Examining the scope of homicide-suicide perpetrated by law enforcement: A population-based retrospective study using multiple frames, 2003 - 2017

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Abstract

Examining the scope of homicide-suicide perpetrated by law enforcement: A population-based retrospective study using multiple frames, 2003 - 2017

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Background: Domestic violence perpetrated by law enforcement is an understudied public health issue. Previous studies examining the prevalence domestic violence by law enforcement primarily rely on convenience sampling and self-reported measures, producing unreliable estimates. Homicide-suicide events, as a subset of domestic violence offenses, present a unique opportunity for study given the data collection practices of existing public health surveillance infrastructure. The present study contributes to the literature by using population-based data and vital statistics to estimate a single subset of domestic violence offenses: homicide-suicide perpetration.

Methods: We joined homicide-suicide perpetration data from the National Violent Death Reporting System (NVDRS) with population data from the American Community Survey for the years 2003 – 2017, analyzing the joined data as a multiple-frame sample. Our exposure of

interest was occupation type, classified as employment in (a) law enforcement, (b) military occupations, (c) other life-threateningly dangerous or traumatic occupations. Our unexposed reference group was persons in all other general occupations. To address issues of exposure misclassification, we applied conservative and anti-conservative classification methods. Our outcome of interest was perpetration of single-suspect homicide-suicide. Primary analyses used robust Poisson regression to calculate incidence ratios and 95% confidence intervals. Secondary analyses described years-of-life-lost (YLLs) to homicide victimization by homicide-suicide perpetrators, stratified by perpetrator occupation.

Results: Compared to the incidence of homicide-suicide perpetration among persons employed in all other general occupations, law enforcement (aIRR = 1.6; 95% CI: 1.2 – 2.1), military personnel (aIRR = 3.7, 95% CI: 2.7 – 5.0), and persons employed other life-threateningly dangerous or traumatic occupations (aIRR = 2.9, 95% CI: 2.1 – 4.0) were at an elevated risk for homicide-suicide perpetration when exposure was classified conservatively. Using anti-conservative exposure classification yielded higher point estimates with largely overlapping confidence intervals. Altogether, homicide-suicide perpetrators from law enforcement, military, and other life-threateningly dangerous occupations were responsible for approximately 6 – 7% of the total homicide-suicide victim count and 6 – 7% of the total victim YLLs.

Conclusions: Law enforcement officers commit homicide-suicide at a higher rate than the generally employed population, as do military personnel and persons employed in other life-threateningly dangerous or traumatic occupations. NVDRS and ACS data can be joined and analyzed as a multiple-frame sample for the study of rare health outcomes.

Introduction

Little is known about the prevalence of officer involved domestic violence (OIDV), where law enforcement officers perpetrate violence against intimate partners or family members. Studies estimate anywhere between 1 and 40% of law-enforcement commit OIDV during their lifetime.[1–12] The impractical range of these estimates reflect the limited generalizability of OIDV research, which relies heavily on non-representative sampling and self-reported measures.[1–12] Yet improving upon these limitations is uniquely challenging because the power imbalance between law enforcement and civilians systematically undermines the reporting of OIDV.[7–9,12,13] The present study contributes to the literature by using population-based data and vital statistics to examine a single subset of OIDV incidents: law enforcement homicide-suicide perpetration.

Officer-Involved Domestic Violence

Institutional concern for OIDV grew notably during the 1990s.[1,14–17] In 1991, Johnson presented the earliest findings on OIDV prevalence before the U.S. Select Committee on Children, Youth, and Families. [1,14–17] By 1996, Congress passed the Lautenberg Amendment, effectively prohibiting law-enforcement officers with a documented history of domestic violence perpetration from accessing firearms.[15] Following passage of the Lautenberg Amendment, several law-enforcement conferences presented findings on OIDV, including a 1998 symposium organized by the Federal Bureau of Investigation (FBI) dedicated entirely to OIDV research.[14–16] Motivated by this momentum, the International Associations of Chiefs of Police (IACP) issued a landmark position paper in 1999 articulating pathways for law-enforcement departments to standardize their policy responses to OIDV.[17] However, in spite of increasing public recognition, research describing the scope of OIDV remains limited.

Johnson's (1991) groundbreaking congressional testimony that 40% of law enforcement commit OIDV comes from a survey of two large police departments where officers were asked if they lost control or behaved violently towards their spouse or child in the past 6 months. [1,14,18] Since then, most studies that report on OIDV prevalence continue to rely on convenience sampling [2–12] and unvalidated self-report measures. [2,4–6,8,9,11] Domestic violence researchers have long criticized these methods for their salient vulnerability to selection and reporting biases.[19–22] Some studies have taken alternative approaches, such as using criminal records[3,23] or data from open-source news-media databases,[24–26] but these alternatives offer minimal improvement. Victims of OIDV underreport incidents to the police, and when they do report, procedural barriers and law enforcement culture can impede formal documentation of data. [5,7,9,11,12,14,18–23] Reliable data sources to estimate the prevalence of OIDV in its totality are scarce but focusing the scope of inquiry to specific subsets of OIDV could make better use of existing sources.

Homicide-Suicide and the National Violent Death Reporting System

Incidents of homicide followed by perpetrator suicide (homicide-suicide) are rare, with an estimated incidence of 0.2 – 0.3 per 100,000 person-years.[24,25,27–34] Approximately 80 – 90% of homicide-suicides involve intimate partners or family members, a probable underestimation given that the relationship between perpetrator and victim(s) is not always known.[24,25,27–34] Violanti's (2000) descriptive analysis of law-enforcement homicide-suicide and Klinoff et al.'s (2015) replication study collectively identified 72 law-enforcement homicide-suicide events between 2003 – 2014, all of which involved intimate partners or family members.[24,25] Research examining characteristics associated with homicide-suicide frequently identify a history of domestic violence, criminal history, and relationship stress as salient factors.[24,25,27–34] In general, homicide-suicide can be described as a subset of domestic violence, and because death is a health

outcome reliably captured by public health surveillance infrastructure, study of homicide-suicide can circumvent issues of reporting bias that limit studies of other forms of domestic violence.

