Interpersonal violent injury and subsequent risk of suicide and deliberate self-harm: a register-based national cohort study from Norway, 2010–2018

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Summary

Background Interpersonal violence is a leading cause of morbidity, with potentially severe adverse consequences for the mental health of the injured persons. The extent to which violent injury is associated with subsequent suicidal behavior, however, remains unclear. This study aimed to examine how violent injury was associated with subsequent deliberate self-harm and death by suicide.

Methods This retrospective cohort study used nationwide longitudinal registry data from Norway to identify all individuals presenting to emergency services in 2010–2018 with a violence-related injury, along with sex- and age-matched control individuals from the general population. The primary outcomes were any emergency visit for deliberate self-harm (DSH) and suicide death, observed through 31 December 2018. Rates of each outcome were compared between violence-injured patients and comparison individuals using stratified multivariable Cox regression models, controlling for sociodemographic characteristics as well as history of psychiatric treatment and DSH. Secondary analyses tested for moderation by sex, age, and prior psychiatric treatment.

Findings Violence-injured patients (n = 28,276) had substantially higher rates of DSH (946.7 per 100,000 person-years) and suicide death (74.5 per 100,000) when compared to controls (n = 282,760; 90.0 and 15.2 per 100,000, respectively). The hazard ratios (HRs) remained significantly higher even after accounting for covariates (HR_{adj} for DSH: 5.11; 95% CI: 4.62, 5.66; HR_{adj} for suicide: 2.40; 95% CI: 1.78, 3.24). Sex differences in this association were negligible, but the association between violence injury and DSH increased with age. Violence-injured patients with prior psychiatric treatment had the highest risk of suicidal behavior.

Interpretation Violence-injured patients experience significantly excess rates of suicidal behavior, a finding with potential to inform both clinical intervention and population-level suicide prevention strategies.

Funding Fulbright Norway Scholarship.

Keywords: Violence; Injury; Deliberate self-harm; Suicide; Population study

Introduction

Interpersonal violence, defined as the intentional use of physical force or power against other persons by an individual or group,[1] is a leading cause of mortality and morbidity.[2] It is also societally costly, accounting for over $115 billion per year in the United States alone.[3] For individuals who have experienced interpersonal violence, the consequences can include not just the immediate effects of traumatic injury but more enduring problems with psychosocial and physical functioning.[1,4] The most serious effects may be psychological. Strong associations have been documented between violent injury (such as physical assault, sexual violence, intimate partner violence, and childhood abuse) and subsequent psychopathology, including depression, anxiety, and substance use disorders.[5–8] Less well understood, however, is how violent injury is related to the most severe mental health outcome of all: suicide and suicidal behavior. Yet experiences of violence and associated injury may be an especially

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Research in context

Evidence before this study

Interpersonal violence is a well-established risk factor for mental health problems among victimized individuals, but its relationship with suicidal behavior is less well studied. Most research in this area also uses narrow definitions of violence, typically focusing exclusively on intimate partner violence, childhood abuse, or sexual assault. These narrow definitions exclude other kinds of assault and violent injury and often result in studies on subgroups (e.g., women, children, or psychiatric patients). A search of PubMed and Google Scholar conducted January 6 through February 30, 2023 (with no date restrictions, using any of the search terms 'interpersonal violence', 'violence,' 'assault,' 'violent injury,' AND any of the terms 'suicide,' 'suicidality', 'suicidal', 'self-harm', 'suicide attempt', 'self-injury') revealed little research on the impact of violent injury, broadly-defined, on suicidal behavior. Existing studies mostly use cross-sectional designs (precluding establishment of temporal precedence between violent injury and suicidal behavior and examination of suicide death) or, if longitudinal, use hospital-based rather than population-based control groups (which have potential for selection bias), rarely adjust for important social and psychiatric factors that often characterize people injured through violence, and have low generalizability.

Added value of this study

Using nationwide longitudinal data from Norway, we found that patients presenting to emergency services with violence-related injury had ten-fold increased risk of subsequent deliberate self-harm and five-fold increased risk of suicide death when compared with a sex- and age-matched general population control cohort. The substantially elevated risks remained even after adjustment for sociodemographic characteristics (income, education, marital status, immigrant status) as well as history of prior psychiatric treatment and deliberate self-harm for both male and female patients. The association between violent injury and nonfatal deliberate self-harm was stronger among older individuals, and violence-injured patients with a history of psychiatric treatment had the highest risk of suicidal behavior.

