

# The Role of Interpersonal Conflict as a Determinant of Firearm-Related Homicide–Suicides at Different Ages

**Bindu Kalesan, PhD, MPH,<sup>1</sup>**  
**Matthew E. Mobily, MD, MPH,<sup>2</sup>**  
**Sowmya Vasam, MS,<sup>2</sup>**  
**Michael Siegel, MD, MPH,<sup>3</sup>**  
**and Sandro Galea, MD, DrPH<sup>3</sup>**

## Abstract

Although firearm-related homicide–suicides and firearm-related suicides are tragic and catastrophic events, there is increasing evidence that the two events have different precipitants and that understanding these precipitants may help prevention efforts. We aimed to assess the role of interpersonal conflict (IPC) and recent crises in firearm-related homicide–suicides as compared with firearm-related suicides alone. We also assessed whether these differences were consistent across young and old perpetrators. Using an unmatched case-control study, we compared firearm-related homicide–suicides and suicides alone from 2003 to 2011 in the National Violent Death Registry data to assess the risk associated with IPC and

---

<sup>1</sup>Boston University School of Medicine, MA, USA

<sup>2</sup>Columbia University, New York, NY, USA

<sup>3</sup>Boston University School of Public Health, MA, USA

## Corresponding Author:

Bindu Kalesan, Department of Medicine, Boston University School of Medicine, 801 Massachusetts Ave., Room 475, Boston, MA, USA.

Email: [kalesan@bu.edu](mailto:kalesan@bu.edu)

crisis. Survival analysis was performed to compare time-to-incident of homicide–suicide versus suicide only. We derived odds ratios (ORs) and 95% confidence intervals (95%CI) due to IPC and recent crisis from mixed logistic regression models. Stratified analysis by age on the effect of IPC and recent crisis, and type of incident was also performed. After adjusting for relevant covariates, homicide–suicides were more likely than suicide alone following IPC (OR = 20.6, 95%CI = [16.6, 25.7]) and recent crisis (OR = 14.5, 95%CI = [12.4, 16.9]). The risk of firearm homicide–suicide compared with suicide associated with IPC was twice greater among those >30 years compared with those ≤30 years ( $p$ -interaction = .033), and no differential by age associated with recent crisis ( $p$ -interaction = .64). IPC and recent crisis are risk factors for committing homicide–suicides compared with suicides alone, with the risk doubly greater among older than younger perpetrators.

## Keywords

firearm, homicide–suicide, suicide

## Introduction

*Homicide–suicides*, also referred to as dyadic deaths, involve homicide committed against one or more victims followed shortly thereafter by the suicide of the perpetrator (Marzuk, Tardiff, & Hirsch, 1992). The rate of these events in the United States is approximately 3 per million persons accounting for as many as 1,500 deaths annually (Large, Smith, & Nielssen, 2009; Logan et al., 2008; Marzuk et al., 1992). Homicide–suicide events often receive a great deal of public and media attention and can have a long-term psychological impact on survivors (Eliason, 2009; Panczak, Zwahlen, et al., 2013). Although there are similarities between homicide–suicides and homicides or suicides alone, there are many differences that indicate these devastating events should be viewed as distinct entities (Panczak, Geissbuhler, et al., 2013).

Many studies characterize homicide–suicide occurrences as rare, dramatic events occurring in distinctive settings, motivated by interpersonal issues with definitive, yet common, individual and social determinants across different countries (Campanelli & Gilson, 2002; Logan et al., 2008; Panczak, Zwahlen, et al., 2013). The most common scenario involves a male perpetrator who takes his own life after killing his former intimate female partner (Comstock et al., 2005; Panczak, Zwahlen, et al., 2013). The perpetrators of homicide–suicide events as compared with suicide alone are more likely to be male, older, married, or separated from their victims and more likely to use a firearm, and less likely to be under the influence of alcohol, have a history of domestic violence, or recent unemployment (Panczak, Geissbuhler, et al., 2013). In the United

States, homicide–suicide perpetrators are more likely to be Black compared with perpetrators of suicide alone who are more likely to be White (Logan et al., 2008). Nearly 90% of the homicide–suicides in the United States involve the use of a firearm, compared with 16% to 36% among countries within the European Union (Liem & Nieuwbeerta, 2010; Panczak, Geissbuhler, et al., 2013).

Factors such as interpersonal conflict (IPC) and stressful events are considered to be important, yet shared risk factors leading up to homicide–suicides and separate events of homicides and suicides (Dowd, Knapp, & Fitzmaurice, 1994; Fowler, Gladden, Vagi, Barnes, & Frazier, 2015; Logan et al., 2008; Norstrom & Gronqvist, 2015). However, IPC and antecedent crises may be of greater relevance in homicide–suicide incidents than in suicide alone. A 3-year analysis of violent deaths found that IPC precipitated homicide–suicide (Logan et al., 2008) whereas an Italian study found social stressors to be an important factor driving homicide–suicide (Roma et al., 2012). Although these studies establish the risk of IPC and stressful events as risk factors of homicide–suicide over suicide alone, these studies are limited by sample size and lack of consideration of these risk factors together.

There is also some suggestion that the role of IPC and crises in precipitating homicide–suicide versus suicide alone differs by age. A recent study presented initial evidence regarding dissimilarities with regard to motivation of homicides–suicides where younger couples were motivated by personal relationship factors such as “jealousy” (De Koning & Piette, 2014). Marital discord involving divorce and domestic violence was often implicated in homicide–suicide of older perpetrators (Bourget, Gagne, & Whitehurst, 2010; Malphurs & Cohen, 2005). Although previous studies have attempted to understand the effect of age in homicides–suicides, there are no studies that explored the age-stratified difference in risk factors such as IPC and recent crisis of homicide–suicides.

