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Trends in the Incidence and Lethality of Suicidal Acts in the United States, 2006 to 2015

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IMPORTANCE Understanding changes in the incidence rates and lethality of suicidal acts may explain increasing suicide rates.

OBJECTIVE To examine trends in the incidence rates and lethality of suicidal acts from 2006 to 2015 among persons aged 10 to 74 years.

DESIGN, SETTING, AND PARTICIPANTS This cross-sectional study was conducted from May 2, 2018, to January 30, 2019. Medically treated nonfatal suicide attempts were identified from the 2006 to 2015 Nationwide Inpatient Sample and Nationwide Emergency Department Sample databases. Suicides were identified from the 2006 to 2015 mortality files of the National Vital Statistics System.

MAIN OUTCOMES AND MEASURES The incidence rate of suicidal acts was calculated by dividing the number of total suicidal acts by the US population. Lethality was measured through the case fatality rates (CFRs) of suicidal acts by dividing the number of suicides by the total number of suicidal acts.

RESULTS A total of 1 222 419 (unweighted) suicidal acts, which included both suicides and nonfatal suicide attempts, were identified from 2006 to 2015. Overall, the incidence rates of total suicidal acts increased 10% from 2006 to 2015 (annual percentage change [APC], 0.8%; 95% CI, 0.3%-1.3%), and the CFRs of suicidal acts increased 13% during the 2006 to 2015 period (APC, 2.3%; 95% CI, 1.3%-3.3%). In subgroup analyses, incidence rates increased by 1.1% (95% CI, 0.6%-1.6%) per year for female individuals during the 2006 to 2015 period but remained stable for male individuals. The CFRs increased for both sexes (APC, 5.0% [95% CI, 3.1%-6.9%] since 2010 for female individuals; 1.6% [95% CI, 0.6%-2.5%] since 2009 for male individuals). Incidence rates increased among adolescents from 2011 to 2015 and among older adults aged 65 to 74 years throughout the 2006 to 2015 period. Conversely, the CFRs increased since 2009 among persons aged 20 to 44 years (APC, 3.7%; 95% CI, 2.5%-5.0%) and since 2012 for those aged 45 to 64 years (APC, 2.7%; 95% CI, 0.0%-5.4%). Persons aged 20 to 44 years and 45 to 64 years experienced increases in suicidal acts by more lethal means, whereas adolescents and older adults aged 65 to 74 years showed increased incidence by all means.

CONCLUSIONS AND RELEVANCE This study found increased suicidal acts among female persons, adolescents, and older adults aged 65 to 74 years, implying the need to address emerging or exacerbating suicide risk factors for these populations. The findings on the increased lethality particularly among persons aged 20 to 64 years highlighted the need to reduce access to materials that could be used as lethal means among persons at risk of suicide. These findings on population-level epidemiologic patterns can be used to guide the development of comprehensive suicide prevention strategies.

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Author Audio Interview

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Suicide is the tenth leading cause of death in the United States, claiming more than 47 000 lives in 2017.[1] Age-adjusted suicide rates increased 33% from 1999 to 2017.[2] The increase occurred for both sexes and for ages 10 to 74 years.[2] Moreover, the increase in suicide has been a factor in declining life expectancy for 3 years in a row.[3-5] However, the reasons behind this increase remain unclear.

Suicidal acts can be fatal (referred to as suicides hereafter) or nonfatal (referred to as suicide attempts hereafter). Many suicides are preceded by 1 or more suicide attempts.[6] In 2017, there were approximately 10 times as many emergency department (ED) visits for nonfatal self-harm as there were suicides in the United States.[1] The risk of death, or lethality, varies among suicidal acts. Thus, suicide rates may be affected by both incidence and lethality of suicidal acts. Effective suicide prevention efforts must be informed by an understanding of whether increased suicide rates are associated with more suicidal acts, greater lethality of suicidal acts, or a combination of both.

A number of studies indicated greater incidence of suicide attempts among certain adult subgroups and youth (**Table 1**).[7-13] Other research demonstrated changing patterns in means used for suicide over time.[14] Between 2000 and 2010, the rate of suicide by suffocation increased 52% compared with a 19% increase in suicide by poisoning and a 3% increase in firearm-related suicides in the US.[14] Thus, the lethality of suicidal acts, which largely depends on the means used, may be affected.[15] However, to date, no studies have examined the trends in both incidence and lethality of suicidal acts to understand the association between suicide rates and these 2 factors.

Consequently, this study analyzed the trends in both the incidence and lethality of suicidal acts in the US from 2006 to 2015 among persons aged 10 to 74 years.

Key Points

Question Are increases in suicide rates associated with more suicidal acts, suicidal acts becoming more lethal, or a combination of both?

Findings In this cross-sectional study based on national representative data of 1 222 419 suicidal acts, increased suicide rates were associated with an increase in both incidence rates and lethality of suicidal acts from 2006 to 2015. In subgroup analyses, incidence of suicidal acts increased among female persons, adolescents, and older adults aged 65 to 74 years, whereas suicidal acts became more lethal among both sexes and persons aged 20 to 64 years.

Meaning These findings on population-level epidemiologic patterns may advance the understanding of suicide trends to guide prevention efforts.

Methods

This cross-sectional study, which was conducted from May 2, 2018, to January 30, 2019, examined medically treated suicide attempts and suicides among persons aged 10 to 74 years. This age range was selected because ascertaining the intent to self-harm among children younger than 10 years is difficult,[16] and suicide rates were higher in 2017 than in 1999 among individuals between 10 and 74 years of age but not among those 75 years or older.[2] According to the Centers for Disease Control and Prevention's institutional review board policy, this study was exempt from review because it used publicly available data.

