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Suicide in Canadian veterans living in Ontario: a retrospective cohort study linking routinely collected data

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Structured Abstract

Objectives: To compare the risk of death by suicide in male veterans with age-matched civilians.

Design: Retrospective cohort study linking provincial administrative databases between 1990 and 2013 with follow-up complete until death or December 31, 2015.

Setting: Population-based study in Ontario, Canada.

Participants: Ex-serving Canadian Armed Forces and Royal Canadian Mounted Police veterans living in Ontario who registered for provincial health insurance were included. A civilian comparator group was matched 4:1 on age, sex, and residential region.

Main Outcome: Death by suicide was classified using a standard cause of death diagnosis codes from a provincial registry of mandatory data collected from death certificates. Cox-proportional hazards regression compared the risk of death by suicide between veterans and civilians. Analyses adjusted for age, residential region, income, rurality, and major physical and mental comorbidities.

Results: 20,397 male veterans who released to Ontario between 1990 and 2013 and 81,559 age-sex- matched civilians were included. 4.2% of veterans died during the study timeframe, compared with 6.5% of the civilian cohort. Death by suicide was rare in both cohorts, accounting for 4.6% and 3.6% of veteran and civilian deaths. After adjustment for confounders, veterans had an 18% lower risk of dying from causes other than suicide (HR 0.82, 95% CI 0.76-0.89) and a similar risk of dying by suicide (HR 1.01, 95% CI 0.71-1.43), compared to civilians.

Conclusions: Deaths by suicide were rare in male veterans residing in Ontario. Our findings demonstrate that veterans had a similar risk of suicide-related mortality as an age-matched civilian population. A better understanding of how to prevent the number of suicides as well as understand pathways to seeking and receiving mental health supports and services are important areas for future consideration.

Article Summary

Strengths and limitations of this study

- Population-based design cohort study linking universal health system data with national mortality data ensures excellent follow-up coverage and similar capture of deaths by suicide between veterans and civilians.
- Although both matching and inclusion of key variables associated with suicide risk that were not on a causal pathway to death by suicide (e.g., socioeconomic status, physical comorbidity), residual confounding is still possible.
- This first study of suicide risk in Canadian veterans did not have details on potential explanatory factors of suicide risk specific to military service which would be important to understanding heterogeneity in risk within the veteran population.
- The absolute risk of suicide and the presented associations may not be generalizable to other countries with different military culture, length of service, deployment and combat experience may not be appropriate.

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Competing Interests Statement: The authors do not have anything to disclose.

Data Statement: The data set from this study is held securely in coded form at ICES. While data sharing agreements prohibit ICES from making the data set publicly available, access may be granted to those who meet pre-specified criteria for confidential access, available at www.ices.on.ca/DAS. The full data set creation plan and underlying analytic code are available from the authors upon request, understanding that the programs may rely upon coding templates or macros that are unique to ICES.

Introduction

A constellation of factors may increase the likelihood of death by suicide in military veterans. Established population-based risk factors, including being male, having a personal history of childhood abuse, a personal history of trauma and/or mental disorders, experiencing current financial hardship or the breakdown of intimate relationships, are relevant to the ex-serving population [1]. Military-specific risk factors, such as operational conditions of training and deployment including sleep deprivation, stress, and exposure to traumatic events [1-6] may interact with these established factors and continue to exert an effect long after initial exposure, further increasing the risk of suicide over time [7].

Despite the large amount of attention on the issue of suicide among veterans, the literature on this issue is sparse and inconsistent [8-13]. Findings vary depending on country of origin, service period of reference, and the definition of veteran status. There are even fewer Canadian studies of veteran populations [14]. A recent governmental report from Veterans Affairs Canada (VAC) used national vital statistics data linked to administrative Department of National Defence (DND) records concluded a higher risk of suicide for young male veterans, and female veterans, relative to the general population [15]. This study and many others internationally cannot make direct comparisons with a similar civilian cohort or control for established risk factors such as socioeconomic status or rurality of primary residence.

The primary aim of this paper was to describe and compare the rates of death by suicide in Canadian male veterans living in Ontario with age- and sex- matched civilians, adjusting for key confounders.

Methods

Study Design

This was a retrospective, cohort study using provincial, routinely collected data and set in Ontario [16-19]. Ontario is home to eight of the thirty-eight Canadian federal military bases, including the major operational bases Canadian Forces Base Kingston and Petawawa, the Royal Military College of Canada, the Department of National Defence (DND) Headquarters, and national headquarters for the RCMP. In Ontario, universal healthcare planning and delivery is separated into fourteen distinct geographic regions [www.lhins.ca]. With 13.7 million inhabitants, Ontario is also the most populous province in Canada, making it an ideal province to study rare outcomes such as death by suicide. This study received ethics approval from the Queen's University Health Sciences Research Ethics Board. The authors followed the STROBE reporting guidelines [20].

Study Population

Veterans were defined as previous Canadian Armed Forces (CAF) and RCMP members who provided evidence to the Ontario Ministry of Health and Long-Term Care (MOHLTC) of their career history, typically at the time of Ontario Health Insurance Plan (OHIP) provincial healthcare registration. The MOHLTC provided the authors with the anonymized list of people with an administrative CAF and RCMP service code linked to their health card number, as well as career start and end dates. At the time of service departure, health insurance coverage is switched from federal to provincial oversight and waiting periods for provincial health insurance are waived which has resulted in a population-based cohort of veterans in Ontario.

VAC estimated that 31% of veterans —approximately 1,050 individuals— transition from the military to civilian residence in Ontario each year [21]. We do not know the true denominator of veterans living in Ontario during our study timeframe; however, the number of veterans entering our cohort per year was similar to the expected number. We found a similar age, sex, and length of service distribution in our cohort as reported by VAC. Our cohort has fewer younger veterans and a larger number of older veterans than expected; however, this is likely explained by our inclusion of RCMP veterans [18]. We are unable to separately study CAF and RCMP veterans. The large majority of our cohort are likely to be CAF veterans, rather than RCMP [18] as less than 200 RCMP retire to Ontario per year (personal communication, Drouin).

We included male ex-serving members in this study if they registered for OHIP between January 1, 1990 and March 31, 2013. Female veterans were not included given the small percentage of the military who are female and the rarity of the outcomes. We excluded individuals with OHIP coverage while still engaged in CAF or RCMP service, as indicated by OHIP billing record dates. Individuals were followed until death, OHIP coverage ended (e.g., moved out of province), or until the end of the study period (December 31, 2015). The date of OHIP registration is a close approximation of the veterans release date from the CAF or RCMP [18].

Two civilian comparator groups were created by matching at a ratio of four civilians for one veteran: 1) on age (using birth year) and sex; and 2) on age, sex, and residential geogrpahy in the

year following transition. Geographic region of residence was determined by Local Health Integration Networks (LHIN). Fourteen LHINs manage the financial planning and provision of healthcare in Ontario. Individuals were assigned to a LHIN based on their postal code.
Our previous work demonstrated temporal stability for the majority demographic details and that veterans are most likely to live within three regions of Ontario with close proximity to major bases and governmental departments [18]. The two reference groups were chosen to be most comparable with other Canadian studies (age and sex alone [15]) and a study from Scotland that applied matching (age, sex, and geography [8]). The OHIP registration date of the veteran was used as the index date for entry into the cohort for both the veteran and the matched civilian reference groups. Eligible civilian controls had to be alive at the study index date.