We hypothesized that although IPC and crises maybe involved in instigating suicide, the role maybe greater in homicide–suicide events. Therefore, given this preliminary evidence about the role of IPC and crises in precipitating homicides–suicides versus suicide alone, we assessed (a) the factors associated with homicides–suicides versus suicide alone, (b) the risk of homicides–suicides versus suicide alone associated with IPC and recent crises, and (c) the differential risk of homicides–suicides versus suicide alone after IPC and recent crises by age. Given the preponderance of firearms as the cause of death in homicides–suicides and suicides in the United States (Liem, Barber, Markwalder, Killias, & Nieuwbeerta, 2011), and the potential differences in etiology between firearm and nonfirearm homicides–suicides versus suicide (Logan et al., 2008), we limited the analysis to firearm-related homicides–suicides and suicides alone.

## **Method**

### *Data Source*

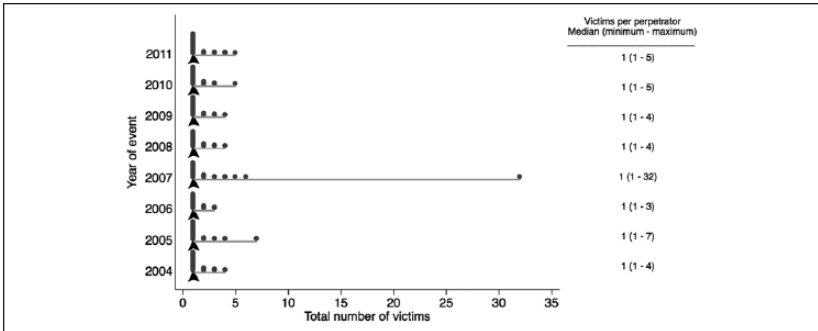
The data used in this study were obtained through the National Violent Death Reporting System (NVDRS), a violent death information database collected by the Centers for Disease Control and Prevention (CDC). The details of the NVDRS data collection procedures are detailed elsewhere (Butchart, 2006; Paulozzi, Mercy, Frazier, & Annett, 2004). The NVDRS is a surveillance system that pools information on violent deaths collected from multiple sources including state and local coroner/medical examiner reports, death certificates, law enforcement reports, crime laboratories, and vital statistics to better understand the circumstances involved in the violent event. We submitted a data request to the CDC's restricted access data center after obtaining an institutional ethics committee review board exempt status from Columbia University according to federal regulations for the protection of human research participants that allows analysis of de-identified secondary data.

### *Study Design*

Using an unmatched case-control study design, we compared perpetrators of homicide-suicides with those who committed suicides alone to assess the independent effect of life and health factors.

### *Study Population*

The defined study period was from 2003 to 2011 for which 17 states had voluntarily provided information to the NVDRS for at least a proportion of the intervening years. The 17 states included Alaska, Colorado, Georgia, Kentucky, Maryland, Massachusetts, New Jersey, New Mexico, North Carolina, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, Utah, Virginia, and Wisconsin. Seven states (Alaska, Maryland, Massachusetts, New Jersey, Oregon, South Carolina, and Virginia) provided data from 2003 to 2011, six states (Colorado, Georgia, North Carolina, Oklahoma, Rhode Island, and Wisconsin) started contributing in 2004, three states (Kentucky, New Mexico, and Utah) joined in 2005, and one state (Ohio) started in 2011. The distribution of all violent deaths from 2003 to 2011 in NVDRS data is presented in Online Supplementary Figure 1. Those events without the involvement of at least one firearm were excluded from our analysis. In addition, homicides involving law enforcement intervention or gang-related violence were also excluded from our study population because these were considered to represent special scenarios that are not apt



**Figure 1.** Distribution of victims in homicide–suicide events in each year, NVDRS 2003–2011.

Note. Beam plot has dots that demonstrate the number of victims per perpetrator in each year. The arrow is placed at the median number of victims in each year. NVDRS = National Violent Death Reporting System.

for comparison with the traditional homicide–suicide events. The details of inclusion and exclusion are presented in Online Supplementary Appendices 1 and 3.

### Case Ascertainment

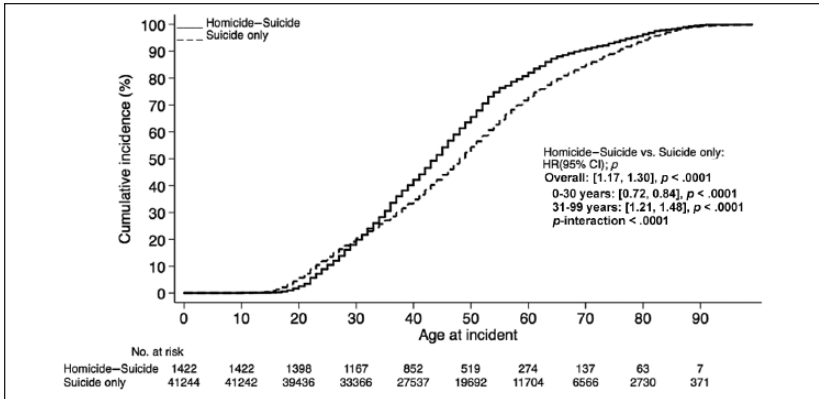
The data from each violent event were initially organized into three groups based on intent of death, homicide, suicide, and homicide–suicide. A *homicide–suicide* was defined as a suicide event in which the perpetrator had committed at least one homicide in the preceding year. Several inconsistencies were noted in the events during this portion of case ascertainment. Each event was carefully reviewed and assigned to the appropriate groups. The details of this allocation are provided in Online Supplementary Appendices 1, 2, and 3. The resulting homicide–suicide events were comprised of one perpetrator who killed one or more victims prior to taking his or her own life. Because there were two groups for comparison within each homicide–suicide event (perpetrator and victim), the analysis was conducted with three distinct cohorts: (a) perpetrator of homicide–suicides, (b) victims of homicide–suicides, and (c) decedents of suicide alone. There were a total of 1,422 perpetrators of homicide–suicide events, who were compared with 41,244 decedents of suicide alone. With respect to victims, there were a total of 1,697 victims of homicide–suicide events, who were also compared with 1,422 perpetrators of homicide–suicide events.