The National Violent Death Reporting System (NVDRS) is a frequently-cited data source for homicide-suicide research.[35–39] Developed in 2002, the NVDRS abstracts incident-level data from a variety of sources including death certificates and law enforcement, criminal laboratory, and medical examiner reports. [35–37,40] As of 2018, all 50 U.S. states, the District of Columbia, and the territory of Puerto Rico participate in the NVDRS. [35–37,40] It is the most extensive, population-based homicide-suicide database in the U.S. Most homicide-suicide studies using the NVDRS are descriptive in nature, though case-control designs have also been used.[41,42] Prior studies have joined NVDRS data with data from the American Community Survey (ACS) to estimate and compare rates of suicide by varying subpopulations, but this approach has not been applied to studies of homicide-suicide.[43,44] Calculating the rate of law enforcement homicide-suicide using such an approach could produce the most robust estimation of any singular type of OIDV to date.

Law Enforcement Occupational Spillover

Analytic investigation of whether risk of homicide-suicide perpetration differs for those employed in law-enforcement requires identification of an appropriate comparison group. Melzer's (2002) study of occupation type as a risk factor for domestic violence perpetration presents a compelling methodological approach.[45] Melzer's theoretical framework of occupational spillover asserts that work-related stress and coping strategies can play out in the home, which aligns with research on mediators of OIDV. [14,46–49] Law enforcement officers endure unique work-related stress and wield unique license to employ violence as an occupational tool. Studies have found associations between spillover of work-related stress, occupational violence (also known as authoritarian spillover), and OIDV. [14,46–49] Melzer

hypothesized that persons in jobs that endorse occupational violence (e.g. law enforcement, military personnel, etc.) share similarities in work-related stress as persons in other jobs characterized by exposure to life-threatening danger and trauma (e.g., firefighters, miners, etc.).[45] Melzer's subsequent approach to exposure classification distinguishes between these two groups and the referent, suggesting occupations with overlapping work-related stress but distinct endorsements of occupational violence may differ in meaningful ways.[45] Altogether, Melzer's study can inform investigations of law-enforcement homicide-suicide perpetration in two ways. First, their framework of occupational spillover sets a strong theoretical foundation for examining the relationship between occupation type and homicide-suicide perpetration.[45] Second, given an occupational spillover framework, their approach to exposure classification isolates from the reference population the joint set of occupations characterized by exposure to endorsement of occupational violence and to life-threatening danger or trauma,[45] which makes for cleaner comparisons between occupation-exposure groups of interest and the referent.

Study Overview

OIDV is an underexamined public health issue that presents unique research challenges. The objective of this population-based retrospective study is to examine the scope of law enforcement homicide-suicide, a fatal subset of OIDV. We hypothesized that the incidence of homicide-suicide among law enforcement is higher compared to persons employed in other occupations. We applied Melzer's occupational-spillover framework to identify three exposure occupation groups: (a) law enforcement, (b) military, (c) other life-threatening or traumatic occupations. Our unexposed reference population consisted of all other general occupations. Primary analyses joined data from the NVDRS and ACS from 2003 – 2017, treating them as a multiple-frame sample.[50–52] We used robust Poisson regression to compare the incidence of

homicide-suicide among occupation groups exposed to life-threatening danger or trauma to all other general occupations. Additionally, given that homicide-suicide is overwhelmingly committed by men, we conducted sensitivity analyses by restricting our study sample to the employed male subpopulation to better address the confounding role of masculinity.[53] Secondary analyses described the burden of law enforcement homicide-suicide in years-of-victim-life-lost by joining data from the NVDRS with sex and race-specific life expectancy data from the National Vital Statistics System (NVSS).[54]

Methods

Data Sources

The NVDRS is the foremost active surveillance system of violent deaths in the U.S. Homicide-suicide incident data were obtained from the NVDRS for years the 2003 – 2017. During 2003, the NVDRS was active in 7 states and by 2017 it was active in 37 states, the District of Columbia, and the territory of Puerto Rico. The NVDRS's exhaustive data collection practices have been described elsewhere.[35–38,40] Some states have elected to partially participate in the NVDRS. Between 2003 – 2017, four states contributed data from only a subset of jurisdictions, per funding requirements. **Supplement A** presents a description of participating NVDRS jurisdictions by duration of participation and type of participation.

The ACS is an annual survey administered by the U.S. Census Bureau that collects demographic, social, economic, and housing data on approximately 1% of all U.S. households.[55] Population occupation data were obtained from single-year ACS files furnished by the Integrated Public Use Microdata Series – USA (IPUMS-USA). IPUMS-USA is an online database that collates ACS and Census data for public use.[56,57] Data from the ACS are weighted to be representative of the U.S. population at several levels, including national and state levels.[55,58]

The design, methodology, and weighting of the ACS have been described elsewhere. Studies joining ACS samples and NVDRS data vary in their methodology.[43,44,55,58]

The NVSS is the vital statistics data sharing program of the National Center for Health Statistics, which synthesizes vital registration data from all 50 U.S. states and 5 U.S. territories.[54] Among its regular reports, the NVSS produces annual period-cohort estimates of life expectancy based on U.S. birth and death records.[54] A period-cohort measure of life expectancy estimates the additional years of life remaining for an individual who survives to age *x* and is subject to the same mortality conditions as those observed during the period-cohort time frame.[54] Life expectancy data indexed by year-age-sex were obtained from the NVSS for years 2003 -2017. Life expectancy data was matched to all homicide-suicide records based the age and sex of the decedent and the year they died. Life expectancy conditional on year, age, and sex was treated as years-of-life-lost.