Implications of all the available evidence

Experiencing a violent injury is associated with substantially increased short- and long-term risk of fatal and nonfatal suicidal behavior. Clinicians should consider providing suicide risk screening and intervention measures to violence-injured patients, particularly if they are struggling with other psychosocial adversities. National suicide prevention strategies should include violence prevention initiatives.

salient form of the pain, provocation, and psychological shame and alienation that can lead to suicidality,[9,10] making violent injury a potentially important and specific trigger of increased suicide risk.[11,12]

Cross-sectional surveys have documented associations between interpersonal violent injury and nonfatal suicidal behavior, but their focus is often exclusively on intimate partner violence or childhood adversity,[13] and their design precludes definitive establishment of temporal precedence between violent injury and suicidality or examination of suicide death.[14,15] Longitudinal studies have focused on health care settings, which are an important context for identifying violence patients, deploying interventions, and tracking the public health burden of violent injury.[16] Hospital-based studies have shown that patients presenting with assault- or violence-related injuries have substantially elevated risk of subsequent emergency department (ED) or hospital visits for nonfatal deliberate self-harm (DSH)[11] or suicide death[17,18] when compared to patients presenting with other conditions (or in one case when compared to the general population[19]). However, using hospital-based control groups involves potential selection bias and questionable counterfactual comparisons[6]; moreover, these studies could not account for important factors—in particular, prior violence involvement, psychopathology, substance abuse problems, and suicidality, as well as socioeconomic disadvantage—that confound the association between violence victimization and suicidality.[7,20–22] This underscores the need for more population-based studies with longitudinal data to enhance our understanding of the link between violent injury and subsequent suicidal behavior, and to better inform psychosocial interventions and mental healthcare for these patients.

In this study, we used nationwide register-based cohort data from Norway to examine how violent injury was associated with subsequent deliberate self-harm and death by suicide. We also tested whether demographic characteristics, as well as history of psychological problems, moderated the association between violent injury and suicide outcomes, to inform the design of interventions.[6] Norway is a high-income country with universal healthcare and relatively low violent crime rates, including annual rates of 0.6 homicides per 100,000[23] and ~117 assaults per 100,000.[24] Nevertheless, substantial proportions of Norwegians report experiencing severe physical violence at least once after age 18,[25] with up to 22% reporting lifetime sexual violence,[26] 5.5% of partnered women reporting past-year intimate partner violence,[27] and ~4% of adolescents reporting physical or sexual abuse.[28] The nation's rates of suicide (13.4 per 100,000, or 19.5 per 100,000 among men and 7.3 per 100,000 among women)[29] and hospital-treated deliberate self-harm (121 per 100,000)[30] are approximately average among

European countries.[31] These characteristics, as well as the country's robust registry data, make it a rigorous setting in which to examine this topic.

Methods

Data sources and study population

Data for this retrospective matched cohort study were obtained from several Norwegian longitudinal registers that were interlinked on an individual level via the encrypted personal identifier of all residents in Norway.

Data used to construct the exposure group of interest were retrieved from two databases of the Norwegian Patient Register (NPR): the somatic database (2008–) and the injury database (2009–). The somatic database records episodes of somatic treatment in all specialist healthcare services, including hospitals and associated emergency services.[32] The injury database records supplemental information for all acute somatic injuries treated in specialist healthcare services and municipality emergency centers in Oslo, Bergen and Trondheim, including the reason, mechanism, and severity of the injury.[33] We defined the exposure group as all Norwegian residents who presented to emergency services at least once in 2010–2018 with an injury recorded as due to violence or assault (hereafter referred to as violence-injured patients). We restricted our analysis to data beginning in 2010 to ensure that no individual in our study population had had a violent injury within the prior two years, and to allow adjustment for the confounding effect of pre-existing psychiatric treatment.

Qualifying injuries comprised those with the Norwegian version of the International Classification of Diseases, 10th Revision (ICD-10) diagnosis of X85-Y09 (injuries inflicted by another person with intent to injure or kill, by any means) or X8n (violent injury or assault; a Norway-specific supplemental code) in the somatic database; and/or those with a diagnosis of physical injury and a contact reason of violence or assault injury in the injury database. This case definition encompasses incident events of physical assault, violent mugging, injuries sustained during street fighting, intimate partner violence, childhood abuse, sexual assault, bullying, or miscellaneous violent injury, in which the injured person sought emergency medical care. For each violence-injured patient, the first-observed violent injury during the study period (hereafter referred to as the index event) was selected for inclusion; the date of this event is referred to throughout as the index date.