## *Covariates*

Sociodemographic characteristics considered were gender, race (White, Black, and Other), ethnicity (Hispanic or not Hispanic), and marital status (never, previous, and current). Life factors were IPC, recent crisis in past 2 weeks, financial stressors, history of suicide, job/school issue, suicide/death of family or friend, recent criminal legal issues, and victim of interpersonal violence (IPV). Health factors were alcohol dependency, drug dependency, depression or mental health issues, and physical health problem. The setting for death, whether by homicide, suicide, or undetermined, was assessed for factors such as mental health history and status, whether a victim disclosed intent to die by suicide, IPCs, and criminal acts. Victim of IPV was recategorized as IPC, whereas alcohol and drug dependency was pooled for regression analysis. "Recent crisis" was when the person experienced a very current crisis or acute precipitating event that appears to have contributed to the death (e.g., the victim was just arrested, divorce papers were served that day, the victim was about to be laid off, the victim had a major argument with his or her spouse the night before, the victim broke up with her boyfriend and he killed her the next day).

## *Statistical Analysis*

The sociodemographic and life factors were compared between perpetrators of homicide–suicide events and victims of suicides alone, and then with victims of homicide–suicides using descriptive statistics. Kaplan–Meier curves were constructed to compare the cumulative incidence between perpetrators of homicide–suicide events and victims of suicides alone (time-to-age at incident). Hazard ratios (HR) and 95% confidence intervals (95% CIs) were calculated to assess risk between perpetrators of homicide–suicide events and victims of suicides alone and by age ( $\leq 30$  years and  $> 30$  years). We used mixed likelihood logistic regression with state of residence as random coefficient to assess the risk by IPC and recent crisis adjusted for other covariates and year of incident. Relative risk estimates were presented as odds ratios (ORs) and 95% CIs. A bivariate analysis was first performed by entering the specific covariate and adjusted for year of event. This was followed by multivariable regression to identify the risk of perpetrating homicide–suicide as compared with suicide alone due to IPC and recent crisis after adjusting for covariates. Interaction by age in the association between IPC and homicide–suicide as compared with suicide alone were performed using a test for interaction between the event types and age ( $\leq 30$  vs.  $> 30$  years). Stratified analysis along with interaction tests was also performed to assess the differential in



**Figure 2.** Kaplan–Meier curves comparing time-to-death among those committing homicide–suicide deaths and suicide, NVDRS 2003-2011.

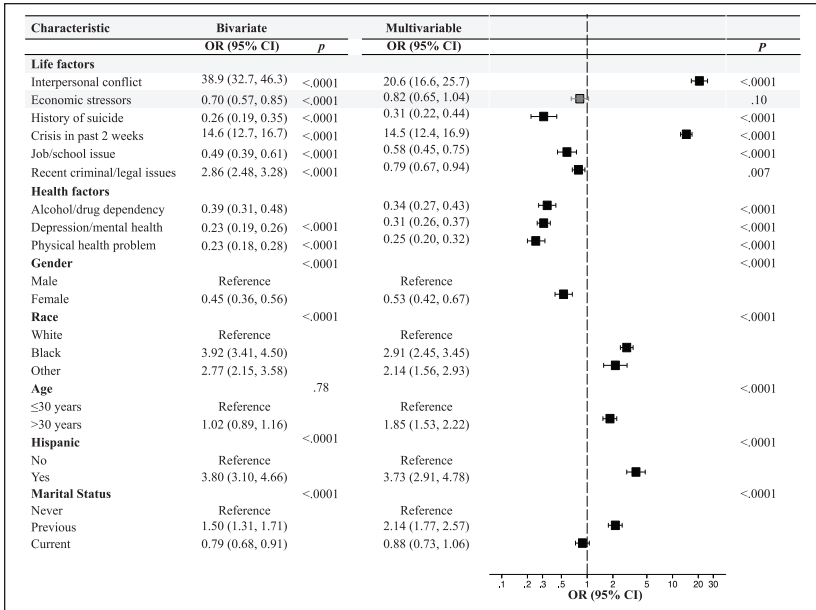
Note. Survival curves of the two groups; homicide–suicide (solid line) and suicide alone (broken line) are time-dependent and cross at 33 years of age. The x-axis denotes the age at death, and y-axis is the cumulative incidence. NVDRS = National Violent Death Reporting System; CI = confidence interval; HR = hazard ratio; 95%CI = 95% confidence interval.

risk by age in the association between IPC and recent crisis, and type of incident. Those covariates with sample size <10 in the homicide–suicide cohort were not used for multivariable analysis. STATA version 13.1 was used for all analyses (College Station, TX, USA).