Nonfatal Medically Treated Suicide Attempts

We identified suicide attempts that were treated at EDs or hospitals using data from the 2006 to 2015 Nationwide Emergency Department Sample (NEDS) and Nationwide Inpatient Sample (NIS).[17,18] Both NEDS and NIS are large, nationally representative, all-payer databases containing data on ED and hospital medical encounters. We used NEDS to estimate the number of suicide attempts that were treated in the ED but did not result in admission, and NIS to estimate suicide attempts that resulted in admission.

Suicide attempts had *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) codes of E950 to E958. We categorized these suicide attempts according to the means used: firearm (*ICD-9-CM* codes E955.0 to E955.4); suffocation, predominantly by hanging (*ICD-9-CM* code E953); poisoning, by drug overdose or by other substances (*ICD-9-CM* codes E950 to E952); and other (*ICD-9-CM* codes E954, E955.5 to E955.9, and E956 to E958). The other category comprised cutting (70%), drowning (0.3%), jumping (2%), and miscellaneous (28%) means. Each of these means accounted for less than 3% of all suicides. Given that the implication of other means for the overall suicide trend is small, we did not analyze these means individually. Persons who used multiple means (approximately 2% of all attempts) were categorized according to the most lethal means recorded (eg, firearm, suffocation, poisoning, or other). After the adoption of the *International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM)* coding schema in October 2015, suicide attempt rates showed some abrupt changes, which were likely attributable to the coding switch.[19] Thus, we estimated the number of suicide attempts in 2015 by multiplying the counts in the first 3 quarters by four-thirds to extrapolate counts for the whole year.[20] Based on the 2006 to 2014 data, we found that case fatality rates (CFRs) and incidence rates calculated from extrapolated counts differed from the true rates by less than 5% in relative terms, and thus the bias should be minimal.

We initially included 980 519 suicide attempts in the study. Patients who transferred to another hospital (n = 90 181) were excluded to avoid duplicate counts. Patients with a deceased status at discharge (n = 8951) were excluded, assuming they were captured as suicides in death records. To be conservative, we also excluded patients with unknown death status at discharge (n = 14 338), leaving 867 049 (unweighted) suicide attempts in the study.

Suicides

We identified suicides from the 2006 to 2015 multiple cause-of-death mortality files of the National Center for Health

Table 1. Summary of Studies on the Trends in Suicide Attempts in the United States

Source	Outcome measure	Study period	Study population	Setting	Data source	Findings
Olfson et al,[7] 2017	Suicide attempts in the 3 y before the interview	2004-2005 to 2012-2013	Adults aged ≥21 y	Self-report	National Epidemiologic Survey on Alcohol and Related Conditions	Rates of suicide attempts increased from 0.62% in 2004-2005 to 0.79% in 2012-2013 in the US. Among subgroups, the rates increased for adults aged 21-34 y, those of non-Hispanic white and black race/ethnicity, and those with ≤ high school education.
Olfson et al,[8] 2015	Rate of hospital-treated self-harm events	2001-2011	All ages	Hospitalizations	Nationwide Inpatient Sample	Hospital-treated self-harm events increased from 5.5-7.1 per 10 000 population among middle-aged adults (45-64 y) but not among other age groups.
Han et al,[9] 2018	12-mo Prevalence of suicidal ideation and suicide attempts	2009-2015	Young adults aged 18-25 y	Self-report	National Survey on Drug Use and Health	Prevalence of suicidal ideation increased overall, for both men and women, and for all racial/ethnic groups. Prevalence of suicide plan increased overall, for both men and women, and for non-Hispanic white individuals. Prevalence of suicide attempt increased overall, for women, and for non-Hispanic white individuals.
Mercado et al,[10] 2017	Rates in emergency department (ED) visits for self-inflicted injuries	2001-2015	Individuals aged 10-24 y	ED visits	National Electronic Injury Surveillance System—All Injury Program	Overall rates of ED visits for self-inflicted injuries increased 5.7% annually during 2008-2015. The rates increased for all age groups among female individuals but were stable for male individuals
Plemmons et al,[11] 2018	Emergency and inpatient encounters for suicidal ideation and suicide attempts	2008-2015	Children and adolescents aged 5-17 y	ED visits, observation stays, and hospitalizations	Pediatric Health Information System database, which included data from 49 children's hospitals in the US	Percentage of all visits for suicidal ideation or suicide attempts increased from 0.66% to 1.82%. Significant increases were noted in all age groups and for both girls and boys.
Burstein et al,[12] 2019	Pediatric ED encounters for suicidal ideation or suicide attempts	2007-2015	Children aged 5-17 y	ED visits	National Hospital Ambulatory Medical Care Survey ED database	Proportion of all pediatric ED encounters for suicidal ideation or suicide attempts increased from 2.17% to 3.50%.
Kalb et al,[13] 2019	ED visits for suicide attempts	2011-2015	Individuals aged 6-24 y	ED visits	National Hospital Ambulatory Medical Care Survey ED database	ED visit rates for suicide attempts or self-injuries increased from 4.6 to 11.7 visits per 1000 persons among adolescents (aged 12-17 y) but not among children (aged 6-11 y) or young adults (18-24 y).