Study Populations

Our primary study population was a multiple-frame sample of employed ACS respondents and single-suspect perpetrators of homicide suicide from fully participating NVDRS state-years between 2003 and 2017. Traditionally, multiple-frame samples are constructed by directly sampling from two or more independent frames, the union of which better represents the target population. [50–52] However, multiple-frame samples can also be constructed post-hoc by joining existing independent samples into a composite sample that is analyzed collectively. [50–52]

We constructed a post-hoc multiple-frame sample by appending NVDRS and ACS data. Our NVDRS component sample consisted of all employed perpetrators of single-suspect homicide-suicide from fully participating NVDRS state-years between 2003 and 2017. The process of identifying our NVDRS component sample is described in **Figure 1**. Our ACS

component sample consisted of employed respondents from the same NVDRS state-years. Because ACS data are weighted to be population-representative, joining NVDRS and ACS data required the assignment of design and weighting values to NVDRS component data. We treated the NVDRS component sample as an exhaustive sample of homicide-suicide perpetrators by incident and by year. Accordingly, each record was assigned a person-weight of one, a unique cluster value by incident, and a unique stratum value by year. When weighted, the multiple-frame sample enumerated by year the total count of employed persons who perpetrated single-suspect homicide suicide (contributing numerator data for incidence calculations) and estimated by year the total count of employed persons (contributing denominator data) from fully participating NVDRS state-years between 2003 and 2017.

Our secondary study population consisted of all single-suspect homicide-suicide incidents perpetrated by employed suspects, from fully participating NVDRS state-years between 2003 – 2017, which corresponds to the incident-level sample from which the NVDRS component sample in primary analyzes was derived.

Exposures

Our exposure of interest was occupation group. Adopting Melzer's occupational-spillover framework,[45] we identified three occupation groups characterized by their exposure to similar life-threatening danger but qualitatively distinct endorsements of occupational violence: (a) law enforcement, (b) military, and (c) other life-threatening or traumatic occupations. Our unexposed reference group was all other occupations. Occupation data differed between NVDRS and ACS data sources, and thus exposure classification required two distinct approaches.

Occupation data for the ACS was captured using an occupation classification scheme adapted from the U.S. Bureau of Labor Statistics' (BLS) Standard Occupation Classification

System. Using Melzer's exposure classification criteria as a model, we determined the exposure status of ACS records based on their standard occupation classification code. **Table 1** presents the ACS standard occupation classification codes and categories that comprise each exposure group.

NVDRS occupation data are abstracted from standard occupation codes and free-text descriptive fields on the decedent's death certificate. Standard BLS occupation codes were missing for most decedents in our sample, therefore we classified exposure based on three free-text employment variables describing a decedent's (a) usual business or industry, (b) usual occupation, and (c) current occupation. Each record was evaluated individually, with equal weight given to the value of each free-text occupation variable. The value of each free-text variable was compared to ACS general occupation categories for each exposure group and coded accordingly.

Records with any indication of student status, retirement, or unemployment were categorized as singularly unemployed. Similarly, persons whose occupation was solely listed as disabled was also categorized as singularly unemployed. Records where all occupation variables aligned with a single exposure group were classified as singularly exposed. Records where the totality of occupation variables aligned with multiple exposure groups were classified as exposed to more than one group. Our method for classifying occupation exposure for NVDRS records resulted in 14 suspects classified as employed in either a life-threatening or traumatic occupation (e.g., law enforcement, military, or other life-threatening or traumatic jobs) or in a general occupation. No suspects were classified as exposed to more than one life-threatening or traumatic occupation. To address this issue of alternative exposure classification for these 14 suspects, we applied two 4-level exposure classification approaches: conservative and anti-

conservative. Conservative exposure classification maintains life-threatening or traumatic occupation groups that are singularly exposed (e.g., all occupation variables for that suspect denote employment in the same life-threatening or traumatic occupation) but a general occupation group that contains both those singularly exposed to a general occupation and those multiply exposed (e.g., suspects for whom at least one occupation variable denotes employment in a life-threatening or traumatic occupation and another that denotes employment in a general occupation). Anti-conservative exposure classification inversely maintains a general occupation group that is singularly exposed but life-threatening or traumatic occupation groups that contain both singularly and multiply exposed persons.

Outcomes

Our outcome of interest was the perpetration of (single-suspect) homicide-suicide. Homicide-suicide events are defined by the NVDRS as incidents of homicide wherein the suspect dies by suicide within 24 hours of the index homicide. The NVDRS classifies all homicide-decedents as either victims or suspects and indicates the total number of suspects per incident. We limited our sample to perpetrators of single-suspect homicide-suicide to reduce the risk of outcome misclassification. The NVDRS classified 14 homicide-suicide incidents as involving more than one homicide-suicide suspect, however, review of medical examiner and law enforcement narratives clarified that only 9 of these incidents ultimately involved more than one suspect.

Covariates

We identified four literature-based covariates associated with both occupation type and perpetration of homicide suicide, and present across both ACS and NVDRS component samples: age (in years), sex (female or male), mutually exclusive race/ethnicity (White, Black or African

American, American Indian or Alaskan Native, Asian or Pacific Islander, Other, Multiracial, and Hispanic), and history of military service (whether or not an individual has any history of military service, including current military employment). All covariates were included in adjusted primary analyses as *a priori* confounders, with sex removed as a covariate in sensitivity analyses that focused exclusively on male suspects.

Analyses

We applied ACS furnished weights to our multiple-frame sample to account for the necessary re-weighting of the ACS sample. Because person-weights for NVDRS records were set to one during construction of the multiple-frame sample, application of weights did not inflate the total count of homicide-suicide events.