## Results

There were a total of 3,119 homicide–suicide deaths in 1,422 events among 17 states between 2003 and 2011 in the NVDRS data. The total number of firearm-related homicide–suicide violent deaths in each year and state is presented in Online Supplementary Figure 2, and the temporal distribution of firearm-related homicide–suicide violent deaths among all the homicide–suicide, homicide, and suicide violent deaths by states in the NVDRS data is presented in Online Supplementary Figure 3. Figure 1 presents a beam plot representation of number of victims of firearm homicide–suicide events. Overall median was 1 victim per perpetrator and ranged from a minimum of 1 to a maximum of 32 (32 victims were a mass shooting incident, where the shooter shot 32 people and then killed himself).

Table 1 presents the comparison of sociodemographic characteristics and life and health factors between perpetrators of homicide–suicide (*n* = 1,422) versus suicide only (*n* = 41,244) and between victims of



**Figure 3.** Predictive factors for homicide-suicide versus suicide alone among all ages, NVDRS 2003-2011.

Note. All estimates are from bivariate mixed likelihood logistic regression models with each covariate and adjusted for year; state as random coefficient. Suicide/ death of family or friend is not included in the regression ( $n < 10$ ). Interpersonal conflict includes victim of interpersonal violence. OR = odds ratio; 95%CI = 95% confidence intervals.

homicide-suicides ( $n = 1,697$ ). The perpetrators of homicide-suicide were more likely to be male (93.3% vs. 86.4%), Black (21.4% vs. 6.6%), Hispanic (8.9% vs. 2.9%), previously married (41.4% vs. 29.5%), to have had IPC (21.1% vs. 0.5%), a crisis in the past 2 weeks (78.6% vs. 25.3%), and recent criminal or legal issues (18.9% vs. 7.9%) as compared with suicides only. In contrast, in comparison with suicides only, the perpetrators of homicide-suicide were less likely to have a history of suicide, job or school issue, suicide or death of a family member, a history of alcohol dependency, mental health issue, and physical health problem. Perpetrators of homicide-suicide as compared with their victims were more likely to be men, older, previously married (victims were currently married), have economic stress, have a history of suicide, have a crisis in the past 2 weeks, job or school issue, recent criminal/legal issues, alcohol dependency, depression, and history of physical health.



**Table 1.** Comparison of Sociodemographic Characteristics Between Perpetrators of Firearm Homicide–Suicide Deaths and Suicide Alone and Between Those of Victims of Homicide–Suicide.

Characteristic	H-S, Perpetrator	Suicide Only	<i>p</i>	H-S, Victim	<i>p</i> *
<i>n</i>	1,422	41,244		1,697	
Gender			<.0001		<.0001
Male	1,326 (93.3)	35,633 (86.4)		447 (26.3)	
Female	95 (6.7)	5,606 (13.6)		1,250 (73.7)	
Unknown	1 (0.1)	5 (0.01)		0 (0)	
Age group			.60		<.0001
≤30	282 (19.9)	8,413 (20.4)		611 (36.0)	
>30	1,138 (80.0)	32,781 (79.5)		1,083 (63.8)	
Unknown	2 (0.1)	50 (0.1)		3 (0.2)	
Year			.64		.83
2003	56 (3.9)	1,703 (4.1)		73 (4.3)	
2004	138 (9.7)	3,957 (9.6)		154 (9.1)	
2005	180 (12.7)	4,585 (11.1)		202 (11.9)	
2006	156 (10.9)	4,684 (11.4)		186 (10.9)	
2007	158 (11.1)	4,743 (11.5)		226 (13.3)	
2008	157 (11.0)	4,896 (11.9)		184 (10.8)	
2009	188 (13.2)	5,122 (12.4)		215 (12.7)	
2010	189 (13.3)	5,328 (12.9)		225 (13.3)	
2011	200 (14.1)	6,226 (15.1)		232 (13.7)	
Race			<.0001		.16
White	1,043 (73.4)	37,486 (90.9)		1,289 (75.9)	
Black	305 (21.4)	2,732 (6.6)		317 (18.7)	
Other	74 (5.2)	1,026 (2.2)		91 (5.4)	
Hispanic			<.0001		.43
Yes	126 (8.9)	1,204 (2.9)		137 (8.1)	
No	1,296 (91.1)	40,040 (97.1)		1,560 (91.9)	
Marital status			<.0001		<.0001
Never	370 (26.0)	11,543 (28.0)		587 (34.6)	
Previous	589 (41.4)	12,145 (29.5)		459 (27.1)	
Current	442 (31.1)	17,152 (41.6)		638 (37.6)	
Unknown	21 (1.5)	404 (1.0)		13 (0.8)	
Life factors					
IPC	300 (21.1)	214 (0.5)	<.0001	1,129 (66.5)	<.0001
Economic stressors	111 (7.8)	4,592 (11.1)	<.0001	36 (2.1)	<.0001
History of suicide	43 (3.0)	4,498 (10.9)	<.0001	6 (0.4)	<.0001
Disclosed intent of suicide	162 (11.4)	10,911 (26.5)	<.0001	14 (0.8)	<.0001
Recent crisis	1,117 (78.6)	10,419 (25.3)	<.0001	102 (6.0)	<.0001
Job/school issue	83 (5.8)	4,752 (11.5)	<.0001	12 (0.7)	<.0001
Suicide/death of family or friend	5 (0.4)	653 (1.6)	<.0001	3 (0.2)	.27