Members of the comparison cohort were randomly selected from a 25% representative sample of the national population recorded in the Central Population Register, which is administered by the Norwegian Tax Administration. Each violence-injured patient was matched on sex and date of birth (within ten days) with ten individuals who were alive, resident in Norway, and had no record of violent injury as of the index date. Our sampling approach was based on risk-set sampling with replacement, in which comparison individuals could be matched to more than one violence-injury patient. This approach is well-established in the literature[34–36] and has been shown to produce unbiased estimates in population-based register datasets through preventing immortal time bias.[37,38] We chose a 1:10 ratio for the matched comparison group to maximize precision of our estimates and ensure availability of comparison individuals for subgroup analyses.[37,39]

Demographic data on residents' sex, date of birth, citizenship, and date of immigration or emigration were retrieved from the Central Population Register. Data on individuals' socioeconomic characteristics, including annual income, educational attainment, and marital status, were retrieved from the Statistics Norway's Events Database (FD-Trygd), administered by Statistics Norway (SSB).

Data on nonfatal deliberate self-harm (DSH) events and psychiatric treatment were obtained from the NPR, which covers the entire national population of Norway and contains data on both somatic and psychiatric contacts with specialist healthcare services.[40] Data on date and cause of residents' deaths were obtained from the Cause-of-Death Register, administered by the Norwegian Institute of Public Health.

The study was approved by the Regional Committee for Medical and Health Research Ethics and owners of the registers. Informed consent from participants is deemed unnecessary for register-based research with de-identified data.

Outcome measures

We examined two study outcomes. The first outcome was deliberate self-harm events. Due to known issues with underreporting of DSH in clinical contexts,[41] we used a broader approach that includes episodes of probable DSH. This approach applies a sophisticated process of data selection and a data-driven algorithm described in detail previously.[30,42] Briefly, we used NPR data to first identify all episodes of injury and poisoning that received emergency treatment and were at least one day apart from any previous episode. We excluded from consideration all planned treatments, fatal injuries, and poisonings or injuries that were accidental, inflicted by others, or secondary outcomes of other medical conditions. We then carried out a hierarchical procedure to ascertain probable DSH episodes: included first were treatment contacts for injuries with an ICD-10 (Norwegian version) diagnosis of DSH (i.e., having a diagnosis of X6n or Y87.0 in primary or secondary diagnoses); included second were treatment contacts with a diagnosis of specific types of either poisoning or injury *if* they had a comorbid psychiatric diagnosis; and included last were treatment contacts with medication poisoning codes that were not covered in the first two steps.

Additional specific details are described in an earlier publication.[30]

The second outcome, suicide death, was identified using Cause-of-Death register data and comprised deaths with an ICD-10 underlying-cause code of X60-X84 or Y87.0. Retrieval of data from source registers and construction of the data set for analysis were conducted using SAS/STAT software, version 9.4 of the SAS System for Windows.

Confounding psychosocial characteristics

We assessed several covariates and/or potential effect modifiers, recorded as of the index date. Sex was classified as male or female, and age was categorized as 0–19, 20–29, 30–39, 40–49, 50–59, or ≥60 years. Completed educational attainment, achieved either in Norway or abroad, was classified into four independent categories based on the Norwegian Standard Classification of education NUS2000: compulsory education (primary education and lower secondary education), intermediate education (upper secondary or post-secondary non-tertiary education), tertiary education (bachelor, master or doctoral degrees), or no or unknown education. Income was classified according to 'G,' the Norwegian Insurance scheme basic-benefit amount that is used as the basis for pensions, unemployment support, child support, and other social welfare allowances.[43] G is adjusted annually to account for inflation; an annual income of 4–5 G is considered average in Norway. We classified all study individuals' income in the year prior to the index date as <1 G, 1–2.99 G, 3–4.99 G, or ≥5 G. Immigrant background was classified as native Norwegian, first-generation immigrant, second-generation immigrant, Norwegian-born with one foreign-born parent, or foreign-born with ≥1 Norwegian-born parent (including inter-country adoptees). Given the young median age of the study population, marital status was classified as single, married, or divorced/separated/widowed. We also used patient record data retrieved from the NPR, and available from 2008 onwards, to assess whether study individuals received any psychiatric treatment within two years prior to the index date (yes or no) or any DSH event prior to index date (yes or no). Data in Norwegian registers are considered to be high quality with little missing data; however, where applicable, we have included a 'missing' category in the relevant variable.

Statistical analyses

Descriptive statistics were used to characterize violence-injured patients and the matched comparison group, and to summarize follow-up time. For the cohort analyses, we followed all violence-injured patients and their matched comparison individuals from their index date to the date of the first DSH event (for the nonfatal DSH analysis), suicide (for the suicide analysis), death from a competing cause, migration to another country, or December 31, 2018, whichever came first. Incidence rates by study group were calculated as the number of events (DSH or suicide deaths) divided by person-years at risk during follow-up.