Statistics' National Vital Statistics System.[21] These suicides had *ICD-10* codes of U03, X60 to X84, and Y87.0 as the underlying cause of death. Similar to the classification of suicide attempts, suicides were categorized by the means used: firearm (*ICD-10* codes X72 to X74), suffocation (*ICD-10* code X70), poisoning (*ICD-10* codes X60 to X69), and other (*ICD-10* codes U03, X71, X75 to X84, and Y87.0).

Primary Outcomes

To calculate the incidence rates, we obtained population counts from the Centers for Disease Control and Prevention's bridged-race population estimates.[22] Lethality was measured using the annual CFR.[23] The primary outcomes were the annual incidence rate of total suicidal acts and the CFR. The annual incidence rate was calculated as follows: incidence rate of total suicidal acts = (number of total suicidal acts/US population estimates) × 100 000. The CFR was calculated as follows: CFR = (number of suicides/number of total suicidal acts) × 100.

Statistical Analysis

We conducted all analyses with SAS, version 9.1.3 (SAS institute Inc), and SUDAAN, version 11.0.1 (Research Triangle Institute), to account for the complex sample design of NEDS and NIS. Appropriate trend weights were applied to the 2006 to 2011 NIS data because of the NIS redesign of sampling methods in 2012.[24] The incidence rates of total suicidal acts were age adjusted to the 2000 US census population. The CFRs were age adjusted by the age-group distributions among total suicidal acts in 2006. Joinpoint regression software (National Cancer Institute) was used to assess trends in (1) the incidence rates of total suicidal acts, (2) the CFRs of total suicidal acts, and (3) the incidence rates of total suicidal acts by means. We used the annual percentage change (APC), a measure of relative percentage, to describe the rate of change for each identified linear trend and average annual percentage change, a summary measure, to describe the average rate of change over the entire 2006 to 2015 study period. We examined all trends by sex

Table 2. Characteristics of Nonfatal Medically Treated Suicide Attempts and Suicides Among Those Aged 10-74 Years, 2015[a]

Characteristic	Nonfatal medically treated suicide attempts, weighted No. (%)[b]	Suicides, No. (%)	CFR, %
Total	437 000 (100)	40 474 (100)	9
Age, y			
10-19	118 000 (27)	2470 (6)	2
20-44	220 000 (50)	17 313 (43)	7
45-64	90 000 (21)	16 490 (41)	16
65-74	9000 (2)	4201 (10)	31
Sex			
Male	179 000 (41)	30 815 (76)	15
Female	258 000 (59)	9659 (24)	4
Suicide means			
Firearms	2000 (1)	19 282 (48)	90
Suffocation	11 000 (3)	11 485 (28)	51
Poisoning	274 000 (63)	6413 (16)	2
Other	149 000 (34)	3294 (8)	2

Abbreviation: CFR, case fatality rate.

[a] Data from Health Cost and Utilization Project[17,18] and Centers for Disease Control and Preventions.[21]

[b] Weighted numbers for nonfatal medically treated suicide attempts are weighted estimates derived from survey sampling procedures. As of October 1, 2015, the Nationwide Emergency Department Sample and Nationwide Inpatient Sample adopted the *International Classification of Diseases, Tenth Revision, Clinical Modification* coding schema. The number of nonfatal medically treated suicide attempts in 2015 was estimated by multiplying the counts in the first 3 quarters by four-thirds to extrapolate counts for the whole year. The weighted numbers for subgroups may not add to total because of rounding.

and age group (10-19, 20-44, 45-64, and 65-74 years). Analyses were not stratified by race/ethnicity because a large percentage of records were missing the race/ethnicity information in the earlier years of the Healthcare Cost and Utilization Project data. Statistical significance on whether an APC was different from 0 was set at $P < .05$ for a 2-tailed test based on t distribution.