Data Sources

The study linked multiple administrative datasets held at ICES. ICES is a prescribed entity under section 45 of PHIPA and may collect data and conduct analyses to improve health and healthcare without individual consent. These datasets were linked at the individual level using unique encoded identifiers and analyzed at ICES. The Registered Persons Database provided sociodemographic data on age, sex, region, and rurality of residence in Ontario, as well as aggregate community-level median income. The OHIP database provided information on eligibility for provincial health services and was used to identify major physical and mental comorbidities. The Canadian Institute of Health Information Discharge Abstract Database (CIHI-DAD) provided information on hospitalizations and was also used to identify physical and mental health comorbidities. The National Ambulatory Care Reporting System (NACRS) provided diagnostic and service information on ED visits and was also used to identify physical and mental comorbidities. The Ontario Registrar General (ORG) database provided information on vital status and cause of death.

Identifying Deaths by Suicide

Death by suicide was the primary outcome of this study. We identified deaths using the ORG database which contains mandatory reported information from provincial death certificates. Deaths occurring between January 1, 1990 and December 31, 2015 were captured using an established method that uses the underlying cause of death diagnoses related to suicide as per the International Classification of Disease (9th edition) classification system (E950-E959) and a manner of death equal to suicide for deaths occurring in 2013 and later. This method has 97% sensitivity in identifying suicides from the ORG database [22]. All other deaths were classified as being due to other causes.

Covariates

Covariates were selected from known predictors of suicide risk that were not along the causal pathway and measured in the first year of provincial health insurance eligibility. The presence of major comorbidities was classified using the John's Hopkins Aggregate Diagnosis Groups (ADGs) [23]. The aggregate diagnosis groups are created using hospitalization (CIHI-DAD), ED visits (NACRS), and physician billing (OHIP) data in Ontario in the two years following the index date. Using information on the type, diagnoses, and number of encounters, six ADGs are

classified as 'major' and summed [23]. Major ADGs included time-limited: major, time limited: major-primary infections, likely to recur: progressive, chronic medical: unstable, chronic specialty: unstable orthopedics, injuries/adverse effects: major, and malignancy. The major psychosocial ADG was not included in the measure of comorbidity as differences in the occurrence of mental disorders could explain differences in suicide risk between veterans and civilians. Categories of 0, 1, and 2+ major comorbidities were used in the analysis based on the distribution of data. Socioeconomic status was defined according to median community income quintile using census data linked to postal codes (1 = lowest to 5 = highest). Rurality of patients' residence was defined according to the Rurality Index of Ontario, in which municipalities are assigned a score (0-100) based on total population, population density, and travel times to healthcare centres [24]. Patients were assigned to a municipality using their postal code.

Statistical Analysis

Descriptive statistics compared demographic characteristics between the veteran and civilian populations using Chi square tests for independence and t-tests for categorical and continuous data respectively. Crude death by suicide incidence rates, incidence rate ratios, and 95% confidence limits were calculated using the gamma distribution. Incidence rates were further stratified by age at release (<30, 30-39, 40-49, 50+), calendar year of release (1990-1999, 2000-2013), length of service (<5 years, 5-9 years, 10-19 years, 20+ years), and in five-year time intervals following release (0-5 years, 5-10 years, 10-15 years, and 15-20 years) to explore temporal and service-related patterns. Statistical comparisons of these strata were not completed given small sample sizes.

Multivariable Cox-proportional hazards regression was used to compare the risk of death by suicide and death by other causes between veterans and civilians. Individuals were censored at the end of the follow-up period if they had not experienced the event of interest for the analysis. Hazard ratios and 95% confidence intervals were presented, further adjusted for baseline age (continuous), presence of major comorbidities (0, 1, 2+), median community income (quintiles), and rurality of residence (Rurality Index of Ontario, 0-9 (most Urban), 10-30, 31-50, 51-70, 70+ (most rural)). Confounders were selected because their values differ between veterans and civilians and are associated with suicide risk. Given the negligible amount of missing data on covariates (2.3%), only individuals with complete data were included in the multivariable analyses. These results did not differ qualitatively from the crude incidence rate comparisons including the entire cohort. P-values less than 0.05 were considered statistically significant; 2-sided hypothesis tests were completed. All analyses were performed using SAS 9.3 Copyright 2008 (Cary, NC, USA).

Results

20,397 veterans releasing to Ontario between 1990 and 2013 and 81,559 age-matched non-veterans were included in this analysis (Figure 1). Together they contributed over one million person-years of follow-up. Median follow-up from index was 10 years in veterans and 12 years in civilians. Almost half of veterans left the CAF or RCMP before 2001, and half released in 2001 or later. Length of service varied; 19.5% served less than five years, 16.4% served for five to nineteen years, and 54.1% served twenty or more years. Table 1 compares characteristics of

the veteran and age-matched civilian cohorts. Veterans had significantly fewer major or minor physical and mental health conditions, were significantly less likely to live in communities with the lowest median income, and were more likely to live in rural areas than the civilian cohort.

Over the study period, 4.2% of the male veteran cohort died (n deaths=854, total=20,397) compared with 6.5% of the non-veteran cohort (n deaths= 5,294, total=81,559). 52% of deaths in male veterans occurred in those under the age of 50 years compared to 43% of male civilians. The most common causes of death in both groups were cancer or diseases of the circulatory system. Overall, veterans had an 18% lower adjusted risk of dying from causes other than suicide, compared to age-matched civilians (HR 0.82, 95% CI 0.76-0.89; p<0.0001).

Death by suicide was rare in both cohorts; 4.6% of deaths in the veteran cohort (n=39) and 3.6% of deaths in the non-veteran cohort (n=189). The crude incidence rate of death by suicide in the veteran cohort was 16.1 per 100,000 person-years (95% CI 11.2-22.2) and 17.7 per 100,000 person-years in the non-veteran cohort (95% CI 15.2-20.6). Veterans and non-veterans had a similar risk of dying by suicide during the study period (Table 2). The adjusted hazard ratio (HR) of death by suicide for veterans was 1.01 (95% CI 0.71-1.43) compared to the age-matched non-veteran comparator group. The results did not change when the civilian cohort was matched on both age and geography (results not shown but available from authors).

Table 3 describes the incidence rates of suicide within the veteran cohort by age at release, length of service and calendar year of release. The patterns in crude incidence rates suggest that veterans aged 30-49 years at the time of release and veterans who released after 2000 have the highest risk of death by suicide compared to other veterans. Veterans serving 5-9 years also appeared to have a higher risk of suicide, compared to other veterans. However 95% confidence limits overlapped for all estimates.

Discussion

In our study we found a similar risk of suicide among Canadian veterans compared to civilians. Patterns in suicide incidence rates suggest that veterans aged 30-49 years at the time of release, veterans who released after 2000, and veterans who served 5-9 years have the highest risk within the veteran population; however, these were not statistically significant. Our findings of a similar risk of death by suicide in the veteran and civilian population is consistent with contemporary studies comparing ex-serving veteran populations and the general population in the United Kingdom[8 11 25 26], deployed veterans in Sweden[13] and in the United States prior to 2009[10].

Our study is inconsistent with suicide rates and comparisons with the general population reported by the Canadian[15] and Australian governments[9], and the American peer-reviewed literature published since 2009 for veterans of the Afghanistan and Iraq conflicts[12]. The VAC report concluded suicide rates in veterans were 1.4 times higher than in the general population, and their reported crude rates were double those described in our study[15]. Differences may exist between our study and the VAC report may result from differences in study time frames, identification of veteran populations, geography, and analytic approaches. Differences between our study findings and the American and Australian experiences may be explained by variation

in the underlying prevalence of post traumatic stress disorder or suicide across military or general populations, or different combat and deployment experiences[27].