Stratified multivariable Cox proportional hazards regression analysis, with strata defined by the matched groups, was used to calculate hazard ratios (HRs) and 95% confidence intervals (95% CIs) between violent injury and each study outcome, and to test two-way multiplicative interactive associations between violent injury and prior psychiatric treatment. Non-independence of comparison individuals in our risk-set sampling design was accounted for by our use of stratified Cox regression and the robust sandwich estimator for the covariate matrix.[35] To account for the multiple comparisons involved in our analyses, we applied a Bonferroni corrections procedure and used $p < 0.002$ as the threshold for statistical significance. All analyses were conducted using Stata v. 17 (StataCorp, College Station, Texas, U.S.).

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

A total of 28,276 violence-injured patients and 282,760 sex- and age-matched comparison individuals were included in the study population. More than 70% of study individuals were male, and three-quarters of them were under age 40 (see Table 1). Violence-injured patients had, on average, lower income and education levels than matched comparison individuals, and they were more likely to be of an immigrant background and to be single. One-fifth (20.6%; n = 5815) of violence-injured patients had received psychiatric treatment in the two years prior to the date of their index violent injury, and 4.5% (n = 1283) had a previous DSH event, vs. 6.0% (n = 17,004) and 0.6% (n = 1579), respectively, among comparison individuals.

Nonfatal deliberate self-harm

Being exposed to violent injury was associated with a higher crude rate of nonfatal deliberate self-harm during follow-up (Table 2). Among violence-injured patients, incidence of at least one DSH event during follow-up was 946.7 per 100,000 person-years; among the comparison group, the incidence was 90.0 per 100,000 person-years. The crude hazard ratio (HR) was 10.47 (95% CI = 9.74, 11.25). Controlling for covariates reduced this association by half, but violence-injured patients still had more than five-fold excess risk of DSH (HR = 5.11, 95% CI = 4.62, 5.66). As shown in Fig. 1, panel A, DSH events tended to be more concentrated near the index date among violence-

	Violence-injured patients (n = 28,276)	Comparison group (n = 282,760)[a]	χ^2 test for differences
Sex, n (%)			
Male	20,127 (71.2%)	201,270 (71.2%)	χ^2 < 0.001, p = 1.0
Female	8149 (28.8%)	81,490 (28.8%)	
Age group, n (%)			
0–19 years	4831 (17.1%)	48,310 (17.1%)	χ^2 < 0.001, p = 1.0
20–29 years	10,721 (37.9%)	107,210 (38.0%)	
30–39 years	5847 (20.7%)	58,470 (20.7%)	
40–49 years	3879 (13.7%)	38,790 (13.7%)	
50–59 years	2016 (7.1%)	20,160 (7.1%)	
≥60 years	982 (3.5%)	9820 (3.5%)	
Income, n (%)[b]			
<1 G	6866 (24.3%)	68,360 (24.2%)	χ^2 = 2934.8, p < 0.001
1–2.99 G	9231 (32.7%)	60,928 (21.6%)	
3–4.99 G	6862 (24.3%)	62,870 (22.2%)	
≥5 G	5000 (17.7%)	86,761 (30.7%)	
Missing	317 (1.1%)	3841 (1.4%)	
Education (completed), n (%)			
Compulsory education	12,453 (44.0%)	76,982 (27.2%)	χ^2 = 4222.5, p < 0.001
Intermediate education	7557 (26.7%)	101,160 (35.8%)	
Tertiary education	4292 (15.2%)	70,416 (24.9%)	
No or unknown education	3974 (14.1%)	34,202 (12.1%)	
Immigrant background, n (%)			
Native Norwegian	16,044 (56.7%)	204,913 (72.5%)	χ^2 = 4362.3, p < 0.001
1st-gen immigrant	8093 (28.6%)	56,178 (19.9%)	
2nd-gen immigrant	1755 (6.2%)	5146 (1.8%)	
Norwegian-born with one foreign-born parent	1777 (6.3%)	12,164 (4.3%)	
Foreign-born with ≥1 Norwegian-born parent	607 (2.2%)	4359 (1.5%)	
Marital status, n (%)			
Single	21,134 (74.7%)	195,900 (69.3%)	χ^2 = 3352.4, p < 0.001
Married	3650 (12.9%)	70,349 (24.9%)	
Separated/divorced/widowed	3492 (12.4%)	16,511 (5.8%)	
Psychiatric treatment in prior 2 years, n (%)	5815 (20.6%)	17,004 (6.0%)	χ^2 = 8006.6, p < 0.001
Any prior deliberate self-harm event, n (%)	1283 (4.5%)	1579 (0.6%)	χ^2 = 4464.0, p < 0.001

[a]Does not represent unique individuals, due to the matched risk-sampling method. [b]G is the Norwegian Insurance scheme basic-needs amount, adjusted every year to account for inflation. An income of 4–5 G is considered "average." Annual G amounts across the study period can be found at https://www.skatteetaten.no/en/rates/national-insurance-scheme-basic-amount/.