Primary analyses estimated incidence rate ratios (IRRs) and 95% confidence intervals (95% CIs) using robust Poisson regression, wherein incidence was calculated as the number of employed single-suspect homicide-suicides per corresponding population count per year (a proxy for exposed person-years). The use of population estimates (traditionally mid-year population counts) as a proxy for exposed person-time is an established alternative when individual-level person-time data are not available.[59] We ran separate models for conservative and anti-conservative exposure classifications. Sensitivity analyses repeated primary analyses, with the study sample subset to only males. Secondary descriptive analyses summarize years-of-life-lost (YLLs) among victims homicide-suicide perpetration, by perpetrator's occupation exposure. Data management and secondary analyses were conducted using base R version 4.1.1 within RStudio version 1.4.1717. Primary and sensitivity analyses were conducted using Stata version 16.1. We applied sample weights using Stata's survey commands. We subset the sample by

NVDRS participating state-years, employed status, and sex (for sensitivity analyses) using Stata's *subpop* command.

Results

As shown in **Figure 1**, of the 3,397 homicide-suicide incidents identified within participating NVDRS state-years, 3,388 incidents involved a single suspect. Of these 3,388 incidents, 243 (7.17%) involved unemployed suspects, 466 (13.75%) involved suspects with unknown or missing occupation, and 250 (7.38%) occurred in partially participating NVDRS state-years, yielding 2,429 homicide-suicide incidents eligible for study inclusion. When classified conservatively, approximately 2.3% of homicide-suicide incidents were perpetrated by law enforcement, 2.2% by military personnel, and 1.5% by persons employed in other life-threatening or traumatic occupations, with 94.1% of incidents committed by persons in all other general occupations. The distribution of homicide-suicides using anti-conservative classification was comparable to the conservative distribution. Our weighted multiple-frame sample reflects the composition of the generally employed U.S. population within participating NVDRS state-years by occupation group. A full description of demographic characteristics by occupation for the multiple-frame sample is presented in **Table 2**.

Persons employed in the Military were notably younger on average (M = 29.7) than any other occupation exposure group. Law enforcement retained the greatest proportion of Black or African American (18.8%) employees and the smallest proportion of Hispanic (5.1%) employees. Military occupations retained the greatest proportion of Multiracial (10.9%) and Hispanic (2.9%) personnel. Persons employed in other life-threatening or traumatic occupations were more likely than any other occupation exposure group to be White (80.5%) and American Indian or Alaskan Native (2.0%). Persons employed in all other general occupations were most

likely than any other occupation exposure group to be Asian or Pacific Islander (4.1%). All three occupation groups characterized by exposure to life-threatening danger or trauma were highly male dominated, while the gender distribution among the generally employed population was relatively equal. Additionally, approximately 1-in-4 law enforcement officers had a history of military service, compared to the generally employed population where approximately 1-in-13 had any such history.

The incidence of homicide-suicide among law enforcement was 0.7 – 0.8 per 100,000 person-years, depending on exposure classification method. After adjusting for age, sex, race/ethnicity, and history of military service, the incidence of homicide-suicide among law enforcement was 1.6 times greater (aIRR = 1.6, 95% CI: 1.2 – 2.1) than the generally employed population when occupation exposure was classified conservatively and 1.8 times greater (aIRR = 1.8, 95% CI: 1.4 – 2.4) when occupation exposure was classified anti-conservatively. Comparatively, the adjusted incidence of homicide-suicide among military personnel was 3.7 times greater (aIRR = 3.7, 95% CI: 2.7 – 5.0) when occupation exposure was classified conservatively and 4.1 times greater (aIRR = 4.1, 95% CI: 3.0 – 5.5) when occupation exposure was classified anti-conservatively. Adjusted incidence of homicide-suicide among persons in other life-threateningly dangerous or traumatic occupations was 2.9 times greater (aIRR = 2.9, 95% CI: 2.1 – 4.0) when occupation exposure was classified conservatively and 3.3 times greater (aIRR = 3.3, 2.4 – 4.5) when occupation exposure was classified anti-conservatively. Altogether, anti-conservative exposure classification yielded slightly higher point estimates with confidence intervals that largely overlapped with conservative estimates.

Sensitivity analyses of the male subpopulation estimated the incidence homicide-suicide among law enforcement to be 0.8 – 0.9 per 100,000 person-years, depending on exposure

classification method. Subsetting to the male subpopulation attenuated differences between crude and adjusted IRR estimates, suggesting strong confounding by sex. Interestingly, while adjusting for confounders decreased IRR estimates for all exposure groups in primary analyses, within the male subpopulation, controlling for covariates resulted in higher IRR estimates for military and other life-threateningly dangerous or traumatic occupation exposure groups. Ultimately, however, all adjusted estimates for the sensitivity analyses were comparable to those of the primary analyses.

Secondary analyses indicated 2,429 employed single-suspect homicide-suicide perpetrators were responsible for 2,882 victims and a corresponding 101,361 YLLs. Victims killed by military personnel were younger on average compared to victims killed by persons from any other occupation group, while victims killed by persons in life-threateningly dangerous or traumatic occupations were oldest on average. Altogether, homicide-suicide perpetrators from law enforcement, military, and other life-threateningly dangerous occupations were responsible for approximately 6% of the total homicide-suicide victim count and 6% of the total victim YLLs. Proportional estimates of victim count and victim YLLs were comparable between conservative and anti-conservative exposure classifications.

Discussion

To our knowledge, the current study presents the first estimates of homicide-suicide incidence among the employed U.S. population, and by specific occupation groups. We found the incidence of homicide-suicide among persons employed in general occupations to be 0.3 per 100,000 person-years, which aligns with prior estimates regarding the incidence of homicide-suicide among the overall U.S. population.[27,30,31,33,34] Sensitivity analyses estimated a higher incidence among the generally employed male subpopulation, 0.5 per 100,000, which affirms

previous observations that homicide-suicide is committed primarily by men.[27,29–31,33] While death from homicide-suicide perpetration is a rare, the incidence of homicide-suicide among the generally employed population is comparable to the rates of death from tuberculosis, meningitis, and Hodgkin's lymphoma,[60,61] all of which benefit from strong preventative public health campaigns.