Age, length of service, era of release, and the period following release modified the risk of death by suicide in our study and these results support previous work performed in other countries; however, they differ with respect to the exact trends. Our study suggests a higher risk of death by suicide for veterans aged 30-39 at release, in those who served 5-9 years, in those veterans who released between 2000-2013, and in the first five years following release. Given the small number of deaths by suicide in our cohort, these different findings likely represent the same group of individuals. Whereas some authors have found a higher risk in young male serving and ex-serving military members [11 15], as well as in older veterans [8 9], others identified significantly lower rates for older veterans compared to the general population [9 15]. Many studies highlight a higher risk in early service leavers: those who spend the least amount of time in the military, who may be medically released for mental health reasons, and who may have less access to support [11 15]. Our study may not adequately capture those who serve the least amount of time if they are less likely to identify with the provincial health system as a veteran. In additional to military-specific differences and underlying suicide rates, these studies may reach different conclusions given their choice of referent population or due to statistical uncertainty.

Many factors may explain why suicide rates could be similar in the veteran and general populations, even if exposure to trauma and rates of mental disorders differ. The presence of positive psychological factors, such as resiliency[1], exposure to mental health training and suicide prevention efforts within the CAF and public safety occupations may mitigate the risk of suicide in the veteran population. Canadian serving members had higher odds of experiencing mental health-related stigma than the general population but were more likely to report seeking care [28]. Many civilians in the general population do not have access to the same level of training, supports, or resources that are available to serving and ex-serving personnel, and so, although exposure to trauma or stressful conditions may be higher and stigma may still exist, Canadian military members, veterans, and their networks may be better prepared to deal with them.

The healthy worker effect, defined as the bias that exists when comparing an occupational cohort to a general population that includes those unable to work due to illness or disability, and possible differential misclassification of suicide for veterans are two key limitations of this study. We addressed the healthy worker effect by adjusting for comorbidity and saw an increase in the point estimate of the adjusted results. In addition, comorbidity may change over time resulting in residual confounding. However, we do not anticipate this would occur differently between the veteran and civilian population. Given these limitations, similar rates of death by suicide may be as meaningful as identifying an elevated risk. Physicians may be less likely to attribute deaths in ex-serving personnel to suicide than in the general population, given societal stigma, out of respect for service, or due to previous benefit and pension eligibility. This could also underestimate the risk of suicide for veterans in our study.

We would have preferred to study risk within reservist and female veteran populations, or by service experience (e.g., deployments, locations of service, combat experiences) or account for previous trauma experience or childhood adversity [8 15]; however, we were unable to do so given data availability. We were also unable to study the risk of death by suicide separately for CAF and RCMP veterans and this may over or underestimate the effect. A recent survey of mental

health disorders among public safety personnel suggests many RCMP screen positive for trauma exposure and various mental health problems [29], although there are no data on suicide risk. In addition, RCMP personnel do not have the same access to mental health training and support as those in the CAF. These data may not be generalizable to young veterans who serve a short period of time prior to release, as they may be less likely to identify as a veteran on provincial health insurance.

Conclusions

Our study findings of a similar suicide risk among veterans compared to a matched general population control sample deviates from findings of elevated risk observed in other studies. While our study's primary strength is its population-based design, including rigorous adjustment for confounding, the divergence between our results and the existing literature, combined with an international focus on the issue of suicide amongst individuals serving or who have served in the military, raises a need to conduct high quality research on the topic of suicide in the military. Similar rates of suicide-related mortality highlight the need and opportunity for earlier intervention. We recommend continued efforts around help-seeking for mental health conditions, increased focus on mental health and suicide prevention in the defence community, and further suicide prevention strategy development.

Author Contributions: AM, AK, MW, and PK contributed to the conception and design of the work. AM, MW, and PK contributed to the acquisition of data. AM and MW contributed to the analysis of the work. All authors (AM, AK, MW, HT, HC, NF, PK) contributed to the interpretation of data, drafting and revising the manuscript critically for important intellectual content, approve the final version to be published and agree to be accountable for all aspects of the work.

Table 1: Demographic characteristics of the veteran and age-matched civilian cohorts

	Veterans (n=20,397)	Civilians (n=81,559)	p-value[1]
Age at index (mean, SD)	42.1 (10.1)	42.1 (10.1)	0.88
# Major ADGs			<0.001
0	12,095 (59.3%)	45,328 (55.6%)	
1	5,428 (26.6%)	22,476 (27.6%)	
2+	2,874 (14.1%)	13,755 (16.9%)	
# Minor ADGs			<0.001
0	4,248 (20.8%)	14,896 (18.3%)	
1	3,129 (15.3%)	11,112 (13.6%)	
2	3,213 (15.8%)	11,870 (14.6%)	
3+	9,807 (48.1%)	43,681 (53.6%)	
Socioeconomic Status			<0.001
Lowest	2,090 (10.2%)	16,017 (19.6%)	
2	3,439 (16.9%)	15,929 (19.5%)	
3	4,196 (20.6%)	15,950 (19.6%)	
4	5,225 (25.6%)	16,121 (19.8%)	
Highest	4,519 (22.2%)	16,119 (19.8%)	
Missing	928 (4.5%)	1,423 (1.7%)	
Rurality			<0.001
Most Urban	11,619 (57.0%)	58,447 (71.7%)	
10-30	3,812 (18.7%)	11,300 (13.9%)	
31-50	2,483 (12.2%)	7,093 (8.7%)	
51-70	1,381 (6.8%)	1,803 (2.2%)	
Most Rural	197 (1.0%)	1,222 (1.5%)	
Missing	905 (4.4%)	1,694 (2.1%)	

ADG= John's Hopkins adjusted diagnostic groups; SD= standard deviation; Socioeconomic status=median community income quintiles, Rurality=Rurality Index of Ontario score, 0-100. [1]p-value from Kruskal-Wallis test (continuous) and chi-square test (categorical)

Table 2: Risk of death in male veterans residing in Ontario (n=20,397), compared to age-matched civilians (n=81,559)

	# deaths	Unadjusted Hazard Ratio (95% CI)	p-value[1]	Adjusted[2] Hazard Ratio (95% CI)	p-value[1]
Death by suicide					
Veteran Status					
Civilian	189 (0.23%)	1.00 (reference)	0.41	1.00 (reference)	0.96
Veteran	39 (0.19%)	0.86 (0.62-1.22)		1.01 (0.71-1.43)	
Death from other causes					
Veteran Status					
Civilian	5,105 (6.3%)	1.00 (reference)	<0.001	1.00 (reference)	<0.001
Veteran	815 (4.0%)	0.68 (0.63-0.74)		0.82 (0.76-0.89)	

[1]p-value from Wald chi-square statistic of Cox-proportional hazards regression model; [2]Adjusted for age, number of major physical and mental comorbidities (0, 1, 2+), socioeconomic status (quintiles of median community income), rurality (rurality index of Ontario score, 0-9, 10-30, 31-50, 51-70, 70+); CI= confidence interval

Table 3: Incidence rates of suicide in male veterans releasing between 1990 and 2013[1]