(continued)

**Table 1. (continued)**

Characteristic	H-S, Perpetrator	Suicide Only	<i>p</i>	H-S, Victim	<i>p</i> *
Recent criminal legal issues	268 (18.9)	3,242 (7.9)	<.0001	10 (0.6)	<.0001
Victim of interpersonal violence	10 (0.7)	138 (0.3)	.020	96 (5.7)	<.0001
Health factors					
Alcohol dependency	86 (6.1)	6,083 (14.8)	<.0001	18 (1.1)	<.0001
Drug dependency	2 (0.1)	54 (0.1)	.56	29 (1.7)	<.0001
Depression/mental health issue	175 (12.3)	15,856 (38.4)	<.0001	19 (1.1)	<.0001
Physical health problem	92 (6.5)	9,729 (23.6)	<.0001	39 (2.3)	<.0001

Note. Recent crisis is within past 2 weeks. *p* value was derived from Pearson's chi-square test without including the unknown. *p*\* compares H-S perpetrators versus H-S victims. H-S = homicide–suicide; IPC = interpersonal conflict.

Figure 2 presents and compares the Kaplan–Meier curves of time-to-homicide–suicide and time-to-suicide alone. Young perpetrators of homicide–suicides had more victims than the older ones:  $\leq 30$  versus  $> 30$  years, mean (standard deviation)—4.2 (8.6) versus 1.4 (0.9). Overall, the risk of firearm mortality was 24% greater among perpetrators of homicide–suicides as compared with suicide alone (HR = 1.24, 95% CI = [1.17, 1.30],  $p < .0001$ ). In the age-dependent analysis, there was a 22% relative risk reduction in firearm mortality for perpetrators of homicide–suicides as compared with suicide alone (HR = 0.78, 95% CI = [0.72, 0.84],  $p < .0001$ ) among those  $\leq 30$  years, while among those  $> 30$  years, the risk was 34% greater (HR = 1.34, 95% CI = [1.21, 1.48],  $p < .0001$ ) ( $p$ -interaction  $< .0001$ ).

Figure 3 presents the risk factors associated with committing homicide before suicide with firearm as compared with suicide only. In the comparison of all ages of perpetrators of homicide–suicide versus suicides alone, the life and health predictors were IPC (OR = 20.6, 95% CI = [16.6, 25.7],  $p < .0001$ ) and recent crisis (OR = 14.5, 95% CI = [12.4, 16.9],  $p < .0001$ ) whereas history of suicide (OR = 0.31, 95% CI = [0.22, 0.44],  $p < .0001$ ), job/school issue (OR = 0.58, 95% CI = [0.45, 0.75],  $p < .0001$ ), recent criminal/legal issues (OR = 0.79, 95% CI = [0.67, 0.94],  $p = 0.007$ ), alcohol/drug abuse (OR = 0.34, 95% CI = [0.27, 0.43],  $p < .0001$ ), depression (OR = 0.31, 95% CI = [0.26, 0.37],  $p < .0001$ ), and physical health problem (OR = 0.25, 95% CI = [0.20, 0.32],  $p < .0001$ ) reduced the risk. Those who committed homicide–suicide were less likely to be females (OR = 0.53, 95% CI = [0.42, 0.67],  $p < .0001$ ) and more likely to be minority race, older, Hispanic, and previously married.

Table 2 presents the age-specific risk factors for perpetrating homicide–suicide as compared with suicide alone. In a multivariable model and adjusting for gender, race, ethnicity, marital status, and year of event, the independent risk factors for committing homicide–suicide among those  $\leq 30$  years were IPC (OR = 13.1, 95% CI = [8.32, 20.6],  $p < .0001$ ) and having a recent crisis (OR = 14.0, 95% CI = [9.76, 20.1],  $p < .0001$ ), whereas all other covariates did not increase the risk of homicide–suicide as compared with suicides alone. In a similar analysis among those  $> 30$  years, the independent risk factors for committing homicide–suicide among those  $\leq 30$  years were IPC (OR = 23.4, 95% CI = [18.2, 30.2],  $p < .0001$ ) and having a recent crisis (OR = 14.5, 95% CI = [12.2, 17.1],  $p < .0001$ ), whereas all other covariates did not increase the risk as compared with suicides alone. Preexisting IPC increased the risk of homicide–suicides over suicide alone among  $> 30$  years as compared with  $\leq 30$  years,  $p$ -interaction = .033. The interaction by age in the association of recent crisis and the risk of homicide–suicides over suicide alone was not significant ( $p$ -interaction = .64).

## Discussion

We used the largest available violent data registry consisting of data from 17 states in the United States to compare firearm-related homicides–suicides with suicides. We found first that IPC and a recent crisis were the most important factors that increased the risk of committing homicide before suicide as compared with suicide alone. Second, we found an age-dependent effect for the risk of committing homicide–suicide as compared with suicide alone, where risk of homicide–suicide was less likely among those who were below or equal to 30 years as compared with above 30 years. Third, we found that the independent risk of homicide–suicide associated with IPC was twice greater among older perpetrators as compared with the younger ones.