Though primary analyses found differences in the incidence of homicide-suicide perpetration by occupation group, secondary analyses did not find differences in the distribution of YLLs by perpetrator occupation. Bui et al. (2018) have argued that analyses of fatal encounters involving law enforcement may underestimate the burden of such violence when using count data, suggesting that years of life lost analyses may better characterize disparities.[62] While we modeled our secondary analyses after Bui et al.'s approach,[62] we were unable to estimate race-specific YLLs due to limitations among the publicly available NVSS life tables.[54] Life expectancy differs by race for persons of the same age and sex,[54] thus future analyses of YLLs among homicide-suicide victims using race-specific estimates could result differently.

OIDV and Homicide-Suicide

Our findings advance the field of OIDV research by demonstrating that law enforcement officers are at an elevated risk of homicide-suicide perpetration compared to the generally employed population. The limitations of prior OIDV studies have yielded impractical estimates of OIDV prevalence, between 1 and 40%. [1–12] In applying population-based methods, we found that law enforcement officers commit homicide-suicide at a rate of 0.7 – 0.8 per 100,000 person-years, which is 60 – 80% greater than the generally employed population, comparable to mortality due to mesothelioma and malnutrition.[60]

Interpreting these results within the context of OIDV requires caution. Despite its strong association with domestic violence, [24,25,27–34] several studies suggest that homicide-suicide is unique due to its varied motivations, complicating its characterization as a domestic violence offense. [27–31,33,34,63] For example, researchers have classified some homicide-suicide events, primarily among elderly persons and persons of declining health, as mercy killings or joint suicide pacts. [27–31,33,34,63] Additionally, there are homicide-suicides which do not involve intimate partners or family members (e.g., those motivated by workplace retaliation), which cannot be classified as domestic violence. [27–31,33,34,63] However, our study sample excluded homicide-suicide perpetrators who were retired, unemployed, or disabled with no additional employment indication, reducing the representation of elderly perpetrators and perpetrators of poor or declining health in our study population. Further, research has found extra-familial homicide-suicides to be rare, [27–31,33,34,63] and prior studies of homicide-suicide in law enforcement primarily characterize the offense as one of domestic violence overwhelmingly preceded by other domestic violence offenses.[24,25] Altogether, our findings that law enforcement officers disproportionately commit homicide-suicide suggests that other disproportionalities among other OIDV offenses likely exist.

Additionally, our findings contribute to a growing body of quantitative evidence documenting the negative impacts of law enforcement on public health.[62,64–71] Most studies examine fatal and non-fatal interactions with on-duty law enforcement, as both exposures and outcomes.[62,64–71] OIDV studies purporting law enforcement officers disproportionately commit domestic violence suggest that interpersonal interactions with off-duty officers may also negatively impact public health, but sampling and measurement limitations among these studies preclude the generalization of their findings to population-level outcomes.[1–12] Our primary and

secondary analyses support the hypothesis that employment in law enforcement may detrimentally affect specific public health outcomes, even outside the line of duty. Accordingly, law enforcement employment as a social determinant of public health merits further investigation.

Occupational Spillover Effects

We hypothesized that life-threateningly dangerous or traumatic occupational stress and authoritarian spillover mediated the relationship between occupation exposure and perpetration of homicide-suicide. [14,46–49] Melzer's (2002) model of exposure classification delineated a method for differentiating among occupations that experience similar life-threateningly dangerous or traumatic stress but differing authoritarian spillover and all other occupations,[45] facilitating cleaner comparisons between our exposure groups of interest and the referent population. However, while Melzer further leveraged this approach to distinguish between the mediating effects of occupational stress and authoritarian spillover,[45] our findings presented challenges to such an interpretation.

Melzer classified law enforcement and military occupations as a single group with similar occupational stress and endorsement of violence as an occupational tool.[45] We adapted this classification system to explicitly examine the effect of law enforcement occupation exposure. Interestingly, in both our primary and secondary analyses, the law enforcement occupation exposure group retained the smallest point estimates among the exposed occupation groups while the military occupation exposure group retained the largest. Demographic differences between these two groups could explain the observed differences in homicide-suicide rates.[24,25,72] Patton et al. (2017) found that military perpetrators of homicide-suicide were more likely to be older than civilian perpetrators and they were more likely to be White.[72] These differences hold true

when compared to the findings of Violanti (2007) and Klinoff et al. (2014) on the demographic characteristics of law enforcement homicide-suicide perpetrators, though direct comparison is complicated due to Patton et al.'s definition of military perpetrators including both current military personnel and veterans.[24,25,72] Further descriptive analyses of homicide-suicide by current military personnel compared to law enforcement could improve our understanding of pathways to homicide-suicide perpetration.

Additionally, our findings concerning other persons employed in life-threateningly dangerous or traumatic occupations were surprising. The aIRR estimates for this exposure group overlapped with those of military personnel but not of law enforcement. For parity, we operationalized this exposure group using the same criteria as Melzer,[45] though Melzer provides little theoretical foundation to motivate selection criteria. Indeed, occupation types not included could be characterized by exposure to life-threatening danger or trauma, such as fishing and hunting workers, loggers, certain construction workers, and certain healthcare professionals.[73,74] The heterogeneity of this exposure group complicates comparison to law enforcement and military personnel. However, given the potential inclusion of occupations otherwise classified into the referent category as life-threateningly dangerous or traumatic, the observed estimates of our primary analyses are likely attenuated.

Multiple-Frame Sampling and the NVDRS

To our knowledge, the current study is the first to treat ACS and NVDRS data as a multiple-frame sample for analytic investigation of homicide-suicide. Boulifard and Pescosolido's (2017) case-control study of sociodemographic factors and suicide leveraged ACS and NVDRS data using a similar method, though with a differing weighting approach.[43] Additionally, Peterson et al. (2020) also used ACS and NVDRS data to estimate occupation-

specific suicide incidence rates, but their method is not fully described, and no relative between-group comparisons were made.[44] Analytic study of NVDRS data is uniquely challenging given that data are only collected on incidents for which a given violent death outcome is observed.[42] Our study demonstrates that multiple-frame analysis can address this limitation when using appropriate supplemental data sources, and can be useful for research involving other health surveillance data sources beyond the NVDRS.