	Rate of deaths by suicide per 100,000 person-years (n=20,397)
Age at release	
<30	18.2 (6.7-39.6)
30-39	29.7 (17.0-48.3)
40-49	18.7 (10.7-30.3)
50+	1.5 (0.04-8.2)
Calendar year of release	
1990-1999	13.9 (8.5-21.4)
2000-2013	19.7 (11.9-30.8)
Length of service	
<5 years	10.1 (3.3-23.5)
5-9 years	32.3 (15.5-59.4)
10-19 years	23.5 (10.7-44.5)
20+ years	12.3 (6.9-20.4)
Time period following release	
0-5 years	21.3 (13.5-32.0)
6-10 years	12.5 (5.4-24.6)
11-15 years	9.4 (2.6-24.0)

[1]Absolute numbers of suicides are not reported due to small cell sizes and privacy restrictions

Figure 1: Selection of study cohort

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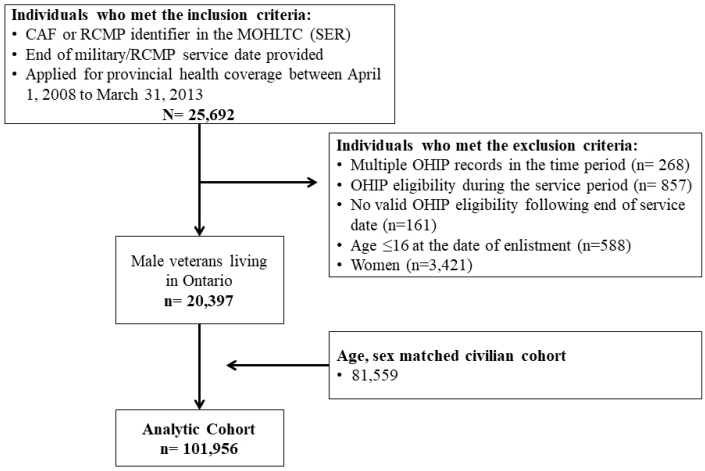

Figure 1: Selection of study cohort

STROBE Statement

Checklist of items that should be included in reports of observational studies

Section/Topic	Item No	Recommendation	Reported on Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6/7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed	6/7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7,8
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7,8
Bias	9	Describe any efforts to address potential sources of bias	10/11
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7/8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7/8
		(*b*) Describe any methods used to examine subgroups and interactions	7/8
		(*c*) Explain how missing data were addressed	7/8
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed	7/8
		(*e*) Describe any sensitivity analyses	7/8

Section/Topic	Item No	Recommendation	Reported on Page No
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9 + Figure 1
		(b) Give reasons for non-participation at each stage	9 + Figure 1
		(c) Consider use of a flow diagram	9 + Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	9,10
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11,12
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	4

**Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.*

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Suicide in Canadian veterans living in Ontario: a retrospective cohort study linking routinely collected data

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Keywords:	veteran, military, Suicide & self-harm < PSYCHIATRY, mortality

Suicide in Canadian veterans living in Ontario: a retrospective cohort study linking routinely collected data

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Structured Abstract

Objectives: To compare the risk of death by suicide in male veterans with age-matched civilians.

Design: Retrospective cohort study linking provincial administrative databases between 1990 and 2013 with follow-up complete until death or December 31, 2015.

Setting: Population-based study in Ontario, Canada.

Participants: Ex-serving Canadian Armed Forces and Royal Canadian Mounted Police veterans living in Ontario who registered for provincial health insurance were included. A civilian comparator group was matched 4:1 on age and sex.

Main Outcome: Death by suicide was classified using standard cause of death diagnosis codes from a provincial registry of mandatory data collected from death certificates. Fine and Gray sub-distribution hazards regression compared the risk of death by suicide between veterans and civilians. Analyses adjusted for age, residential region, income, rurality, and major physical comorbidities.

Results: 20,397 male veterans who released to Ontario between 1990 and 2013 and 81,559 age-sex- matched civilians were included. 4.2% of veterans died during the study timeframe, compared with 6.5% of the civilian cohort. Death by suicide was rare in both cohorts, accounting for 4.6% and 3.6% of veteran and civilian deaths respectively. After adjustment for confounders, veterans had an 18% lower risk of dying from causes other than suicide (HR 0.82, 95% CI 0.76-0.89) and a similar risk of dying by suicide (HR 1.01, 95% CI 0.71-1.43), compared to civilians.

Conclusions: Deaths by suicide were rare in male veterans residing in Ontario. Our findings demonstrate that veterans had a similar risk of suicide-related mortality as an age-matched civilian population. A better understanding of effective suicide prevention as well as clarifying pathways to seeking and receiving mental health supports and services are important areas for future consideration.

Article Summary

Strengths and limitations of this study

- Population-based design cohort study linking universal health system data with national mortality data ensures excellent follow-up coverage and similar capture of deaths by suicide between veterans and civilians.
- Despite both matching and inclusion of key variables associated with suicide risk that were not on a causal pathway to death by suicide (e.g., socioeconomic status, physical comorbidity), residual confounding is still possible.
- This first study of suicide risk in Canadian veterans did not have details on potential explanatory factors of suicide risk specific to military service which would be important to understanding heterogeneity in risk within the veteran population.
- The absolute risk of suicide and the presented associations may not be generalizable to other countries with different military culture, length of service, deployment and combat experience; direct comparison may not be appropriate.

Funding Statement: This study was funded by an unrestricted contribution from True Patriot Love, a philanthropic organization dedicated to supporting Canadian veterans and their families. This study was partially supported by ICES, which is funded by an annual grant from the Ontario Ministry of Health and Long-Term Care (MOHLTC). The opinions, results and conclusions reported in this paper are those of the authors and are independent from the funding sources. No endorsement by ICES or the Ontario MOHLTC is intended or should be inferred. Parts of this material are based on data and/or information compiled and provided by the Canadian Institute of Health Information (CIHI). However, the analyses, conclusions, opinions and statements expressed in the material are those of the author(s), and not necessarily those of CIHI.

Competing Interests Statement: The authors do not have anything to disclose.

Data Statement: The data set from this study is held securely in coded form at ICES. While data sharing agreements prohibit ICES from making the data set publicly available, access may be granted to those who meet pre-specified criteria for confidential access, available at www.ices.on.ca/DAS. The full data set creation plan and underlying analytic code are available from the authors upon request, understanding that the programs may rely upon coding templates or macros that are unique to ICES.

Introduction

A constellation of factors may increase the likelihood of death by suicide in military veterans. Established population-based risk factors, including being male, having a personal history of childhood abuse, a personal history of trauma and/or mental disorders, experiencing current financial hardship or the breakdown of intimate relationships, are relevant to the ex-serving population [1]. Military-specific risk factors, such as operational conditions of training and deployment including sleep deprivation, stress, and exposure to traumatic events [1-6] may interact with these established factors and continue to exert an effect long after initial exposure, further increasing the risk of suicide over time [7].

Despite the large amount of attention on the issue of suicide among military populations, the literature is sparse and inconsistent [8-13]. Findings vary depending on country of origin, service period of reference, and the definition of veteran status. There are even fewer Canadian studies of veteran populations [14]. A recent governmental report from Veterans Affairs Canada (VAC) used national vital statistics data linked to administrative Department of National Defence (DND) records concluded a higher risk of suicide for young male veterans, and female veterans, relative to the general population [15]. The VAC study and many others ~~international~~ studies are limited by their inability to ~~cannot~~ make direct comparisons with a similar civilian cohort or to adjust for established risk factors and potential confounders such as socioeconomic status or rurality.

The primary aim of this paper was to describe and compare the rates of death by suicide in Canadian male veterans living in Ontario with age- and sex- matched civilians, adjusting for key confounders.