We found that IPC experience is an important risk factor for homicide–suicide involving firearms; this is consistent with previous literature that did not restrict the analysis to firearms (Easteal, 1994; Eliason, 2009; Logan et al., 2008). It has been well documented that most homicide–suicides involve a male perpetrator with a current or previous intimate partner as the victim (Easteal, 1994; Eliason, 2009). A newspaper surveillance study noted 70.5% of homicide–suicides were spousal/consortial (Malphurs & Cohen, 2002), corresponding with a review that estimated that one half to three quarters of all homicide–suicides involved intimate partners (Marzuk et al., 1992). A previous analysis of NVDRS data from 2003 to 2005 also found that more than 55% of male perpetrators of homicide–suicide had prior IPC compared with only 26.4% of male suicide-only decedents (Logan et al., 2008). Domestic violence was

**Table 2. Age-Specific Risk Factors for Homicide—Suicide Versus Suicide Alone, NVDRS 2003-2011.**

Characteristic	≤30 Years			>30 Years		
	Bivariate		Multivariable	Bivariate		Multivariable
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
<b>Life factors</b>						
Interpersonal conflict	20.7 [14.5, 29.6]	<.0001	13.1 [8.32, 20.6]	<.0001	48.2 [39.4, 59.0]	<.0001
Economic stressors	0.20 [0.07, 0.53]	<.0001	0.24 [0.08, 0.70]	.009	0.76 [0.62, 0.94]	.010
History of suicide	0.20 [0.10, 0.42]	<.0001	0.29 [0.14, 0.60]	.001	0.28 [0.20, 0.39]	<.0001
Recent crisis	1.38 [9.92, 19.2]	<.0001	14.0 [9.76, 20.1]	<.0001	14.7 [12.7, 17.1]	<.0001
Job/school issue	0.26 [0.13, 0.53]	<.0001	0.42 [0.20, 0.89]	.024	0.53 [0.42, 0.67]	<.0001
Recent criminal/legal issues	2.82 [2.12, 3.74]	<.0001	0.90 [0.65, 1.26]	.54	2.87 [2.45, 3.38]	<.0001
<b>Health factors</b>						
Alcohol/drug dependency	0.35 [0.20, 0.61]	<.0001	0.46 [0.25, 0.86]	.014	0.39 [0.31, 0.49]	<.0001
Depression/mental health	0.19 [0.13, 0.29]	<.0001	0.28 [0.18, 0.43]	<.0001	0.23 [0.19, 0.27]	<.0001
Physical health problem	0.09 [0.01, 0.61]	.014	0.19 [0.03, 1.36]	.10	0.22 [0.17, 0.27]	<.0001
<b>Gender</b>						
Male	Reference		Reference		Reference	
Female	0.25 [0.13, 0.49]	<.0001	0.27 [0.13, 0.55]	<.0001	0.49 [0.39, 0.61]	<.0001
<b>Race</b>						
White	Reference		Reference		Reference	
Black	4.31 [2.32, 5.60]		3.91 [2.83, 5.38]		4.23 [3.59, 4.99]	
Other	2.69 [1.71, 4.23]		2.92 [1.72, 4.95]		2.95 [2.17, 4.01]	
Hispanic						
No	Reference		Reference		Reference	
Yes	2.45 [1.69, 3.56]	<.0001	3.55 [2.29, 5.48]	<.0001	4.90 [3.82, 6.29]	<.0001
<b>Marital status</b>						
Never	Reference		Reference		Reference	
Previous	2.66 [1.86, 3.81]		3.78 [2.43, 5.88]		1.42 [1.19, 1.69]	
Current	0.88 [0.62, 1.26]		0.85 [0.57, 1.26]		0.76 [0.63, 0.92]	

Note. Recent crisis is within past 2 weeks. All estimates from bivariate mixed likelihood logistic regression models are with each covariate and adjusted for year; state as random coefficient. Suicide/death of family or friend is not included in the regression ( $n < 10$ ). NVDRS = National Violent Death Reporting System; OR = odds ratio, CI = confidence interval.

present in 54% of intimate partner homicide–suicides in a New Hampshire study (Campanelli & Gilson, 2002). Similar to our results, other studies have noted a high prevalence of potential indicators of recent crisis such as divorce or separation among homicide–suicide events. For example, one study of Virginia residents found that 48% to 73% of homicide–suicides involved an impending divorce or separation (Hannah, Turf, & Fierro, 1998). Although the trigger of a recent crisis is not specifically discussed in previous studies using the NVDRS database, an analysis using 2003 and 2004 data from NVDRS reports the high risk attributed to situational stressors such as recent legal issues or financial problems as drivers for homicide–suicide (Bossarte, Simon, & Barker, 2006).

The age-associated relationship regarding the risk of homicide–suicide as compared with suicide alone demonstrated in our study is consistent with observations from a study of Belgian residents that demonstrated a difference in intent among the younger and older offenders of homicide–suicides and that the younger offenders are often driven by intentions of amorous jealousy (De Koning & Piette, 2014). Similar to our results, a study from the Netherlands found that, compared with other suicides, individuals committing a homicide–suicide were significantly younger than those committing suicide alone (Liem & Nieuwbeerta, 2010). In addition, we also found a differential by age in the relation between IPC and risk of homicide–suicide; the independent effect of IPC was almost twice greater among those >30 years as compared with those younger. This suggests that the influence of IPC increases with age and further supports the notion that younger perpetrators of homicide–suicide are distinct from older perpetrators. This difference was also noted in a Swiss population study, where a bimodal distribution was observed among the male perpetrators (Panczak, Zwahlen, et al., 2013) and from a previous study using NVDRS data, which showed that perpetrators of homicide–suicides were more likely to be older men, and the most relevant risk factor was relationship problems (Logan et al., 2008). A study from Belgium reported that the underlying influences for committing homicide–suicides are different according to age (De Koning & Piette, 2014).