Limitations

The present study was limited by several factors. First, in joining two independently sampled data frames (the NVDRS and ACS) we risked duplication of observation across both frames. However, the rarity of homicide-suicide renders this potentiality unlikely.[43] Second, exposure misclassification was possible at several steps. To address exposure misclassification resulting from potential inclusion in more than one occupation exposure group, we employed both conservative and anti-conservative exposure classification approaches which yielded relatively similar estimates. We were not able to address exposure misclassification resulting from persons who work in jobs otherwise characterized by exposure to life-threatening danger or trauma as employed in the referent group. However, including these persons within the reference group likely attenuates estimates, biasing them towards the null. Third, we were unable to classify exposure groups with more granular resolution. Research suggests that certain types of law enforcement officers may be overrepresented in counts of homicide-suicide, and more generally that employment in a managerial or supervisory role may protect one against the spillover effects otherwise associated with their occupation.[24–26,45] NVDRS data were not sufficient to stratify by more specific occupation types beyond the general occupation exposure groups. Finally, the timeframe of our study preceded the full nation-wide implementation of the

NVDRS, and data only pertain to a subset of fully participating jurisdictions. However, given the 15-year timeframe of the study, with more than half of U.S. states participating in at least one year, we maintain our results are sufficiently robust to generalize to the greater U.S. population.

Conclusion

Homicide-suicide is an extremely rare event that presents unique opportunities for study. Results from the present study indicate law enforcement officers, military personnel, and persons employed in other life-threateningly dangerous or traumatic occupations commit homicide-suicide at a higher rate than the generally employed population. Within the context of OIDV, these findings set quantitative foundation for future inquiry into law enforcement employment as a risk factor for domestic violence perpetration. More broadly, these findings evidence that those employed within occupations characterized by exposure to life-threatening danger or trauma as a risk factor for homicide-suicide perpetration. Altogether, this study represents an exercise in treating joined comprehensive health surveillance and population-representative survey data as a multiple-frame sample for the investigation of rare health outcomes.

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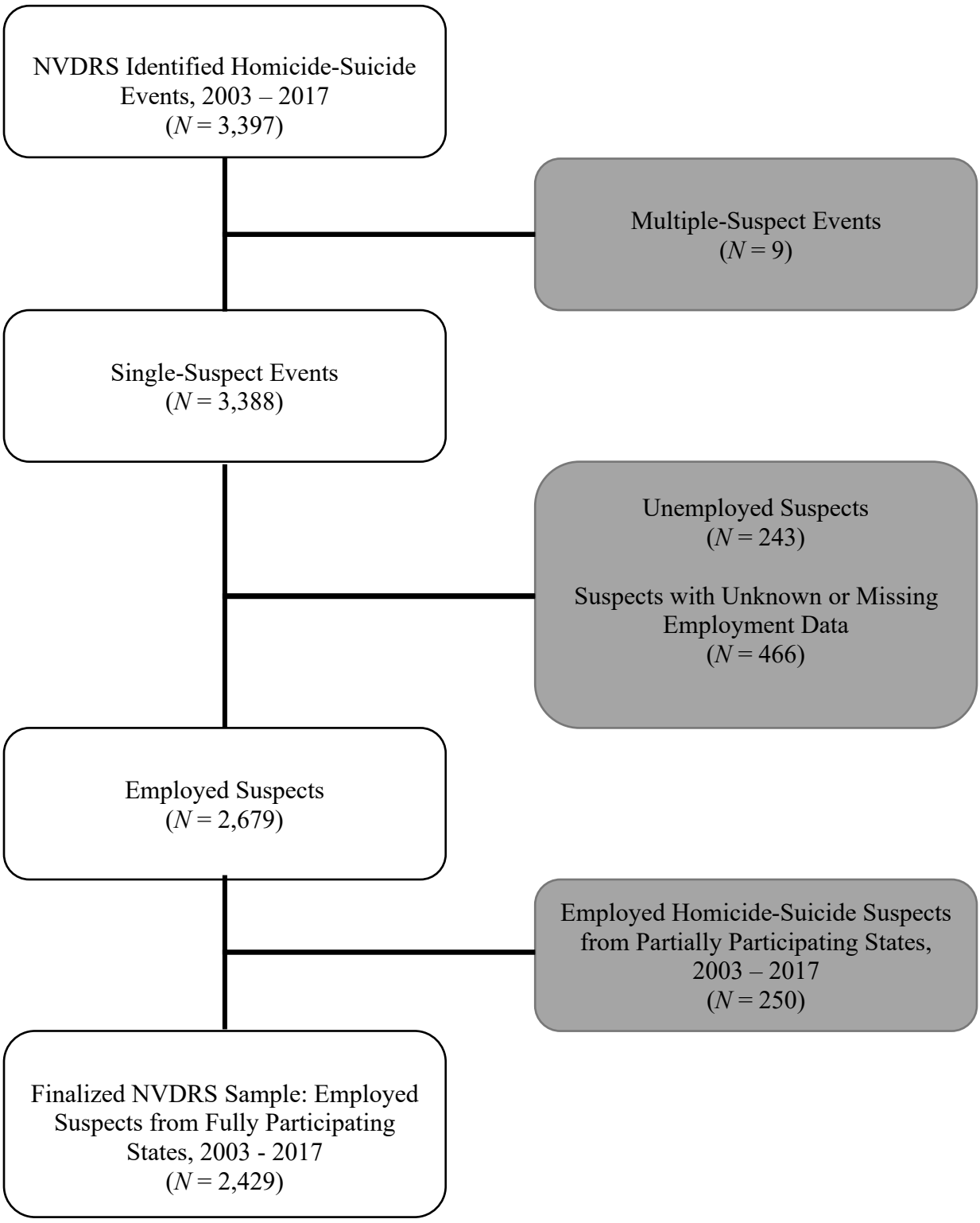
Figure 1. Identification of Employed Homicide-Suicide Suspects from Fully Participating NVDRS State-Years, 2003 – 2017



Note. Shaded boxes represent records removed from the study sample.