Methods

Study Design

This was a retrospective, cohort study using provincial, routinely collected data and set in Ontario [16-19]. Ontario is home to eight of the thirty-eight Canadian federal military bases, including the major operational bases Canadian Forces Base Kingston and Petawawa, the Royal Military College of Canada, the Department of National Defence (DND) Headquarters, and national headquarters for the RCMP. In Ontario, universal healthcare planning and delivery is separated into fourteen distinct geographic regions [www.lhins.ca]. With 13.7 million inhabitants, Ontario is also the most populous province in Canada, making it an ideal province to study rare outcomes such as death by suicide. This study received ethics approval from the Queen's University Health Sciences Research Ethics Board. The authors followed the STROBE reporting guidelines [20].

Patient and Public Involvement

Patients and/or the public were not involved in the design or analysis of this study.

Study Population

Veterans were defined as previous Canadian Armed Forces (CAF) and RCMP members who provided evidence to the Ontario Ministry of Health and Long-Term Care (MOHLTC) of their career history, typically at the time of Ontario Health Insurance Plan (OHIP) provincial healthcare registration. The MOHLTC provided the authors with the anonymized list of people with an administrative CAF and RCMP service code linked to their health card number, as well as career start and end dates. At the time of service departure, health insurance coverage is switched from federal to provincial oversight and waiting periods for provincial health insurance are waived which has resulted in a population-based cohort of veterans in Ontario.

VAC estimated that 31% of veterans —approximately 1,050 individuals— transition from the military to civilian residence in Ontario each year [21]. We do not know the true denominator of veterans living in Ontario during our study timeframe; however, the number of veterans entering our cohort per year was similar to the expected number. We found a similar age, sex, and length of service distribution in our cohort as reported by VAC. Our cohort has fewer younger veterans (<25 years old) and a larger number of older veterans (50 and older) than expected; however, this is likely explained by our inclusion of RCMP veterans [18]. We are unable to separately study CAF and RCMP veterans as the MOHLTC includes both under a single veteran status identifier variable. The large majority of our cohort are likely to be CAF veterans, rather than RCMP [18] as less than 200 RCMP retire to Ontario per year (personal communication, Drouin). We therefore estimate that 80% or more of the cohort are CAF veterans.

We included male ex-serving members in this study if they registered for OHIP between January 1, 1990 and March 31, 2013. Female veterans were not included given the small percentage of the military who are female (~15%)[22] and the rarity of suicide. We excluded individuals with OHIP coverage while still engaged in CAF or RCMP service, as indicated by OHIP billing

record dates. Individuals were followed until death, OHIP coverage ended (e.g., moved out of province), or until the end of the study period (December 31, 2015). The date of OHIP registration is a close approximation of the veterans release date from the CAF or RCMP [18].

Two civilian comparator groups were created by matching at a ratio of four civilians for one veteran: 1) on age (using birth year) and sex; and 2) on age, sex, and residential geography in the year following transition. Geographic region of residence was determined by Local Health Integration Networks (LHIN). Fourteen LHINs manage the financial planning and provision of healthcare in Ontario. Individuals were assigned to a LHIN based on their postal code. Our previous work demonstrated temporal stability for the majority demographic details and that veterans are most likely to live within three regions of Ontario with close proximity to major bases and governmental departments [18]. The two reference groups were chosen to be most comparable with other Canadian studies (age and sex alone [15]) and a study from Scotland that applied matching (age, sex, and geography [8]). The OHIP registration date of the veteran was used as the index date for entry into the cohort for both the veteran and the matched civilian reference groups. Eligible civilian controls had to be alive at the study index date.

Data Sources

The study linked multiple administrative datasets held at ICES (formerly known as the Institute for Clinical Evaluative Sciences). ICES is a prescribed entity under section 45 of PHIPA and may collect data and conduct analyses to improve health and healthcare without individual consent. These datasets were linked at the individual level using unique encoded identifiers and analyzed at ICES. The Registered Persons Database provided sociodemographic data on age, sex, region, and rurality of residence in Ontario, as well as aggregate community-level median income. The OHIP database provided information on eligibility for provincial health services and was used to identify major physical and mental comorbidities. The Canadian Institute of Health Information Discharge Abstract Database (CIHI-DAD) provided information on hospitalizations and was also used to identify physical and mental health comorbidities. The National Ambulatory Care Reporting System (NACRS) provided diagnostic and service information on ED visits and was also used to identify physical and mental comorbidities. The Ontario Registrar General (ORG) database provided information on vital status and cause of death.

Identifying Deaths by Suicide

Death by suicide was the primary outcome of this study. We identified deaths using the ORG database which contains mandatory reported information from provincial death certificates. Deaths occurring between January 1, 1990 and December 31, 2015 were captured using an established method that uses the underlying cause of death diagnoses related to suicide as per the International Classification of Disease (9th edition) classification system (E950-E959) and a manner of death equal to suicide for deaths occurring in 2013 and later. This method has 97% sensitivity in identifying suicides from the ORG database [23]. All other deaths were classified as being due to other causes.

Covariates

Covariates were selected from known predictors of suicide risk that were not along the causal pathway[1] and measured in the first year of provincial health insurance eligibility: age (matching), sex (matching), geography (matching, sensitivity analysis only), physical illness, socioeconomic status, and rurality of residence. Potential explanatory variables, such as mental illness, trauma, or operational experiences (e.g., deployment) were considered to occur along the causal pathway from military career to death by suicide and were not included as potential confounders. The presence of major comorbidities was classified using the John Hopkins Aggregate Diagnosis Groups (ADGs) [24]. A score was used to reduce the number of individual variables in the model, rather than including the presence of particular physical health diagnoses specifically and to ensure only validated measures of such conditions were included. The aggregate diagnosis groups are created using hospitalization (CIHI-DAD), ED visits (NACRS), and physician billing (OHIP) data in Ontario in the two years following the index date. Information on health status while the veteran was still serving was not available, as this is captured in a separate, military healthcare system. By focusing on major ADGs we hoped to decrease the likelihood of capturing new diagnoses that would not have existed the year previous to the transition from military to civilian life. Using information on the type, diagnoses, and number of encounters, six ADGs are classified as 'major' and summed [24]. Major ADGs included time-limited: major, time limited: major-primary infections, likely to recur: progressive, chronic medical: unstable, chronic specialty: unstable orthopedics, injuries/adverse effects: major, and malignancy. The major psychosocial ADG was not included in the measure of comorbidity used to adjust for confounding in the comparison of suicide risk between veterans and non-veterans as differences in the occurrence of mental disorders could explain differences in suicide risk between veterans and civilians. Categories of 0, 1, and 2+ major comorbidities were used in the analysis based on the distribution of data. Socioeconomic status was defined according to median community income quintile using census data linked to postal codes (1 = lowest to 5 = highest). Rurality of residence was defined according to the Rurality Index of Ontario, in which municipalities are assigned a score (0-100) based on total population, population density, and travel times to healthcare centres [25]. Individuals were assigned to a municipality using their postal code.

Statistical Analysis

Descriptive statistics compared demographic characteristics between the veteran and civilian populations using Chi square tests for independence and t-tests for categorical and continuous data respectively. Crude death by suicide incidence rates, incidence rate ratios, and 95% confidence limits were calculated using the gamma distribution. Incidence rates were further stratified by age at release (<30, 30-39, 40-49, 50+), calendar year of release (1990-1999, 2000-2013), length of service (<5 years, 5-9 years, 10-19 years, 20+ years), and in five-year time intervals following release (0-5 years, 5-10 years, 10-15 years, and 15-20 years) to explore temporal and service-related patterns. Statistical comparisons of these strata were not completed given small sample sizes.

