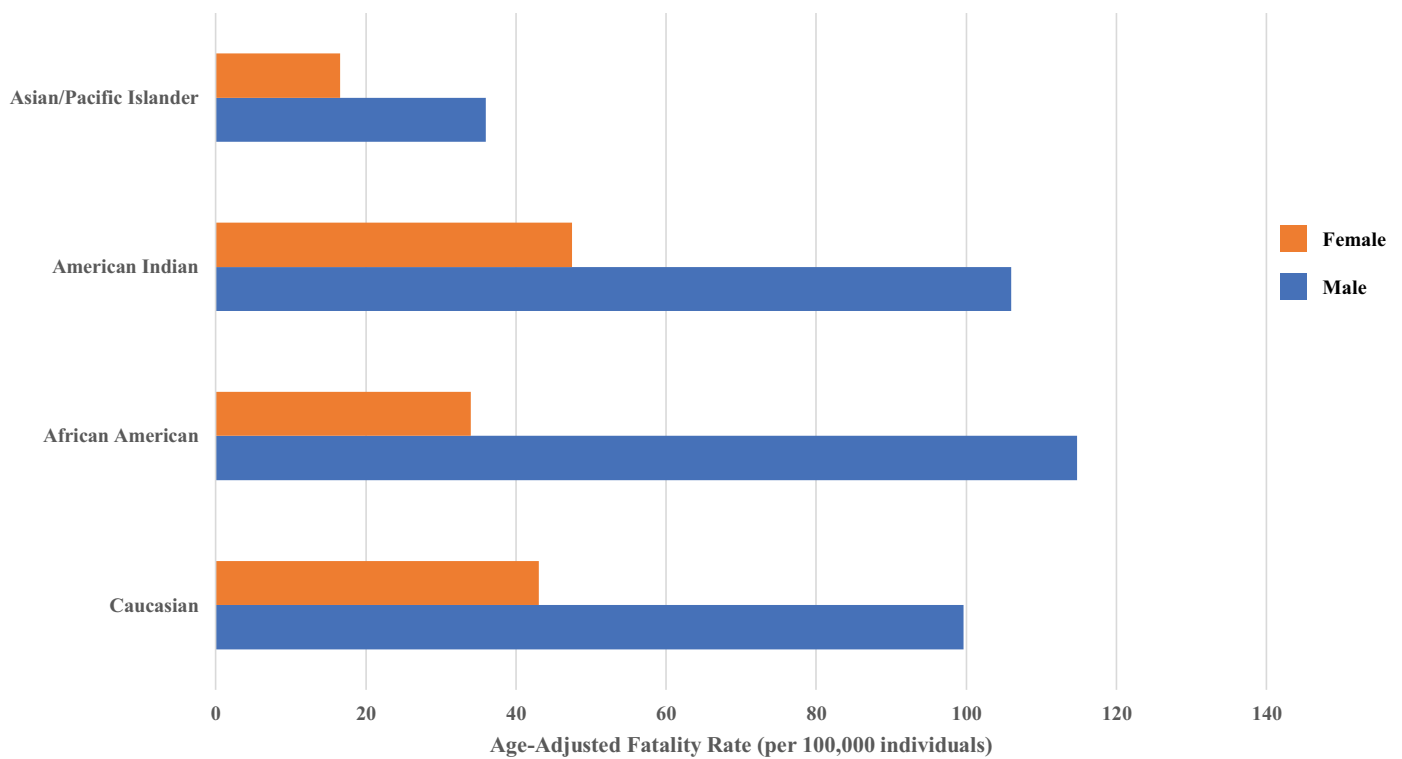| Variable	1	2	3	4	5
1. Suicide fatality counts	–	–	–	–	–
2. Unintentional injury fatality counts	.947*	–	–	–	–
3. Unintentional injury fatality rates	.940*	1.000**	–	–	–
4. Unintentional injury fatality rate change	.971*	.988*	.987*	–	–
5. Suicide fatality rate change	.156	-.200	-.212	.820	–

* $p < 0.05$;
** $p < 0.001$

Fig. 2. Age-adjusted fatality rates by ethnicity and sex, 2016.