Results

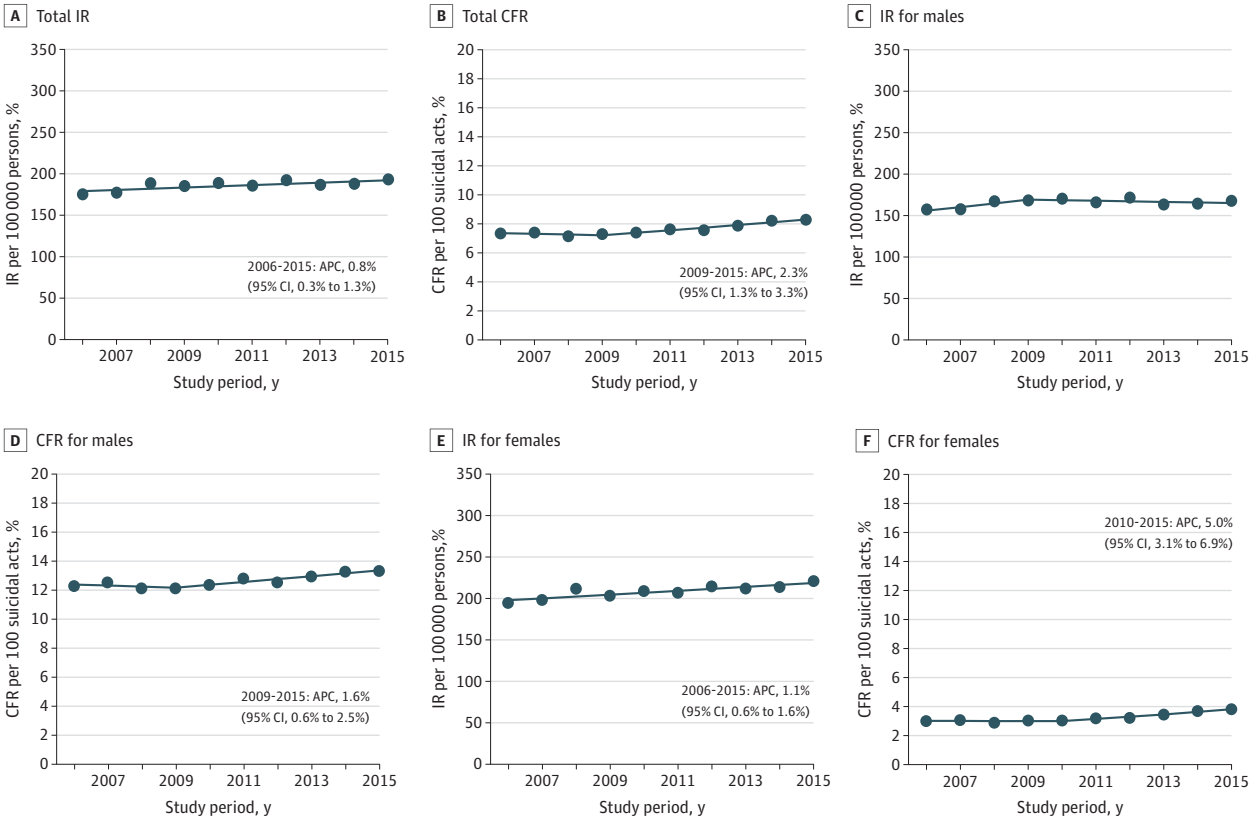
We identified a total of 1 222 419 (unweighted) suicidal acts, which included both suicides and nonfatal suicide attempts from 2006 to 2015. An estimated 437 000 medically treated suicide attempts and 40 474 suicides among persons aged 10 to 74 years were recorded in 2015. Characteristics of suicide attempts and suicides differed by age group, sex, and suicide means (**Table 2**). Among suicide attempts, nearly 80% occurred among people younger than 45 years (10-19 years: 118 000 [27%]; 20-44 years: 220 000 [50%]), 258 000 female individuals (59%) were involved, and the most common means used was poisoning (274 000 [63%]). In contrast, among those who died by suicide, less than 50% were persons younger than 45 years (10-19 years: 2470 [6%]; 20-44 years: 17 313 [43%]), 30 815 male individuals (76%) were involved, and the most common means used was firearm (19 282 [48%]). When CFRs were calculated, suicidal acts by firearms (90%) and suffocation (51%) were more lethal compared with poisoning (2%) or other (2%) means.

Overall, the incidence rate of total suicidal acts increased 10%, from 175.0 per 100 000 persons in 2006 to 193.0 per 100 000 persons in 2015 (APC, 0.8%; 95% CI, 0.3%-1.3%). Similarly, the overall CFR had a relative increase of 13% from 7.3% in 2006 to 8.3% in 2015, with an upward trend during 2009 to 2015 (APC, 2.3%; 95% CI, 1.3%-3.3%). The incidence rates increased 1.1% (95% CI, 0.6%-1.6%) per year throughout the 2006-2015 period for female individuals, but no statistically significant trends were observed for male individuals. The CFRs increased for both sexes, but the increase was more rapid for female individuals (APC, 5.0% [95% CI, 3.1%-6.9%] since 2010 for female individuals vs 1.6% [95% CI, 0.6%-2.5%] since 2009 for male individuals) (**Figure 1**). From 2006 to 2015, a general increase was seen in the incidence of suicidal acts by firearm, suffocation, and other means, but not by poisoning for overall and for both sexes. In particular, suicidal acts by suffocation increased remarkably at 8.2% (95% CI, 7.0%-9.3%) per year throughout the study period among female individuals. (**Table 3**).

Trends in the incidence rates and the CFRs of suicidal acts varied across age groups. Among adolescents aged 10 to 19 years, incidence rates were stable until 2011 and then increased sharply (APC, 7.9%; 95% CI, 5.4%-10.5%). Meanwhile, the CFRs among adolescents remained stable throughout the study period. Although trends varied over time, since 2010 the incidence rates decreased for persons aged 20 to 44 years (APC, -2.3%; 95% CI, -4.6% to -0.0%) and were stable for those aged 45 to 64 years. However, the CFRs increased since 2009 for persons aged 20 to 44 years (APC, 3.7%; 95% CI, 2.5%-5.0%) and since 2012 for those aged 45 to 64 years (APC, 2.7%; 95% CI, 0.0%-5.4%). Among persons aged 65 to 74 years, incidence rates increased from 2006 to 2009 (APC, 5.9%; 95% CI, 2.7%-9.2%) and then at a slower pace from 2009 to 2015 (APC, 2.5% [95% CI, 1.6%-3.4%], whereas CFRs decreased from 2006 to 2015 (APC, -0.8%; 95% CI, -1.5% to -0.1%) (**Figure 2**).