Table 1: **Characteristics of violence-injured patients and population-based matched comparison group at index date, Norway, 2010–2018.**

injured patients than among comparison individuals: for example, 45.1% of first DSH events occurred within one year among violence-injured patients, but only 27.7% among the comparison group.

Suicide death

Suicide death in our study population was far rarer than nonfatal deliberate self-harm, but exposure to violent injury signaled higher risk for this outcome as well (Table 2). During the follow-up period, there were 92 suicide deaths among violence-injured patients (a rate of 74.5 per 100,000 person-years), and 189 suicide deaths among comparison individuals (15.2 per 100,000). The crude HR was 4.89 (95% CI = 3.93, 6.09). Adjusting for covariates again reduced the association by half, but violence-injured patients still had a more than two-fold greater risk of suicide (HR_{adj} = 2.40, 95% CI = 1.78, 3.24). As shown in Fig. 1, panel B, suicide deaths were somewhat less concentrated near the index date than were DSH events. Among violence-injured patients, 23.9% of suicide deaths occurred within one year; among the comparison group, that fraction was 19.6%.

Heterogeneity by sex and age

Females in both study groups had higher rates of DSH compared to their respective male counterparts (Table 2 and Fig. 2, panel A), but the adjusted hazard ratio between violent-injury exposure and subsequent DSH was approximately five for both sexes. The association between violent injury and suicide death, however, was somewhat stronger among males (HR_{adj} = 2.40, 95% CI = 1.70, 3.38) than among females (HR_{adj} = 1.96, 95%

	Events	Incidence rate per 100,000 person-years	Crude HR (95% CI)	Adjusted HR[a] (95% CI)
Deliberate self-harm				
Both sexes				
Comparison individuals	1117	90.0	1.0	1.0
Violence-injured patients	1133	946.7	10.47 (9.74, 11.25)	5.11 (4.62, 5.66)
Males				
Comparison individuals	706	79.6	1.0	1.0
Violence-injured patients	702	817.4	10.20 (9.32, 12.17)	5.01 (4.40, 5.71)
Females				
Comparison individuals	411	116.1	1.0	1.0
Violence-injured patients	431	1275.2	10.93 (9.71, 12.29)	5.45 (4.62, 6.43)
Suicide death				
Both sexes				
Comparison individuals	189	15.2	1.0	1.0
Violence-injured patients	92	74.5	4.89 (3.93, 6.09)	2.40 (1.78, 3.24)
Males				
Comparison individuals	155	17.4	1.0	1.0
Violence-injured patients	63	71.5	4.09 (3.16, 5.30)	2.40 (1.70, 3.38)
Females				
Comparison individuals	34	9.6	1.0	1.0
Violence-injured patients	29	82.2	8.55 (5.58, 13.09)	1.96 (0.97, 3.97)

[a]Models adjusted for income, education, immigrant background, marital status, prior psychiatric treatment (within two years) and any prior deliberate self-harm.

Table 2: **Unadjusted and adjusted estimates of association between violent injury and subsequent deliberate self-harm and suicide death, Norway, 2010–2018.**

CI = 0.97, 3.97), for whom the confidence interval crossed 1.0 after controlling for covariates.

Among violence-injured patients, the rate of DSH per 100,000 person-years increased with age, from a low of 649.4 among those aged 0–19 years at index event to a high of 1329.0 among those aged 50–59. Among comparison individuals, however, the rate of DSH decreased with age. As a result, the associations between violent injury and subsequent DSH became stronger with age (Fig. 2, panel A): the adjusted HR was approximately 4.4 for people aged 0–19 years, but rose to 10.4 for those aged 60 or over. For suicide death, confidence intervals around most age-specific estimates were wide, and there was little overall evidence for heterogeneity by age (Fig. 2, panel B).