3.3. Injury Fatality Rates by Ethnicity and Sex

Caucasian males are reported as those with the highest rates of suicide in the U.S. by a significant margin (Drapeau and McIntosh, 2017), though age-adjusted fatality rates extracted from the WISQARS, represented in Fig. 2, suggest ethnicity- and sex-dependent factors playing roles in this conclusion. This database did not include a distinct Latinx group, limiting the data to Caucasians, African Americans, American Indians, and Asian American/Pacific Islander. Caucasian males ranked third in terms of injury fatality rate in 2016.

African American males demonstrated the highest injury fatality rate than any other group in 2016 (114.74 per 100,000). American Indian females were ranked fourth (47.45 per 100,000), higher than all other female groups as well as Asian American/Pacific Islander males. Table 4 reports rate changes in injury fatality rates by ethnicity, showing that the rate of African Americans rose by 26.93% - the greatest change of any ethnic group. While American Indians still exhibited the highest injury fatality rate in 2016, the increase over five years was significantly lower than African American and Caucasian (17.40%) groups.

Table 4
WISQARS injury fatality rates by ethnicity (per 100,000 people).

Year	Caucasian	African American	American Indian	Asian American/ Pacific Islander
2012	60.40	56.73	68.90	23.60
2013	60.62	57.13	65.49	22.94
2014	62.33	58.01	67.98	23.01
2015	66.01	63.81	72.01	24.71
2016	70.91	72.01	76.46	25.66
2012–16 Change	17.40%	26.93%	10.97%	8.73%

3.4. Effects of New Data

From 2012–2016, we have observed an average increase of 1,090.50 suicide deaths. If this average change in crude suicide deaths remained constant over time, the year 2020 would end with 49,324 suicide deaths. However, according to the AAS (2018; 2020), both 2017 and 2018 have already exceeded these estimates by 1,120.5 and 1,201, respectively. Increases in suicide deaths in recent years have more than doubled the average increase observed from 2012–2016. If extended to 2018, the average rate change equals 1,691, suggesting that suicide deaths in 2020, if this extended trend remains relatively consistent, will equate to 51,726 – a 27.4% increase since 2012. However, these rates are crude estimates and likely to continue rising in the context of coronavirus disease 2019 (COVID-19), increased anxiety and mood disturbances, and greater difficulty in receiving care in the midst of a different, infectious disease pandemic (Reger, Stanley, and Joiner, 2020). While suicide has remained the tenth-leading cause of death in the U.S., it may very well increase in the ranks along with COVID-19, rising above deaths due to kidney disease and other causes of death (Drapeau and McIntosh, 2020).

4. Discussion

This analysis discovered that suicide fatality rates are strongly associated with unintentional injury fatality rates, the latter of which are deemed nonsuicidal in nature. Therefore, it would be suspected, ceteris paribus, that rate changes over five years would follow suit – this was not found to be the case. Instead, there must be extraneous variables impacting the degree to which injury fatalities are being deemed suicidal and nonsuicidal. Over the course of five years, suicide fatalities have remained fairly consistent relative to total U.S. population deaths while there has been an ongoing increase in unintentional injury fatalities relative to this same population. When considering

confounding, age, educational attainment, and time of year are three possibilities that were not included in this retrospective study. It will be important for future studies to focus more specifically on these variables, as both young and older ages are associated with risk of falls and educational attainment is associated with socioeconomic status, ethnicity, and other important variables.

It may also be speculated that suicide deaths are underreported or, more likely, misreported as unintentional injuries. There may exist sociopolitical pressures involved, including an understandable ethical concern with reporting a suicide when intention is unclear. Previously noted causes of death such as poisoning (general), suffocation, and drowning that may be misrepresented following autopsy, should the psychological and psychiatric history not be considered or, conversely, regarded as a requirement to verify suicides. Therefore, these intentions should be thoroughly reviewed by those certified to engage in these investigations to better serve not only families of decedents but the research community striving to reduce injury-related deaths both suicidal and nonsuicidal in nature.