Among adolescents, the incidence rates of suicidal acts increased by all means, particularly after 2011. Similarly, for persons aged 65-74 years, incidence rates for suicidal acts

Figure 1. Incidence Rates (IRs) and Case Fatality Rates (CFRs) of Suicidal Acts in Persons Aged 10 to 74 Years



The IRs were age-adjusted to the 2000 US census population, and the CFRs were age-adjusted by the age-group distributions among total suicidal acts in 2006. Dots indicate observed rates, and lines indicate modeled rates. Annual percentage changes (APCs) are presented only for the significant trends at $P < .05$. The IR of total suicidal acts increased 10% from 2006 to 2015 (APC, 0.8%; 95% CI, 0.3%-1.3%), and the CFR also had an upward trend from 2009 to 2015 (APC, 2.3%; 95% CI, 1.3%-3.3%). The IR increased (APC, 1.1%; 95% CI, 0.6%-1.6%) from 2006 to 2015 for suicidal acts in female individuals, but no significant trends were observed for acts in male persons. The CFR increased for both male individuals (APC, 1.6%; 95% CI, 0.6%-2.5%) from 2009 to 2015 and for female individuals (APC, 5.0%; 95% CI, 3.1%-6.9%) from 2010 to 2015. Data from Health Cost and Utilization Project[17,18] and Centers for Disease Control and Prevention.[21,22]

increased by all means from 2006 to 2015. However, throughout the study period, for persons aged 20 to 44 years, the incidence rates increased for suicidal acts by firearm (APC, 1.6%; 95% CI, 0.9%-2.2%), suffocation (APC, 4.0%; 95% CI, 3.2%-4.8%), and other means (APC, 0.8%; 95% CI, 0.2%-1.3%), but rates of poisoning were stable from 2006 to 2010 and then decreased (APC, -4.4%; 95% CI, -7.1% to -1.7%). Similar incidence increases by means occurred for those aged 45 to 64 years: firearm (APC, 2.8%; 95% CI, 1.9%-3.6% from 2006 to 2012), suffocation (APC, 6.0%; 95% CI, 4.4%-7.7% from 2006 to 2015), and other means (APC, 2.3%; 95% CI, 1.6%-3.0% from 2006 to 2015). Poisoning rates, however, increased from 2006 to 2010 (APC, 3.8%; 95% CI, 0.5%-7.2%) and then leveled off (Table 3).

Discussion

To our knowledge, this study, which used nationally representative data, is the first to examine how increased suicide rates were associated with changes in the incidence and lethality of suicidal acts in the United States. The lethality of suicidal acts largely depends on the means used.[15] Among persons aged 20 to 64 years, suicidal acts by firearms and suffocation (methods of greater lethality) increased, but suicidal acts by poisoning (a method of lesser lethality) decreased or flattened, which may explain the observed increases in lethality. Adolescents and older adults aged 65 to 74 years experienced general increases in suicide attempts by all means, including poisoning, which was associated with stable or declining lethality for these subgroups.

Our finding that suicidal acts occurred more among female individuals, adolescents, and older adults aged 65 to 74 years may warrant further research into emerging or exacerbating risk factors for these subgroups. The finding of increased lethality among both sexes and persons aged 20 to 64 years calls attention to the evolving patterns in the use of more lethal means, particularly increased use of suffocation and firearms in suicidal acts. Findings of this study demonstrated that firearms were used in approximately half of all suicides and underscored that firearms had the highest CFR of all the suicide means examined.

Table 3. Trends in Incidence Rates of Suicidal Acts by Means Among Persons Aged 10-74 Years, 2006-2015[a]