Multivariable competing risks analysis were completed using the Fine and Grey sub-distribution hazards regression was used to compare the risk of death by suicide and death by other causes between veterans and civilians [26]. Individuals were censored at the end of the follow-up period if they had not experienced the event of interest for the analysis. Hazard ratios and 95% confidence

intervals were presented, further adjusted for baseline age (continuous), presence of major comorbidities (0, 1, 2+), median community income (quintiles), and rurality of residence (Rurality Index of Ontario, 0-9 (most Urban), 10-30, 31-50, 51-70, 70+ (most rural)). Confounders were selected because their values differ between veterans and civilians and are associated with suicide risk. Individuals with complete data (97.7% of the cohort) were included in the multivariable analyses. P-values less than 0.05 were considered statistically significant; 2-sided hypothesis tests were completed. All analyses were performed using SAS 9.3 Copyright 2008 (Cary, NC, USA).

Results

20,397 veterans releasing to Ontario between 1990 and 2013 and 81,559 age-matched non-veterans were included in this analysis (Figure 1). Together they contributed over one million person-years of follow-up. Median follow-up from index was 10 years in veterans and 12 years in civilians. Almost half of veterans left the CAF or RCMP before 2001, and half released in 2001 or later. Length of service varied; 19.5% served less than five years, 16.4% served for five to nineteen years, and 54.1% served twenty or more years. Table 1 compares characteristics of the veteran and age-matched civilian cohorts. Veterans had significantly fewer major or minor physical and mental health conditions, were significantly less likely to live in communities with the lowest median income, and were more likely to live in rural areas than the civilian cohort. Supplementary Table S1 compares demographic characteristics between the civilian and age, sex and geography- matched cohorts.

Over the study period, 4.2% of the male veteran cohort died (n=854) compared with 6.5% of the non-veteran cohort (n= 5,294). 52% of deaths in male veterans occurred in those under the age of 50 years, compared to 43% of deaths in male civilians. The most common causes of death in both groups were cancer or diseases of the circulatory system. Overall, veterans had an 18% lower adjusted risk of dying from causes other than suicide, compared to age-matched civilians (HR 0.82, 95% CI 0.76-0.89; p<0.0001).

Death by suicide was rare in both cohorts; 4.6% of deaths in the veteran cohort (n=39) and 3.6% of deaths in the non-veteran cohort (n=189) respectively. The crude incidence rate of death by suicide in the veteran cohort was 16.1 per 100,000 person-years (95% CI 11.2-22.2) and 17.7 per 100,000 person-years in the non-veteran cohort (95% CI 15.2-20.6). Veterans and non-veterans had a similar risk of dying by suicide during the study period (Table 2). The adjusted hazard ratio (HR) of death by suicide for veterans was 1.01 (95% CI 0.71-1.43) compared to the age-matched non-veteran comparator group. The conclusions did not change when the civilian cohort was matched on both age and geography (Supplementary Table S2).

Table 3 describes the incidence rates of suicide within the veteran cohort by age at release, length of service and calendar year of release. The patterns in crude incidence rates suggest that veterans aged 30-49 years at the time of release and veterans who released after 2000 have a higher rate of death by suicide compared to other veterans. Veterans serving 5-9 years also appeared to have a higher rate of suicide, compared to other veterans. However 95% confidence limits are wide and overlapped for all estimates, owing to small absolute numbers within each category.

Discussion

In our study we found a similar risk of suicide among Canadian veterans compared to civilians. Patterns in suicide incidence rates suggest that veterans aged 30-49 years at the time of release, veterans who released after 2000, and veterans who served 5-9 years have the highest risk within the veteran population; however, these were not statistically significant. Our findings of a similar risk of death by suicide in the veteran and civilian population is consistent with contemporary studies comparing ex-serving veteran populations and the general population in the United Kingdom[8 11 27 28], deployed veterans in Sweden[13], and deployed veterans in the United States prior to 2009[10].

Our study is inconsistent with suicide rates and comparisons with the general population reported by the Canadian[15] and Australian governments[9], and the American peer-reviewed literature published since 2009 for veterans of the Afghanistan and Iraq conflicts[12]. The VAC report concluded the age-adjusted suicide standardized mortality ratio in male veterans was 1.36 (95% CI 1.30-1.44) times higher than in the general population when standardized to the 1991 Canadian population, and their reported crude rates were double those described in our study for both the veteran and civilian groups although we used the same data sources and definitions to identify death by suicide [15]. Differences in study time frames, how the veteran populations were selected and who was included (e.g., Canadian population versus Ontario alone), and differences in analytic approaches between our study and the VAC report may explain discordant findings. Differences between our study findings and the American and Australian experiences may be explained by variation in the underlying prevalence of post traumatic stress disorder or suicide across military or general populations, or different combat and deployment experiences[29].

In our study, age, length of service, era of release, and the period following release appeared to modify the risk of death by suicide although our study was underpowered to identify significant differences. These results are situated within ~~previous~~ work performed in other countries; however, they differ in detail. Whereas some authors have found a higher risk in young male serving and ex-serving military members [11 15], as well as in older veterans [8 9], others identified significantly lower rates for older veterans compared to the general population [9 15]. Many studies highlight a higher risk in early service leavers: those who spend the least amount of time in the military, who may be medically released for mental health reasons, and who may have less access to support [11 15]. Our study may not adequately capture those who serve the least amount of time if they are less likely to identify with the provincial health system as a veteran. In additional to military-specific differences and underlying suicide rates, these studies may reach different conclusions given their choice of referent population or due to statistical uncertainty.

Many factors may explain why suicide rates could be similar in the veteran and general populations, even if exposure to trauma and rates of mental disorders differ. The presence of positive psychological factors, such as resiliency[1], exposure to mental health training and suicide prevention efforts within the CAF and public safety occupations may mitigate the risk of suicide in the veteran population. Canadian serving members had higher odds of experiencing mental health-related stigma than the general population but were more likely to report seeking care [30]. Many civilians in the general population do not have access to the same level of training,

supports, or resources that are available to serving and ex-serving personnel, and so, although exposure to trauma or stressful conditions may be higher and stigma may still exist, Canadian military members, veterans, and their networks may be better prepared to deal with them.

The healthy worker effect, defined as the bias that exists when comparing an occupational cohort to a general population that includes those unable to work due to illness or disability [31], and possible misclassification of veteran status are two key limitations of this study. We addressed the healthy worker effect by adjusting for comorbidity and which resulted in an attenuation of the observed difference between veterans and non-veterans, and the difference in respect of suicide remained non-significant. In addition, comorbidity may change over time resulting in residual confounding. However, we do not anticipate this would occur differently between the veteran and civilian population. Given these limitations, similar rates of death by suicide may be as meaningful as identifying an elevated risk. In addition, our means of identifying veterans in publicly funded health data is subject to limitations. A national registry of Canadian Armed Forces or RCMP veterans does not exist. Our process of ascertainment requires self-identification of military or RCMP service history to the provincial ministry of health in order to access the provincial healthcare system. Therefore, while we are confident that those included in the study are truly military and RCMP veterans, as they must provide regulated documentation of their service history, we cannot be certain that all veterans disclose their status, in particular if they are not ill or do not require health services. However, instructions for switching to provincial health services are included and recommended to military personnel during the military-to-civilian transition. Our study observations may not be generalizable to young veterans who serve a short period of time prior to release as they may be less likely to identify as a veteran on provincial health insurance.