In the investigation of deaths, it is critical to question the cause of death if intention is unclear. Psychological autopsy should play a more universal role in these situations in an effort to better represent the suicide deaths occurring in the U.S. This standardized technique requiring specialized training offers direct exposure to data that can aid in determining whether or not a suicide death was intentional from the perspective of the decedent (Cavanagh et al., 2003). While this may not always be the case, evidence related to behaviors of suicide decedents prior to death suggests that there will exist specific antecedents (Nock et al., 2017), better informing medical examiner reports that may otherwise label the death an unintentional injury, overdose, drowning, or other causes of death. In doing so, the epidemiological aspect of suicide can proceed with fewer inaccuracies – a necessity if the field is to move toward metadata and machine learning techniques at a population level.

4.1. Strengths and limitations

Several limitations are present, as this is a retrospective analysis of CDC WISQARS data and is limited by the demographic information available in the public domain, introducing confounding. Misclassification can occur in respect to groups (e.g., ethnicity, age, injury type) and the level of evidence derived from retrospective studies of this kind serves as a limiting factor that would not be of concern with other study designs. Secondly, the database utilized inadequately integrated Latinx groups, significantly limiting the study's ability to report on this marginalized group. Third, educational attainment is a component excluded from the dataset that would further inform interpretation. Fourth, the causes of nonsuicidal unintentional fatalities are highly variable across age groups with some of these causes having no overlap across age groups. This prevented a deeper analysis of causes that may be reported higher as a whole. Further, it is not possible to determine the specific factors noted that are impacting these findings due to the complex nature of death reporting by individual states and the general multitude of possibilities.

In spite of the confronted limitations, injury fatalities, including suicide, are relatively common occurrences. This offers a larger sample size that can offset some of the limitations posed by retrospective studies. WISQARS is a commonly-utilized database that offers the opportunity to view data in various forms and analyze to the degree possible. While confounding cannot be avoided, this study illuminates several areas for growth and improvement in suicide research, such as factors related to ethnicity, sex, death reporting, and how between-group data should be reported to ensure clarity in clinical settings. In the absence of important data points and adequate reporting, clinicians are limited in their abilities to target those at greatest risk.

5. Conclusions

There exist clear associations between unintentional injury fatalities and suicide deaths, with interesting rate discrepancies over the course of time that may be related to confounds noted in this article, as well as others that may not be on our radars. Importantly, these findings highlight areas in need of improvement. Inaccurate information on the global cause of death posed by suicide may result in future research efforts in epidemiology and prevention being misguided and, worse, inhibited from substantial progress in the areas of secondary and tertiary prevention methods. The accurate reporting of injury-related deaths is critical to future suicide research so that it may reflect the true nature of suicide deaths occurring in society – this is arguably necessary if we are to offset its current upward trend.

Author Statement

Jack C. Lennon was responsible for the initial conceptualization, data curation, formal analysis, project administration, writing, and editing of this original manuscript.

Informed consent

The relevant Institutional Review Board (IRB) deemed this analysis exempt. CDC's WISQARS data is publicly-available data for the use in secondary analyses. All WISQARS data is de-identified and no counts of human subjects in this data set were 10 or fewer, ensuring that privacy and confidentiality are maintained.

Human and animal rights in informed consent

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/ or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Cited articles contain studies with human and/or animal work approved by institutional review boards prior to publication.

Data Use

Data use restrictions are noted on the site to be utilized (https:// wisqars-viz.cdc.gov:8006). "The Public Health Service Act (42 U.S.C. 242m(d)) provides that the data collected by the National Center for Health Statistics (NCHS) may be used only for the purposes for which they were obtained; any effort to determine the identity of any decedent, or to use the information for any purpose other than for health statistical reporting and analysis, is against the law." Guidelines pertaining to confidentiality in the context of publicly-available archival data require exclusion of any counts of human subjects ≤ 10 from both basic reports of raw data as well as from any subsequent analyses.

Declaration of Competing Interests

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