Heterogeneity by psychiatric treatment history

Violence-injured patients with a history of psychiatric treatment had the highest DSH and suicide rates of any subgroup we examined—far higher than those of violence-injured patients without psychiatric treatment history (Fig. 2). However, when stratifying by treatment history and comparing violence-injured patients to their matched counterparts in the general population, the relative increase in risk was larger among those without psychiatric treatment history. For DSH, violent injury was associated with a 6.3-fold increase in risk among people with no psychiatric treatment history, but a 3.9-fold increase among people with psychiatric treatment history. For suicide, violent injury was associated with a 3.1-fold increase in risk among those with no psychiatric treatment history, but with *no* significantly increased risk detected among those with treatment history (HR_{adj} = 0.96, 95% CI = 0.41, 2.25). Regression models with interaction terms confirmed that the associations among individuals with psychiatric treatment history were statistically significantly smaller than those in individuals with no such history ($p < 0.05$ for both DSH and suicide models).

Discussion

In this nationwide, longitudinal study using population-based register data from Norway, we found that violence-injured individuals had ten-fold increased risk of subsequent deliberate self-harm and five-fold increased risk of suicide death when compared with a sex- and age-matched general population control group. Their excess risk was concentrated in the first year after the index violent injury, especially for DSH, but endured for several years thereafter. Partial attenuation of these associations after statistical control for a range of confounders (including prior DSH and treatment for psychiatric disorder) indicated that some of the relationship between violent injury and suicidal behavior is likely due to pre-existing psychosocial vulnerability factors. Nevertheless, our findings suggest that patients injured

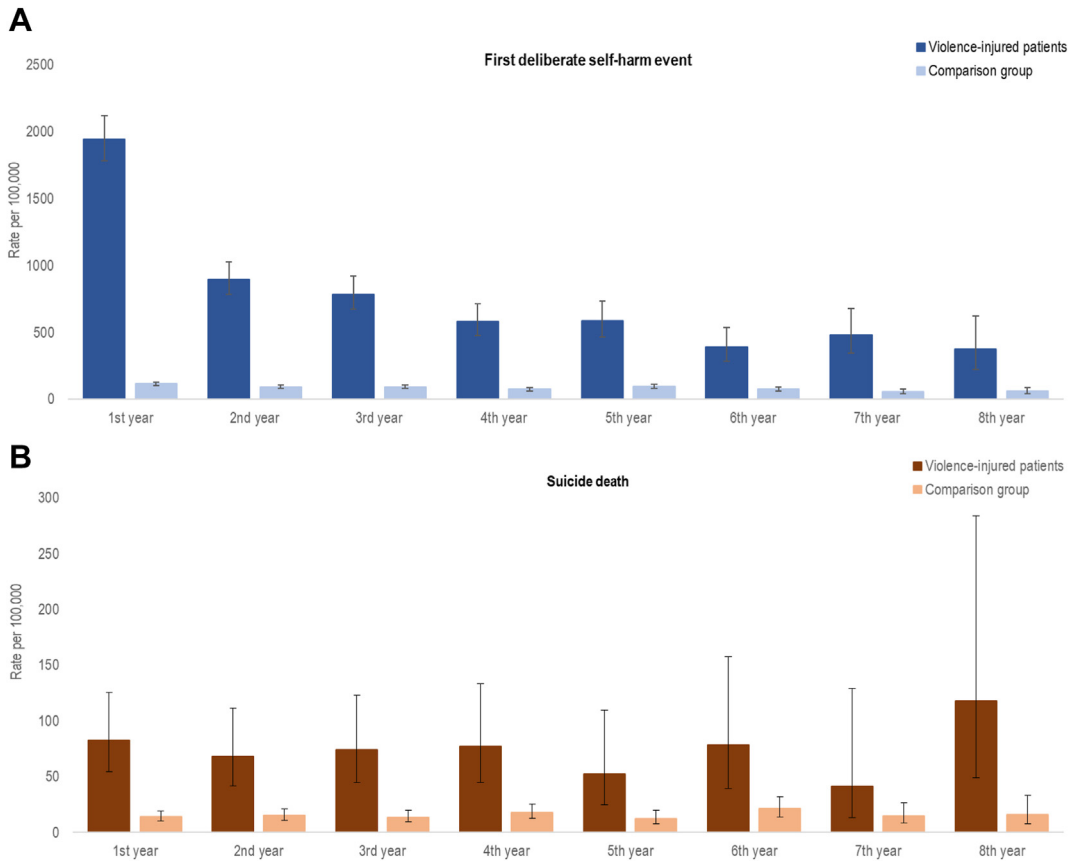

Fig. 1: Rates per 100,000 person-years of first-observed deliberate self-harm (Panel A) and suicide death (Panel B), by year of follow-up and study group. Events after the eighth year are not shown due to estimate instability. Errors bars represent 95% confidence intervals.

through violence should be considered for within-encounter or post-discharge suicide prevention interventions, such as ED-based programs that use caring contacts, safety planning, psychosocial interviewing, or linkage to community services to address the psychosocial challenges faced by these patients.[44–46] Our study may also signify that violence prevention measures could have a broader public health impact through reducing population burden of serious suicidal behavior.