We would have preferred to study risk within reservist and female veteran populations, or by service experience (e.g., deployments, locations of service, combat experiences) or account for previous trauma experience or childhood adversity [8 15]; however, we were unable to do so given data availability. We were also unable to study the risk of death by suicide separately for CAF and RCMP veterans and this may over or underestimate the effect in CAF personnel. A recent survey of mental health disorders among public safety personnel suggests many RCMP screen positive for trauma exposure and various mental health problems [32], although there are no data on suicide risk. In addition, RCMP personnel do not have the same access to mental health training and support as those in the CAF. In depth analyses of other-cause death, such as cancer or motor vehicle accidents were outside the scope of our study. Future studies investigating differences in other-cause deaths are needed to create a more comprehensive picture of the impact of a military career on overall mortality.

Conclusions

Our study observed a similar suicide risk among veterans compared to a matched general population cohort. Our study's primary strength is its population-based design, including rigorous adjustment for confounding. Our observations are consistent with research in the United Kingdom and diverge from the only other Canadian study, as well as studies from the United States. Therefore, given the international focus on the issue of suicide amongst individuals serving or who have served in the military, this work raises a need to conduct further high quality research on the topic of suicide in the military, including veteran populations. Similar rates of

suicide-related mortality highlight the need and opportunity for earlier intervention. We recommend continued efforts around help-seeking for mental health conditions, increased focus on mental health and suicide prevention in the defence community, and further suicide prevention strategy development.

Author Contributions: AM, AK, MW, and PK contributed to the conception and design of the work. AM, MW, and PK contributed to the acquisition of data. AM and MW contributed to the analysis of the work. All authors (AM, AK, MW, HT, HC, NF, PK) contributed to the interpretation of data, drafting and revising the manuscript critically for important intellectual content, approve the final version to be published and agree to be accountable for all aspects of the work.

Table 1: Demographic characteristics of the veteran and age-matched civilian cohorts

	Veterans (n=20,397)	Civilians (n=81,559)	p-value[1]
Age at index (mean, SD)	42.1 (10.1)	42.1 (10.1)	0.88
# Major ADGs			<0.001
0	12,095 (59.3%)	45,328 (55.6%)	
1	5,428 (26.6%)	22,476 (27.6%)	
2+	2,874 (14.1%)	13,755 (16.9%)	
# Minor ADGs			<0.001
0	4,248 (20.8%)	14,896 (18.3%)	
1	3,129 (15.3%)	11,112 (13.6%)	
2	3,213 (15.8%)	11,870 (14.6%)	
3+	9,807 (48.1%)	43,681 (53.6%)	
Socioeconomic Status			<0.001
Lowest	2,090 (10.2%)	16,017 (19.6%)	
2	3,439 (16.9%)	15,929 (19.5%)	
3	4,196 (20.6%)	15,950 (19.6%)	
4	5,225 (25.6%)	16,121 (19.8%)	
Highest	4,519 (22.2%)	16,119 (19.8%)	
Missing	928 (4.5%)	1,423 (1.7%)	
Rurality			<0.001
Most Urban	11,619 (57.0%)	58,447 (71.7%)	
10-30	3,812 (18.7%)	11,300 (13.9%)	
31-50	2,483 (12.2%)	7,093 (8.7%)	
51-70	1,381 (6.8%)	1,803 (2.2%)	
Most Rural	197 (1.0%)	1,222 (1.5%)	
Missing	905 (4.4%)	1,694 (2.1%)	

ADG= John[2]s Hopkins adjusted diagnostic groups; SD= standard deviation; Socioeconomic status=median community income quintiles, Rurality=Rurality Index of Ontario score, 0-100. [1]p-value from Kruskal-Wallis test (continuous) and chi-square test (categorical)

Table 2: Risk of death in male veterans residing in Ontario (n=20,397, median follow-up time 10 years), compared to age-, sex-matched civilians (n=81,559, median follow-up time 12 years)

	# deaths	Unadjusted Hazard Ratio (95% CI)	p-value[1]	Adjusted[2] Hazard Ratio (95% CI)	p-value[1]
Death by suicide					
Veteran Status					
Civilian	189 (0.23%)	1.00 (reference)	0.41	1.00 (reference)	0.96
Veteran	39 (0.19%)	0.86 (0.62-1.22)		1.01 (0.71-1.43)	
Death from other causes					
Veteran Status					
Civilian	5,105 (6.3%)	1.00 (reference)	<0.001	1.00 (reference)	<0.001
Veteran	815 (4.0%)	0.68 (0.63-0.74)		0.82 (0.76-0.89)	

[1]p-value from the Fine & Gray modified Wald statistic; [2]Adjusted for age, number of major physical and mental comorbidities (0, 1, 2+), socioeconomic status (quintiles of median community income), rurality (rurality index of Ontario score, 0-9, 10-30, 31-50, 51-70, 70+); CI= confidence interval

Table 3: Incidence rates of suicide in male veterans releasing between 1990 and 2013[1]

	Rate of deaths by suicide per 100,000 person-years (n=20,397)
Age at release	
<30	18.2 (6.7-39.6)
30-39	29.7 (17.0-48.3)
40-49	18.7 (10.7-30.3)
50+	1.5 (0.04-8.2)
Calendar year of release	
1990-1999	13.9 (8.5-21.4)
2000-2013	19.7 (11.9-30.8)
Length of service	
<5 years	10.1 (3.3-23.5)
5-9 years	32.3 (15.5-59.4)
10-19 years	23.5 (10.7-44.5)
20+ years	12.3 (6.9-20.4)
Time period following release	
0-5 years	21.3 (13.5-32.0)
6-10 years	12.5 (5.4-24.6)
11-15 years	9.4 (2.6-24.0)

[1]Absolute numbers of suicides are not reported due to small cell sizes and privacy restrictions

Figure 1: Selection of study cohort

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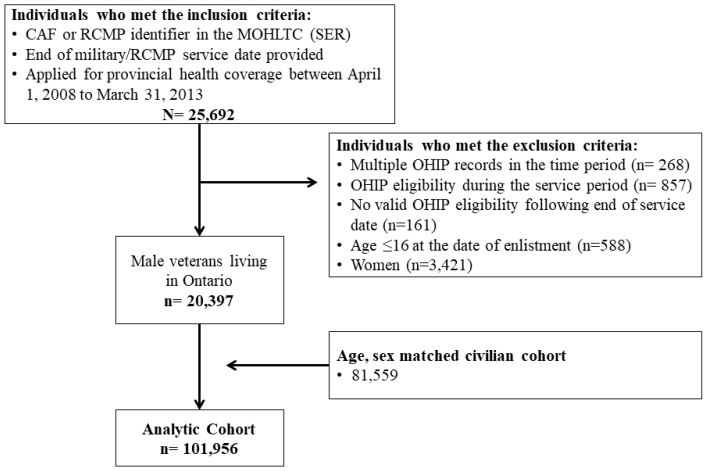

Figure 1: Selection of study cohort

Table S1: Demographic characteristics of the veteran and age-matched civilian cohorts