Table 1. Exposure Classification Criteria by ACS General Occupation Codes and Categories

Occupation Exposure Classification	ACS Standard Occupation Code	ACS Occupation Description
Law Enforcement	331011	First-line supervisors of correctional officers
	331012	First-line supervisors of police and detectives
	333010	Bailiffs, correctional officers, and jailers
	333021	Detectives and criminal investigators
	333050	Police and sheriff's patrol officers (general code)
	333051	Police and sheriff's patrol officers (specifically police officers)
	333052	Police and sheriff's patrol officers (specifically transit and railroad police)
Military	551010	Military officer special and tactical operations leaders
	552010	First-line enlisted military supervisors
	553010	Military enlisted tactical operations and air/weapons specialists and crew members
	559830	Military, rank not specified
Other Life Threatening or Traumatic	331021	First-line supervisors of fire-fighting and prevention workers
	332011	Firefighters
	332020	Fire inspectors
	475010	Derrick, rotary drill, and service unit operators, oil, gas, and mining
	475021	Earth drillers, except oil and gar
	475031	Explosive workers, ordnance handling experts, and blasters
	475040	Mining machine operators
	475061	Roof bolters, mining
	475071	Roustabouts, oil and gas
	475081	Helpers -- extraction workers
	4750XX	Extraction worker (general code)
	4750YY	Extraction worker (general code)
Missing	0	Not applicable (Under 16 years or not in the labor force, who last worked more than 5 years ago
	999920	Unemployed, with no work experience in the last 5 years or earlier or never worked
All other	--	All other occupation codes.

Table 2. Characteristics of Multiple-Frame Study Sample by Conservative Occupation Exposure Classification

Study Sample Characteristics	Occupation Exposure, Conservative Classification Weighted % *(95% CI)*							
	Law Enforcement (n = 73,187)[1]		**Military (n = 36,234)[2]**		**Other Life Threatening or Traumatic (n = 29,731)[3]**		**All Other (n = 8,123,503)[4]**	
Age in years, Mean (95% CI)	41.1	*(41.3 – 41.5)*	29.7	*(29.6 – 29.8)*	39.9	*(39.8 – 40.1)*	42.0	*(42.0 – 42.0)*
Race/Ethnicity								
White	70.7	*(70.2 – 71.1)*	67.7	*(67.0 – 68.3)*	80.5	*(79.8 – 81.1)*	70.3	*(70.3 – 70.4)*
Black or African American	18.8	*(18.3 – 19.2)*	15.0	*(14.5 – 15.5)*	7.1	*(6.7 – 7.6)*	13.4	*(13.3 – 13.4)*
American Indian or Alaskan Native	1.0	*(1.0 – 1.1)*	0.6	*(0.5 – 0.7)*	2.0	*(1.9 – 2.3)*	0.8	*(0.8 – 0.8)*
Asian or Pacific Islander	1.1	*(1.0 – 1.2)*	2.8	*(2.6 – 3.0)*	0.6	*(0.5 – 0.8)*	4.1	*(4.1 – 4.2)*
Other	0.1	*(0.1 – 0.2)*	0.2	*(0.1 – 0.2)*	0.1	*(0.1 – 0.1)*	0.2	*(0.2 – 0.2)*
Multiracial	1.5	*(1.4 – 1.6)*	2.9	*(2.6 – 3.1)*	1.7	*(1.5 – 1.9)*	1.5	*(1.5 – 1.6)*
Hispanic	6.9	*(6.7 – 7.2)*	10.9	*(10.4 – 11.3)*	7.9	*(7.4 – 8.4)*	9.6	*(9.5 – 9.6)*
Sex								
Male	80.2	*(79.9 – 08.6)*	87.0	*(86.5 – 87.4)*	95.8	*(95.4 – 96.1)*	50.8	*(50.8 – 50.9)*
Female	19.8	*(19.4 – 20.1)*	13.0	*(12.6 – 13.5)*	4.2	*(3.9 – 4.6)*	49.2	*(49.1 – 49.2)*
History of Military Service								
Any History	23.4	*(23.0 – 23.8)*	100.0	*(100.0 – 100.0)*	16.3	*(15.8 – 16.9)*	7.5	*(7.5 – 7.6)*
No History	76.7	*(76.2 – 77.1)*	0.0	*(0.0 – 0.0)*	83.7	*(83.1 – 84.2)*	92.5	*(92.5 – 92.5)*

Note. Missingness for all covariates across all exposure categories < 0.001%. Proportions and 95% confidence intervals for study sample by conservative and anti-conservative exposure classification are the same. Some within-occupation-group distributions may not add to 100 due to rounding.

[1]Weighted population count for anti-conservative classified law enforcement exposure is n = 73,192.

[2]Weighted population count for anti-conservative classified military exposure is n = 36,238.

[3]Weighted population count for anti-conservative classified other life threatening or traumatic occupations exposure is n = 29,736.

[4]Weighted population count for anti-conservative classified all other occupations exposure is n = 8,123,489.

Table 3. Comparison of homicide-suicide incidence by occupation exposure, stratified by exposure classification method.