Violence-injured patients in our population-based sample were largely male and young, and, compared to controls, more likely to have low levels of education attainment and income as well as to be unmarried and have an immigrant background. This is consistent with other epidemiologic studies of violence-injured patients.[19,21,47] Our study extends prior literature by showing that one-fifth (20.6%) of violence-injured patients had already been receiving some kind of psychiatric treatment in the two years prior to their index violent injury, and nearly 1 in 20 of them had a prior emergency visit for deliberate self-harm. Together, this underscores the multi-level interconnections between social adversity, psychological disorder, and violence involvement across the lifecourse—processes that are challenging if not impossible to disentangle empirically.[6,48]

Our results indicated little in the way of sex differences in the association between violent injury and suicidal behavior, particularly for DSH. Although the association between violent injury and suicide death was stronger among males, the magnitudes of the sex-specific associations were not drastically different (hazard ratios of 2.40 in males and 1.96 in females), and the lack of statistical significance among females is likely due to low power. This is consistent with the only previous longitudinal study to examine sex differences in the relationship between violent injury and suicidality, which found none for either DSH hospitalization or suicide.[19]

We did, however, find that the association between violent injury and DSH (though not suicide) became stronger with age. The explanation for this age heterogeneity is not clear. It is possible that the violent events experienced by older (vs. younger) individuals were more likely to involve true "victimization," such as

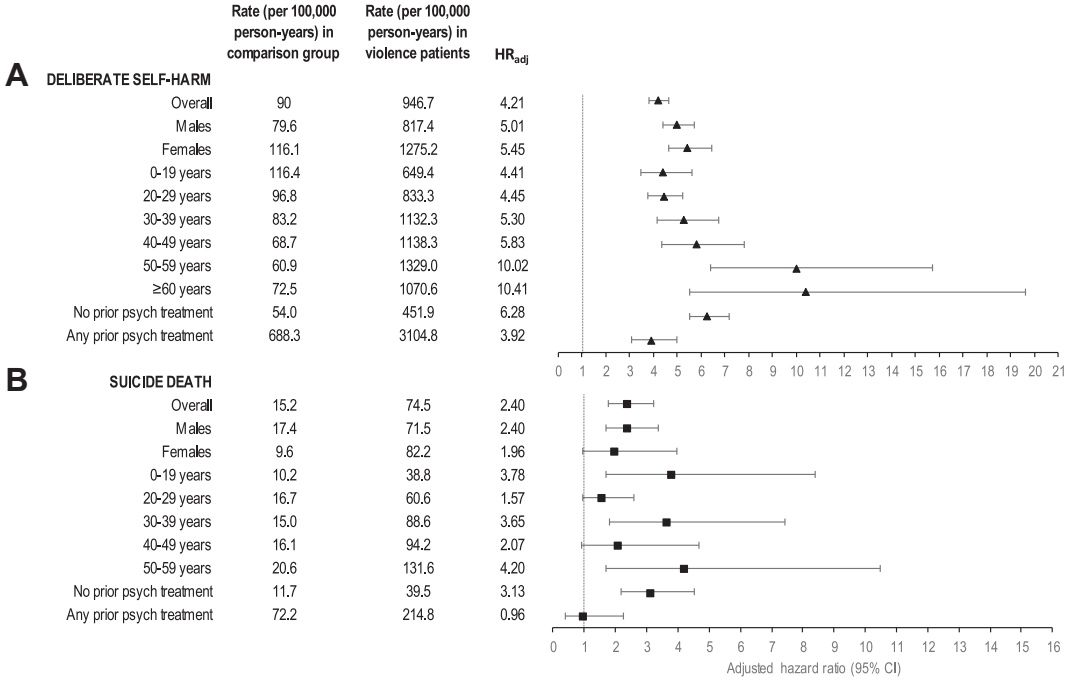

Fig. 2: Heterogeneity in hazard ratio associations between violent injury and subsequent deliberate self-harm (Panel A) and suicide death (Panel B). Hazard ratios are adjusted for income, education, immigrant background, marital status, prior psychiatric treatment and prior deliberate self-harm. *Results for age group ≥60 years in the suicide death graph are suppressed, as the HR model did not converge due to small cell counts.

through being mugged, rather than interpersonal conflict circumstances, such as street fighting. If true, the unpredictable and psychologically traumatizing nature of these events could have exacerbated older adults' DSH risk. We did not have detailed information on injury circumstances and thus could not examine such differences, but future research should explore this important question.