Means	Incidence rate per 100 000 (95% CI)		Trends				
	2006	2015	Trend 1	APC (95% CI), %	Trend 2	APC (95% CI), %	AAPC (95% CI), %
Total[b]							
Firearms	6.8 (6.7 to 6.9)	8.0 (7.9 to 8.1)	2006-2010	3.0 (1.7 to 4.3)	2010-2015	0.9 (0.0 to 1.7)	1.8 (1.3 to 2.4)
Suffocation	5.7 (5.4 to 6.0)	9.1 (8.8 to 9.4)	2006-2015	4.7 (3.8 to 5.7)	NA	NA	4.7 (3.8 to 5.7)
Poisoning	110.6 (106.7 to 114.5)	112.7 (109.3 to 116.1)	2006-2015	−0.3 (−1.1 to 0.5)	NA	NA	−0.3 (−1.1 to 0.5)
Other[c]	52.0 (49.5 to 54.5)	63.3 (60.4 to 66.2)	2006-2015	2.4 (1.9 to 2.8)	NA	NA	2.4 (1.9 to 2.8)
Male individuals[b]							
Firearms	11.8 (11.6 to 12.0)	13.6 (13.4 to 13.8)	2006-2010	3.0 (1.4 to 4.7)	2010-2015	0.4 (−0.6 to 1.4)	1.6 (0.9 to 2.3)
Suffocation	8.9 (8.5 to 9.3)	13.1 (12.6 to 13.6)	2006-2015	3.6 (2.6 to 4.6)	NA	NA	3.6 (2.6 to 4.6)
Poisoning	84.0 (80.6 to 87.4)	80.2 (77.4 to 83.0)	2006-2009	3.4 (−2.5 to 9.6)	2009-2015	−2.5 (−4.2 to −0.8)	−0.6 (−2.3 to 1.2)
Other[c]	52.4 (49.6 to 55.2)	60.6 (57.3 to 63.9)	2006-2015	1.7 (1.3 to 2.0)			1.7 (1.3 to 2.0)
Female individuals[b]							
Firearms	2.0 (1.9 to 2.1)	2.5 (2.4 to 2.6)	2006-2015	3.0 (2.5 to 3.4)	NA	NA	3.0 (2.5 to 3.4)
Suffocation	2.4 (2.2 to 2.6)	5.1 (4.8 to 5.4)	2006-2015	8.2 (7.0 to 9.3)	NA	NA	8.2 (7.0 to 9.3)
Poisoning	137.5 (132.6 to 142.4)	145.9 (141.4 to 150.4)	2006-2015	0.1 (−0.6 to 0.8)	NA	NA	0.1 (−0.6 to 0.8)
Other[c]	51.7 (49.1 to 54.3)	66.2 (63.0 to 69.4)	2006-2015	3.1 (2.4 to 3.8)	NA	NA	3.1 (2.4 to 3.8)
Aged 10-19 y							
Firearms	2.1 (2.0 to 2.2)	2.9 (2.7 to 3.1)	2006-2015	3.6 (2.8 to 4.4)	NA	NA	3.6 (2.8 to 4.4)
Suffocation	5.6 (5.0 to 6.2)	9.3 (8.4 to 10.2)	2006-2015	5.5 (3.7 to 7.4)	NA	NA	5.5 (3.7 to 7.4)
Poisoning	117.9 (110.8 to 125.0)	161.2 (151.6 to 170.8)	2006-2011	0 (−2.4 to 2.5)	2011-2015	7.5 (4.2 to 11.0)	3.3 (1.8 to 4.9)
Other[c]	75.9 (69.2 to 82.6)	115.1 (106.3 to 123.9)	2006-2011	3.0 (0.0 to 6.1)	2011-2015	8.9 (5.0 to 13.0)	5.6 (3.7 to 7.5)
Aged 20-44 y							
Firearms	7.1 (6.9 to 7.3)	8.3 (8.1 to 8.5)	2006-2015	1.6 (0.9 to 2.2)	NA	NA	1.6 (0.9 to 2.2)
Suffocation	7.7 (7.2 to 8.2)	11.5 (10.9 to 12.1)	2006-2015	4.0 (3.2 to 4.8)	NA	NA	4.0 (3.2 to 4.8)
Poisoning	143.2 (135.5 to 150.9)	126.2 (120.2 to 132.2)	2006-2010	1.4 (−2.8 to 5.8)	2010-2015	−4.4 (−7.1 to −1.7)	−1.9 (−3.7 to −0.0)
Other[c]	69.1 (64.4 to 73.8)	75.5 (70.3 to 80.7)	2006-2015	0.8 (0.2 to 1.3)	NA	NA	0.8 (0.2 to 1.3)
Aged 45-64 y							
Firearms	8.8 (8.6 to 9.0)	10.0 (9.8 to 10.2)	2006-2012	2.8 (1.9 to 3.6)	2012-2015	−1.3 (−3.3 to 0.7)	1.4 (0.7 to 2.1)
Suffocation	3.6 (3.4 to 3.8)	6.8 (6.5 to 7.1)	2006-2015	6.0 (4.4 to 7.7)			6.0 (4.4 to 7.7)
Poisoning	79.4 (75.3 to 83.5)	83.9 (80.4 to 87.4)	2006-2010	3.8 (0.5 to 7.2)	2010-2015	−1.8 (−3.7 to 0.1)	0.6 (−0.7 to 2.0)
Other[c]	21.7 (20.1 to 23.3)	25.7 (24.1 to 27.3)	2006-2015	2.3 (1.6 to 3.0)	NA	NA	2.3 (1.6 to 3.0)
Aged 65-74 y							
Firearms	9.1 (8.9 to 9.3)	10.7 (10.4 to 11.0)	2006-2015	1.8 (1.0 to 2.5)	NA	NA	1.8 (1.0 to 2.5)
Suffocation	1.5 (1.4 to 1.6)	2.7 (2.4 to 3.0)	2006-2015	6.1 (4.8 to 7.5)	NA	NA	6.1 (4.8 to 7.5)
Poisoning	19.4 (17.8 to 21.0)	28.3 (26.6 to 30.0)	2006-2015	3.7 (2.3 to 5.0)	NA	NA	3.7 (2.3 to 5.0)
Other[c]	6.3 (5.4 to 7.2)	7.7 (6.9 to 8.5)	2006-2015	3.7 (1.6 to 6.0)	NA	NA	3.7 (1.6 to 6.0)