Our study has several limitations of which the most important one is that the identification of homicide–suicides was assessed from multiple data sources integrated into NVDRS data. Use of multiple data sources improves data accuracy by cross-validation of events and dates, but the chances of misclassification are also increased. Misclassification of outcome, either differential or nondifferential, may affect the association in different ways. In the event of misclassification bias, we expect it to be nondifferential in this study, where the degree of misclassification of outcomes (homicide–suicide vs. suicide alone) will be independent of the exposures (IPC). In this case-control design, such errors will bias the association toward unity, indicating that the

actual estimates maybe even greater than those we report. Second, we are unable to assess or adjust for gun ownership. Homicides are committed by firearms characterized as crime guns (Cook, Molliconi, & Cole, 1973; Wintemute, Romero, Wright, & Grassel, 2004), whereas suicides are performed by the victim's own firearm or the gun in the household (Siegel, Ross, & King, 2014). NVDRS does not actively collect information on gun ownership, and only 18% of all violent incidents have some information on gun ownership. Third, the covariates we use in this study from NVDRS are derived from various official records. In the absence of any recorded information, such information is obtained from different sources such as family or unknown relative. Although the presence of these factors may be an accurate record, the absence does not necessarily mean the absence of such risk factors, but that the information was not recorded in the associated documents. Fourth, although data collection started in 2003, the data collection and participating states differ by year. The data collection procedures have been standardized only recently along with increasing state participation.

### ***Implications***

This case-control study using data from NVDRS highlights the high rates of firearm-associated homicide–suicide in the United States. In general, this study found that IPC and a triggering recent crisis to be the main risk factors for committing homicide–suicides compared with suicide alone. Importantly, the relationship with IPC is particularly true among older perpetrators as compared with younger ones. Understanding the reasons for the observed differences in the impact of IPC and crisis among perpetrators of different ages may contribute to better efforts that aim to mitigate the risk of homicide–suicides. Interventions tailored to different age groups maybe required along with policies to reduce homicide–suicides.

### **Acknowledgments**

We thank Dr. Katherine A. Fowler, Division of Violence Prevention, Centers for Disease Control and Prevention, for providing the data.

### **Declaration of Conflicting Interests**

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### **Funding**

The author(s) received no financial support for the research, authorship, and/or publication of this article.

## References

- Bossarte, R. M., Simon, T. R., & Barker, L. (2006). Characteristics of homicide followed by suicide incidents in multiple states, 2003–04. *Injury Prevention, 12*(Suppl. 2), ii33-ii38. doi:10.1136/ip.2006.012807
- Bourget, D., Gagne, P., & Whitehurst, L. (2010). Domestic homicide and homicide-suicide: The older offender. *Journal of the American Academy of Psychiatry and the Law, 38*, 305-311.
- Butchart, A. (2006). The National Violent Death Reporting System: A new gold standard for the surveillance of violence related deaths? *Injury Prevention, 12*(Suppl. 2), ii63-ii64. doi:10.1136/ip.2006.013516
- Campanelli, C., & Gilson, T. (2002). Murder-suicide in New Hampshire, 1995-2000. *American Journal of Forensic Medicine and Pathology, 23*, 248-251. doi:10.1097/01.PAF.0000022884.82227.20
- Comstock, R. D., Mallonee, S., Kruger, E., Rayno, K., Vance, A., & Jordan, F. (2005). Epidemiology of homicide-suicide events: Oklahoma, 1994-2001. *American Journal of Forensic Medicine and Pathology, 26*, 229-235.
- Cook, P. J., Molliconi, S., & Cole, T. B. (1973). Regulating gun markets. *The Journal of Criminal Law and Criminology, 86*, 59-92.
- De Koning, E., & Piette, M. H. (2014). A retrospective study of murder-suicide at the Forensic Institute of Ghent University, Belgium: 1935-2010. *Medicine, Science and the Law, 54*, 88-98. doi:10.1177/0025802413518018
- Dowd, M. D., Knapp, J. F., & Fitzmaurice, L. S. (1994). Pediatric firearm injuries, Kansas City, 1992: A population-based study. *Pediatrics, 94*, 867-873.
- Eastaerl, P. (1994). Homicide-suicides between adult sexual intimates: An Australian study. *Suicide and Life-Threatening Behavior, 24*, 140-151.
- Eliason, S. (2009). Murder-suicide: A review of the recent literature. *Journal of the American Academy of Psychiatry and the Law, 37*, 371-376.
- Fowler, K. A., Gladden, R. M., Vagi, K. J., Barnes, J., & Frazier, L. (2015). Increase in suicides associated with home eviction and foreclosure during the US Housing Crisis: Findings from 16 National Violent Death Reporting System States, 2005-2010. *American Journal of Public Health, 105*, 311-316. doi:10.2105/ajph.2014.301945
- Hannah, S. G., Turf, E. E., & Fierro, M. F. (1998). Murder-suicide in central Virginia: A descriptive epidemiologic study and empiric validation of the Hanzlick-Koponen typology. *American Journal of Forensic Medicine and Pathology, 19*, 275-283.
- Large, M., Smith, G., & Nielssen, O. (2009). The epidemiology of homicide followed by suicide: A systematic and quantitative review. *Suicide and Life-Threatening Behavior, 39*, 294-306. doi:10.1521/suli.2009.39.3.294
- Liem, M., Barber, C., Markwalder, N., Killias, M., & Nieuwebeerta, P. (2011). Homicide-suicide and other violent deaths: An international comparison. *Forensic Science International, 207*, 70-76. doi:10.1016/j.forsciint.2010.09.003
- Liem, M., & Nieuwebeerta, P. (2010). Homicide followed by suicide: A comparison with homicide and suicide. *Suicide and Life-Threatening Behavior, 40*, 133-145. doi:10.1521/suli.2010.40.2.133