Violence-injured patients with a history of psychiatric treatment had the highest observed rate for suicidal behavior, which is consistent with research reports that pre-existing psychopathology predicts more severe psychological outcomes after violence victimization.[49] However, *relative* associations between violent injury and DSH or suicide were stronger among those without a history of prior psychiatric treatment compared to those with such history. It may be that psychiatric disorder is such a strong predictor of suicidality that for individuals with psychopathology, experiencing a violent event has less impact on suicide risk than it would have for people without psychiatric disorder. Nevertheless, clinicians should be aware that violence-injured patients with a history of psychopathology face extremely high risk of subsequent nonfatal and fatal suicidality.

Our study builds on previous work by examining both nonfatal and fatal suicide outcomes, using a general-population comparison group, and testing for heterogeneity by demographic factors and psychiatric treatment history. It has multiple methodological strengths, including a population-based, nationally representative longitudinal matched cohort design; comprehensively assessed and objectively measured violent-injury ascertainment; and statistical controls for many important confounders.

There are also important study limitations. We could not assess the circumstances or severity of the violence-related injuries, or the relationship of the injury perpetrator to the patient. It is likely that, in some cases, the violent-injury patients themselves provoked or were active participants in the index violent altercation.[21] Furthermore, we did not have information about participants' past experiences of assault, violence, rape, or other traumatic injury that did not result in an emergency-services visit during or prior to our study period. A large fraction of assault or violence-related injury patients never seek medical care, partly due to perceived lack of need but also due to stigma, fear of legal or personal safety repercussions, and other barriers.[21] This could have resulted in ascertainment bias, as those seeking medical assistance after violent injury differ from those who do not.[21] There is no defined medical severity threshold for any emergency services treatment in Norway. We also could not examine the association between exposure to multiple violent injuries or poly-victimization and study outcomes,

important topics that warrant future research,[50,51] or examine the role of history of psychiatric disorder or DSH for which the individual never received treatment. Our study was conducted in a wealthy northern-European country with relatively low crime and suicide rates; our results may not be generalizable to other contexts. Lastly, the observational study design precludes causal inference about the link between violent injury and suicidal behavior.

Methodologically, while our risk-set sampling approach with age- and sex-matched controls is widely employed (e.g.,[52–54]), it is not the only cohort study design used with registry data. Approaches that involve different control sampling methods, particularly propensity score matching, may better account for confounding[55] but are typically implemented in clinical or pharmacoepidemiology contexts involving evaluation of a specific medical treatment (e.g.,[56–58]). Propensity score matching can also result in overmatching or the discard of cases for whom matching controls cannot be found, resulting in a potential decrease of generalizability and accuracy of the results.[59,60] Separately, while analytic results from a risk-set sampling design involve some degree of sampling variability given the random selection of controls, our use of 10 controls for each case patient should minimize such variability to negligible levels.[61]

Our findings indicate that experiencing a violent injury is associated with substantially increased short- and long-term risk of fatal and nonfatal suicidal behavior. This work underscores the need for additional research on the mechanisms underlying this association and calls for intervention strategies designed to reduce suicide risk in violence-injured populations. Clinicians should consider providing suicide risk screening and intervention measures to violence-injured patients, particularly if they are struggling with other psychosocial adversities.

Contributors

S.G.M. acquired project funding, conceptualized and designed the study, conducted data analyses, and drafted the manuscript. P.Q. conceptualized and designed the study, acquired the study data, assisted with data preparation and analysis, and edited the manuscript for key intellectual content. Both authors directly accessed and verified the underlying data reported in the manuscript. Both authors confirm that they had full access to all the data in the study and accept responsibility to submit for publication.

Data sharing statement

The study uses data from Norwegian Patient Register and Central Population Register. The data cannot be shared publicly because of high restrictions related to Norwegian law and legislation protecting personal privacy. The data are available from Department of Health Registries at Norwegian Health Directorate (owner of the Norwegian Patient Register), Norwegian Institute of Public Health (owner of the Cause-of-Death Register) and Statistics Norway (administrator of the Central Population Register and the Statistics Norway's Events Database). To gain the access of these confidential data researchers would need a research protocol and apply for the approvals from the Norwegian Ethical Committee for Medical Research (https://rekportalen.no) and the data owners/administrators of relevant registries.

Declaration of interests

We declare no competing interests.

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Data from the Norwegian Patient Register has been used in this publication. The interpretation and reporting of these data are the sole responsibility of the authors, and no endorsement by the Norwegian Patient Register is intended nor should be inferred. S.G.M. gratefully acknowledges Fulbright Norway for its support of this research.

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