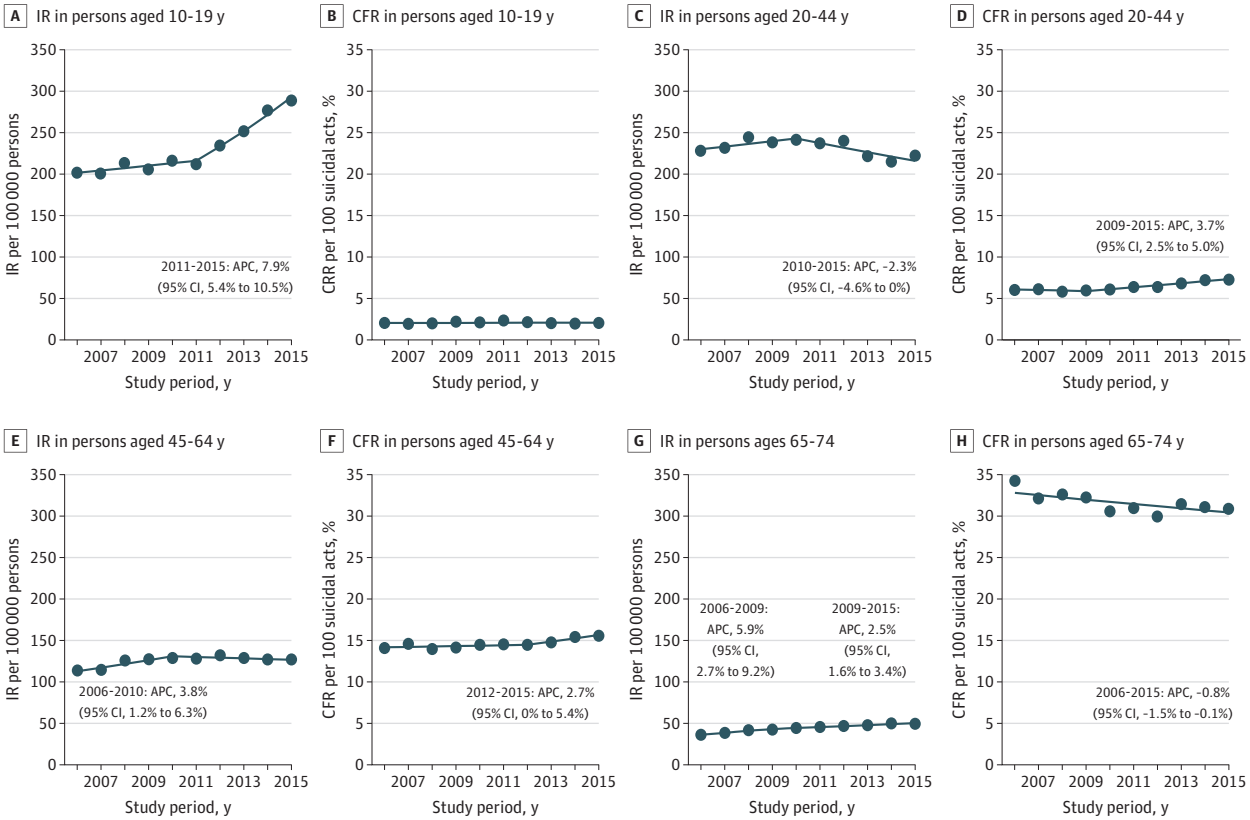
Abbreviations: AAPC, average annual percentage change; APC, annual percentage change; NA, not applicable.

[a] Data from Health Cost and Utilization Project[17,18] and Centers for Disease Control and Prevention.[21,22]

[b] The incidence rates were age adjusted per the 2000 US census population. Total suicidal acts combined both suicides (deaths) and nonfatal medically treated suicide attempts. Incidence rate of suicidal acts was calculated by dividing the number of total suicidal acts by the US population. Joinpoint regression was used to determine the trends in incidence rates of suicidal acts.

[c] Other included all remaining means other than firearm, suffocation, and poisoning, such as drowning, cutting, and jumping from heights.

Figure 2. Incidence Rates (IRs) and Case Fatality Rates (CFRs) of Suicidal Acts by Age Group



Dots indicate observed rates, and lines indicate modeled rates. Annual percentage changes (APCs) are presented only for the significant trends at $P < .05$. The IRs were stable until 2011 and then increased sharply (APC, 7.9%; 95% CI, 5.4% to 10.5%] among adolescents aged 10 to 19 years. Since 2010, the IRs declined for persons aged 20 to 44 years (APC, −2.3%; 95% CI, −4.6% to −0.0%) and were stable for those aged 45 to 64 years. However, the CFRs increased since 2009 for persons aged 20 to 44 years (APC, 3.7%; 95% CI, 2.5% to 5.0%) and since 2012 for those aged 45 to 64 years (APC, 2.7%; 95% CI, 0% to 5.4%]. Among persons aged 65 to 74 years, IRs increased from 2006 to 2009 (APC, 5.9%; 95% CI, 2.7% to 9.2%) and from 2009 to 2015 (APC, 2.5%; 95% CI, 1.6% to 3.4%], while CFRs decreased from 2006 to 2015 (APC, −0.8%; 95% CI, −1.5% to −0.1%). Data from Health Cost and Utilization Project[17,18] and Centers for Disease Control and Prevention.[21,22]

Reducing access to lethal means of suicide among persons at risk, which include not only firearms but also medications and other potentially dangerous household products, may be a helpful approach for reducing suicide rates. Research has shown that safe storage practices (eg, keeping guns in a safe or a lockbox) are associated with fewer firearm suicide attempts among adolescents at risk for suicide.[25] Such practices may also play a role in suicide prevention efforts for other age groups.

In addition, we found a substantial increase in the use of suffocation as a means of suicide attempt. This finding is consistent with a previous report that suicide by suffocation in the US substantially increased from 2000 to 2010.[14] Limiting access to materials that are used in suicide attempts by hanging is challenging. Ultimately, upstream prevention approaches, including teaching coping and problem-solving skills early in life, promoting connectedness, and developing and implementing policies that strengthen economic supports, may mitigate the risk of suicidal behavior for all age groups.[26]

The observed stable or declining trends of suicide attempts by poisoning in certain subgroups appear to be noteworthy because of the rapidly increasing rates of unintentional deaths from drug overdose seen nationally from 1999 to 2016.[27] Misclassification of intent of death could partially explain this finding given that some drug overdose deaths with ambiguous circumstances may not be recognized as suicides.[28,29] However, for nonfatal overdoses, hospital discharge records are considered reliable to identify suicidal intent.[30] Another possible explanation is the leveling off or subsequent decrease in opioid prescriptions since 2010,[31] which could have reduced access to prescription opioids used in suicidal acts, although this rationale does not explain the continued increase in suicidal acts by poisoning among adolescents and persons aged 65 to 74 years. Nevertheless, similar discrepant trends were also reported by studies that used data from US poison control centers. Allen et al[32] showed that the overall rate of prescription opioid exposures among teenagers decreased after 2009, whereas the rate among those with suicide intent aged 13 to 19 years increased from 2000 to 2015.