- Logan, J., Hill, H. A., Black, M. L., Crosby, A. E., Karch, D. L., Barnes, J. D., & Lubell, K. M. (2008). Characteristics of perpetrators in homicide-followed-by-suicide incidents: National Violent Death Reporting System—17 US States, 2003-2005. *American Journal of Epidemiology*, *168*, 1056-1064. doi:10.1093/aje/kwn213
- Malphurs, J. E., & Cohen, D. (2002). A newspaper surveillance study of homicide-suicide in the United States. *American Journal of Forensic Medicine and Pathology*, *23*, 142-148.
- Malphurs, J. E., & Cohen, D. (2005). A statewide case-control study of spousal homicide-suicide in older persons. *American Journal of Geriatric Psychiatry*, *13*, 211-217. doi:10.1176/appi.ajgp.13.3.211
- Marzuk, P. M., Tardiff, K., & Hirsch, C. S. (1992). The epidemiology of murder-suicide. *Journal of the American Medical Association*, *267*, 3179-3183.
- Norstrom, T., & Gronqvist, H. (2015). The Great Recession, unemployment and suicide. *Journal of Epidemiology & Community Health*, *69*, 110-116. doi:10.1136/jech-2014-204602
- Panczak, R., Geissbuhler, M., Zwahlen, M., Killias, M., Tal, K., & Egger, M. (2013). Homicide-suicides compared to homicides and suicides: Systematic review and meta-analysis. *Forensic Science International*, *233*, 28-36. doi:10.1016/j.forsciint.2013.08.017
- Panczak, R., Zwahlen, M., Spoerri, A., Tal, K., Killias, M., Egger, M., & Swiss National Cohort. (2013). Incidence and risk factors of homicide-suicide in Swiss households: National Cohort study. *PLoS ONE*, *8*, e53714. doi:10.1371/journal.pone.0053714
- Paulozzi, L. J., Mercy, J., Frazier, L., Jr., & Annett, J. L. (2004). CDC's National Violent Death Reporting System: Background and methodology. *Injury Prevention*, *10*, 47-52.
- Roma, P., Spacca, A., Pompili, M., Lester, D., Tatarelli, R., Girardi, P., & Ferracuti, S. (2012). The epidemiology of homicide-suicide in Italy: A newspaper study from 1985 to 2008. *Forensic Science International*, *214*, e1-e5. doi:10.1016/j.forsciint.2011.06.022
- Siegel, M., Ross, C. S., & King, C., 3rd. (2014). A new proxy measure for state-level gun ownership in studies of firearm injury prevention. *Injury Prevention*, *20*, 204-207. doi:10.1136/injuryprev-2013-040853
- Wintemute, G. J., Romero, M. P., Wright, M. A., & Grassel, K. M. (2004). The life cycle of crime guns: A description based on guns recovered from young people in California. *Annals of Emergency Medicine*, *43*, 733-742. doi:10.1016/S0196064403012241

## Author Biographies

**Bindu Kalesan**, PhD, MPH, is an assistant professor at Boston University School of Medicine and serves as the vice president of Gun Violence Survivors Foundation. She is a clinical epidemiologist and biostatistician who collaborate with clinical researchers and other scientists performing research studies in cardiovascular and injury



epidemiology. Her current research focuses on the public health consequences of gun violence in the United States along with short- and long-term health outcomes of patients receiving treatment for cardiovascular diseases.

**Matthew E. Mobily**, MD, MPH, is a physician currently undergoing his general surgery residency at the University of Arizona. He completed his MPH in epidemiology at Columbia University Mailman School of Public Health. His primary research interest is firearm violence, legislation, and trauma.

**Sowmya Vasan**, MS, is a biostatistics major from Rutgers University and currently working as a biostatistician at the Department of Epidemiology at Columbia University Mailman School of Public Health. She collaborates with epidemiologists and oncologists and works on studies related to cancer and injury epidemiology. She lends statistical support for the study design and data analysis of projects involving gun violence and quality of care, drug utilization, and cost-effectiveness in cancer treatments.

**Michael Siegel**, MD, MPH, is a physician who completed his residency in preventive medicine at the University of California, Berkeley School of Public Health and trained in epidemiology for 2 years at the Centers for Disease Control and Prevention. His primary research interest is in the area of tobacco control; policies, gun violence, cigarette advertising, and their effects on youths; and evaluation of tobacco control policies and their impact on youth and adult smoking behavior. He is coauthor of a book, titled *Marketing Public Health: Strategies to Promote Social Change*, that grew out of his teaching experience at the school.

**Sandro Galea**, MD, DrPH, is a physician and an epidemiologist. He is dean and professor at the Boston University School of Public Health. He also served as the Anna Cheskis Gelman and Murray Charles Gelman professor and chair of the Department of Epidemiology at the Columbia University Mailman School of Public Health, where he launched several new educational initiatives. He is centrally interested in the social production of health of urban population; causes of brain disorders, particularly mood-anxiety disorders; and substance abuse. He has long had a particular interest in the consequences of mass trauma and conflict worldwide.