Occupation Exposure Group	Conservative Exposure Classification					Anti- Conservative Exposure Classification				
	Inc.	Crude		Adjusted		Inc.	Crude		Adjusted	
		IRR	*(95% CI)*	IRR	*(95% CI)*		IRR	*(95% CI)*	IRR	*(95% CI)*
Law Enforcement	0.7	2.7	*(2.0 – 3.5)*	1.6	*(1.2 – 2.1)*	0.8	2.9	*(2.3 – 3.8)*	1.8	*(1.4 – 2.4)*
Military	1.4	5.4	*(3.2 – 6.2)*	3.7	*(2.7 – 5.0)*	1.5	5.8	*(4.5 – 7.5)*	4.1	*(3.0 – 5.5)*
Other Life Threatening or Traumatic	1.2	4.5	*(3.2 – 6.2*	2.9	*(2.1 – 4.0)*	1.4	5.8	*(3.8 – 7.0)*	3.3	*(2.4 – 4.5)*
All Other	0.3	1.0	*(REF)*	1.0	*(REF)*	0.3	1.0	*(REF)*	1.0	*(REF)*

Note. Inc. = homicide-suicide incidence per 100,000 person-years. IRR = incidence rate ratio. 95% CI = 95% confidence interval. Results presented using conservative and anti-conservative exposure classification methods. All adjusted models control for age in years, mutually exclusive race/ethnicity, binary sex, and history of military service.

Table 4. Sensitivity analysis: Comparison of homicide-suicide incidence among males by occupation exposure, stratified by exposure classification method.

Occupation Exposure Group	Conservative Exposure Classification					Anti- Conservative Exposure Classification				
	Inc.	Crude		Adjusted		Inc.	Crude		Adjusted	
		IRR	*(95% CI)*	IRR	*(95% CI)*		IRR	*(95% CI)*	IRR	*(95% CI)*
Law Enforcement	0.8	1.7	*(1.3 – 2.2)*	1.5	*(1.1 – 2.1)*	0.9	1.9	*(1.4 – 2.4)*	1.7	*(1.3 – 2.3)*
Military	1.6	3.3	*(2.5 – 4.3)*	3.7	*(2.8 – 5.1)*	1.8	3.6	*(2.8 – 4.7)*	4.1	*(3.1 – 5.6)*
Other Life Threatening or Traumatic	1.2	2.4	*(1.7 – 4.3)*	2.8	*(2.0 – 3.9)*	1.4	2.8	*(2.0 – 3.8)*	3.2	*(2.4 – 4.4)*
All Other	0.5	1.0	*(REF)*	1.0	*(REF)*	0.5	1.0	*(REF)*	1.0	*(REF)*

Note. Inc. = homicide-suicide incidence per 100,000 person-years. IRR = incidence rate ratio. 95% CI = 95% confidence interval. Results presented using conservative and anti-conservative exposure classification methods. All adjusted models control for age in years, mutually exclusive race/ethnicity, and history of military service.

Table 5. Descriptive summary homicide-suicide burden by victim counts and victim years-of-life-lost, stratified by exposure classification method

Occupation Exposure Group	Conservative Exposure Classification						Anti-Conservative Exposure Classification					
	Incidents (N)	Victims		YLLs		Average Victim Age	Incidents (N)	Victims		YLLs		Average Victim Age
		N	*(%)*	N	*(%)*			N	*(%)*	N	*(%)*	
Overall	2,429	2,882	*(100.0)*	101,360.6	*(100.0)*	39.4	2,429	2,882	*(100.0)*	101,360.6	*(100.0)*	39.4
Law Enforcement	55	74	*(2.6)*	2,331.0	*(2.3)*	38.1	60	79	*(2.7)*	2,490.0	*(2.5)*	38.2
Military	53	62	*(2.2)*	2,298.9	*(2.3)*	33.6	57	67	*(2.3)*	2,469.9	*(2.4)*	34.4
Other Life Threatening or Traumatic	36	40	*(1.4)*	1,385.3	*(1.4)*	44.2	41	45	*(1.6)*	1,478.4	*(1.5)*	43.2
All Other	2,285	2,706	*(93.9)*	95,345.4	*(94.1)*	39.5	2,271	2,691	*(93.4)*	94,922.4	*(93.6)*	39.5

Note. Incidents = incidents of single-suspect homicide-suicide. YLLs = victim years-of-life-lost conditional on year death, victim age, and victim sex.

Supplement A. Tabulation of NVDRS Participating Jurisdictions from 2003 - 2017

Jurisdiction	First Year of Participation	Total Years of Participation	Type of Participation
Alaska	2003	15	Complete
Arizona	2015	3	Complete
California	2017	1	Partial
Colorado	2004	14	Complete
Connecticut	2015	3	Complete
Delaware	2017	1	Complete
Georgia	2004	14	Complete
Hawaii[1]	2015	2	Complete
Illinois	2016	2	Partial
Indiana	2016	2	Complete
Iowa	2016	2	Complete
Kansas	2015	3	Complete
Kentucky	2005	13	Complete
Maine	2015	3	Complete
Maryland	2003	15	Complete
Massachusetts	2003	15	Complete
Michigan	2014	4	Complete
Minnesota	2015	3	Complete
Nevada	2017	1	Complete
New Hampshire	2015	3	Complete
New Jersey	2003	15	Complete
New Mexico	2005	13	Complete
New York	2015	3	Complete
North Carolina	2004	14	Complete
Ohio	2011	7	Complete
Oklahoma	2004	14	Complete
Oregon	2003	15	Complete
Pennsylvania	2016	2	Partial
Puerto Rico	2017	1	Complete
Rhode Island	2004	14	Complete
South Carolina	2003	15	Complete
Utah	2005	13	Complete
Vermont	2015	3	Complete
Virginia	2003	15	Complete
Washington	2016	2	Partial
Washington D.C.	2017	1	Complete
West Virginia	2017	1	Complete
Wisconsin	2004	14	Complete

[1]The NVDRS collected, but does not share, data from Hawaii for the year 2017 due to incomplete case reporting. The current study treats Hawaii as contributing zero state-years of data for 2017.