In addition, West et al[33] found that the rate of poisoning by prescription opioids with suicide intent decreased after 2011 for persons aged 20 to 59 years but continuously increased for those aged 60 years or older between 2006 and 2013. Further studies are warranted to understand the increasing trends in suicidal acts by poisoning among adolescents and older adults aged 65 to 74 years.

A well-documented suicide paradox exists: suicide attempt rates are higher among female individuals, whereas lethality is higher among male individuals.[6] However, the present study found that both incidence rates and lethality of suicidal acts increased more rapidly in female than male individuals. These trends illustrate the importance of understanding the unique social and behavioral factors in tailoring prevention efforts, particularly for female persons. For example, given that women are more likely than men to seek care for mental health issues and to rely on social support networks,[34] improving suicide prevention approaches in health care settings and strengthening opportunities to promote social connectedness may be especially advantageous for female individuals.[26]

Recent studies have shown increases in suicide attempts among adolescents.[10,11] These trends mirror the growing prevalence of major depressive episodes among adolescents, particularly among girls since 2011.[35] The reasons for the increase are unclear but likely involve a combination of factors. With the rapid adoption of digital technology,[36] some studies have suggested that screen time was associated with depression and suicidal behaviors,[37-39] but other research has shown negligible association between screen time and psychological well-being among teenagers.[40] Furthermore, Brent et al[41] found an association between parental prescription opioid use and higher risk of suicide attempts among their children, suggesting that increased parental prescription opioid use may be related to the trends in suicide attempts among adolescents. Given the increased suicide rates among adults, exposure to a loved one's suicide may also have implications for the increasing trend in suicidal acts among children. Other factors that warrant further investigation are social isolation, problematic parent-child relationships, and academic stress.[42,43]

Findings of the present study suggest that incidence rates for persons aged 65 to 74 years have also been increasing. Few studies shed light on possible reasons for this trend, but risk factors may include social isolation, depression, feeling of being a burden to caregivers, and having a chronic illness. Factors relevant to older adults may merit further investigation.[44,45]

Limitations

This study has some limitations. First, it did not include less severe suicide attempts that did not involve visits to EDs or hospitals; therefore, we may have underestimated the incidence of total suicidal acts and overestimated the lethality. However, suicide attempts by firearm or suffocation are more lethal and generally require treatment, thus the estimates for these 2 means should be reasonable. Furthermore, among adults who reported suicide attempts during the study period, the percentages of those who received medical attention (62% in 2008 and 60% in 2015) or who were hospitalized (45% in 2008 and 41% in 2015) remained fairly steady according to national studies.[46,47] This stable pattern of seeking medical care suggests that (1) the increased incidence observed in the present study cannot be explained by the likelihood that less severe suicide attempts would be treated over time and (2) the trends based on treated cases may reflect the trends based on total cases. Nevertheless, to what extent the trends based on total suicidal acts would differ is unknown.

Second, we identified suicidal acts by their *ICD-9-CM* or *ICD-10* codes, and some misclassification may have occurred. For example, some suicides by poisoning may have been misclassified as unintentional or undetermined owing to the challenges in determining the intent.[48] Furthermore, identifying suicide attempts solely by the *ICD-9-CM* E codes may lead to underestimation if those codes were incomplete in the medical records. In NIS and NEDS, approximately 90% of records with injury as a primary diagnosis listed E codes, and this percentage remained stable during the study period[49]; thus, underreporting of E codes was not a major issue in this study. Third, suicide attempts treated at non-community hospitals were not included in NEDS and NIS. Fourth, multiple suicide attempts by the same person were not identifiable in the data and were treated as separate episodes. However, a systematic review on repeated self-harm injuries reported that about 16% of individuals with a self-harm attempt repeated the attempt within 1 year of the event, with no significant change in this proportion across studies over the past 3 decades.[50,51] Thus, we believe that increases in suicide attempts primarily from repeated attempts by the same persons are unlikely. Fifth, the present study involved simultaneous use of multiple data sources that represented both complex survey and vital statistics data; thus, we tested the trends at the aggregate level using the Joinpoint software. A record-level approach to analyzing the trends in complex survey data is recommended,[52] but to date an approach that incorporates multiple data sources, as in our analyses, is not readily available. Thus, it is unclear how the conclusions of our analytic approach differ from those of the recommended general framework. In addition, this study did not include data after the 2015 transition to *ICD-10-CM* because of the interrupted trends after the coding switch.

Conclusions

This study found increased incidence rates of suicidal acts among female individuals, adolescents, and older adults, and we believe underscores the need for additional research on modifiable risk and protective factors associated with these trends and the importance of interventions to prevent initial suicide attempts and repeated attempts. The elevated lethality observed in both sexes, particularly among those aged 20 to 64 years, suggests the need to reduce access to materials that could be used for lethal means by those at risk of suicidal acts. It appears that comprehensive upstream prevention strategies are fundamental for reducing suicides across the lifespan.

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