	Veterans (n=19,585)	Civilians (n=78,318)	p-value[1]
Age at index (mean, SD)	42.2 (10.1)	42.2 (10.0)	0.89
# Major ADGs			
0	11,427 (58.3%)	43,041 (55.0%)	<0.001
1	5,317 (27.1%)	21,727 (27.7%)	
2+	2,841 (14.5%)	13,550 (17.3%)	
# Minor ADGs			
0	3,765 (19.2%)	14,374 (18.4%)	<0.001
1	2,986 (15.2%)	11,372 (14.5%)	
2	3,145 (16.1%)	12,283 (15.7%)	
3+	9,689 (49.5%)	40,289 (51.4%)	
Socioeconomic Status			
Lowest	2,086 (10.7%)	15,507 (19.8%)	<0.001
2	3,434 (17.5%)	15,341 (19.6%)	
3	4,188 (21.4%)	15,472 (19.8%)	
4	5,220 (26.7%)	15,779 (20.1%)	
Highest	4,513 (23.0%)	15,706 (20.1%)	
Missing	144 (0.7%)	513 (0.7%)	
Rurality			
Most Urban	11,589 (59.2%)	45,553 (58.2%)	<0.001
10-30	3,808 (19.4%)	11,000 (14.0%)	
31-50	2,480 (12.7%)	16,383 (20.9%)	
51-70	1,381 (7.1%)	3,902 (5.0%)	
Most Rural	197 (1.0%)	901 (1.2%)	
Missing	130 (0.7%)	579 (0.7%)	

ADG= Johns Hopkins adjusted diagnostic groups; SD= standard deviation; Socioeconomic status=median community income quintiles, Rurality=Rurality Index of Ontario score, 0-100. [1]p-value from Kruskal-Wallis test (continuous) and chi-square test (categorical)

Table S2: Risk of death in male veterans residing in Ontario (n=20,397, median follow-up time 10 years), compared to age- sex, and geography matched civilians (n=78,318, median follow-up time 12 years)

	# deaths	Unadjusted Hazard Ratio (95% CI)	p-value[1]	Adjusted[2] Hazard Ratio (95% CI)	p-value[1]
Death by suicide					
Veteran Status					
Civilian	174 (0.22%)	1.00 (reference)	0.47	1.00 (reference)	0.58
Veteran	39 (0.19%)	0.88 (0.62-1.25)		1.10 (0.78-1.56)	
Death from other causes					
Veteran Status					
Civilian	5,182 (6.6%)	1.00 (reference)	<0.001	1.00 (reference)	<0.001
Veteran	815 (4.0%)	0.58 (0.53-0.62)		0.77 (0.71-0.83)	

[1]p-value from the Fine & Gray modified Wald statistic; [2]Adjusted for age, number of major physical and mental comorbidities (0, 1, 2+), socioeconomic status (quintiles of median community income), rurality (rurality index of Ontario score, 0-9, 10-30, 31-50, 51-70, 70+) and geography (matching, 14 Local Health Integration Networks); CI= confidence interval

STROBE Statement

Checklist of items that should be included in reports of observational studies

Section/Topic	Item No	Recommendation	Reported on Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6/7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed	6/7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7,8
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7,8
Bias	9	Describe any efforts to address potential sources of bias	10/11
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7/8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7/8
		(*b*) Describe any methods used to examine subgroups and interactions	7/8
		(*c*) Explain how missing data were addressed	7/8
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed	7/8
		(*e*) Describe any sensitivity analyses	7/8

Section/Topic	Item No	Recommendation	Reported on Page No
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9 + Figure 1
		(b) Give reasons for non-participation at each stage	9 + Figure 1
		(c) Consider use of a flow diagram	9 + Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	9,10
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11,12
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	4

**Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.*

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Suicide in Canadian veterans living in Ontario: a retrospective cohort study linking routinely collected data

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Keywords:	veteran, military, Suicide & self-harm < PSYCHIATRY, mortality

Suicide in Canadian veterans living in Ontario: a retrospective cohort study linking routinely collected data

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Key Words: Veterans, suicide, military, mortality

Word Count: 3,521

Structured Abstract

Objectives: To compare the risk of death by suicide in male veterans with age-matched civilians.

Design: Retrospective cohort study linking provincial administrative databases between 1990 and 2013 with follow-up complete until death or December 31, 2015.

Setting: Population-based study in Ontario, Canada.

Participants: Ex-serving Canadian Armed Forces and Royal Canadian Mounted Police veterans living in Ontario who registered for provincial health insurance were included. A civilian comparator group was matched 4:1 on age and sex.

Main Outcome: Death by suicide was classified using standard cause of death diagnosis codes from a provincial registry of mandatory data collected from death certificates. Fine and Gray sub-distribution hazards regression compared the risk of death by suicide between veterans and civilians. Analyses adjusted for age, residential region, income, rurality, and major physical comorbidities.

Results: 20,397 male veterans who released to Ontario between 1990 and 2013 and 81,559 age-sex- matched civilians were included. 4.2% of veterans died during the study timeframe, compared with 6.5% of the civilian cohort. Death by suicide was rare in both cohorts, accounting for 4.6% and 3.6% of veteran and civilian deaths respectively. After adjustment for confounders, veterans had an 18% lower risk of dying from causes other than suicide (HR 0.82, 95% CI 0.76-0.89) and a similar risk of dying by suicide (HR 1.01, 95% CI 0.71-1.43), compared to civilians.

Conclusions: Deaths by suicide were rare in male veterans residing in Ontario. Our findings demonstrate that veterans had a similar risk of suicide-related mortality as an age-matched civilian population. A better understanding of effective suicide prevention as well as clarifying pathways to seeking and receiving mental health supports and services are important areas for future consideration.

Article Summary

Strengths and limitations of this study

- Population-based design cohort study linking universal health system data with national mortality data ensures excellent follow-up coverage and similar capture of deaths by suicide between veterans and civilians.
- Despite both matching and inclusion of key variables associated with suicide risk that were not on a causal pathway to death by suicide (e.g., socioeconomic status, physical comorbidity), residual confounding is still possible.
- This first study of suicide risk in Canadian veterans did not have details on potential explanatory factors of suicide risk specific to military service which would be important to understanding heterogeneity in risk within the veteran population.
- The absolute risk of suicide and the presented associations may not be generalizable to other countries with different military culture, length of service, deployment and combat experience; direct comparison may not be appropriate.

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Competing Interests Statement: The authors do not have anything to disclose.

Data Statement: The data set from this study is held securely in coded form at ICES. While data sharing agreements prohibit ICES from making the data set publicly available, access may be granted to those who meet pre-specified criteria for confidential access, available at www.ices.on.ca/DAS. The full data set creation plan and underlying analytic code are available from the authors upon request, understanding that the programs may rely upon coding templates or macros that are unique to ICES.

Introduction

A constellation of factors may increase the likelihood of death by suicide in military veterans. Established population-based risk factors, including being male, having a personal history of childhood abuse, a personal history of trauma and/or mental disorders, experiencing current financial hardship or the breakdown of intimate relationships, are relevant to the ex-serving population [1]. Military-specific risk factors, such as operational conditions of training and deployment including sleep deprivation, stress, and exposure to traumatic events [1-6] may interact with these established factors and continue to exert an effect long after initial exposure, further increasing the risk of suicide over time [7].

Despite the large amount of attention on the issue of suicide among military populations, the literature is sparse and inconsistent [8-13]. Findings vary depending on country of origin, service period of reference, and the definition of veteran status. There are even fewer Canadian studies of veteran populations [14]. A recent governmental report from Veterans Affairs Canada (VAC) used national vital statistics data linked to administrative Department of National Defence (DND) records concluded a higher risk of suicide for young male veterans, and female veterans, relative to the general population [15]. The VAC study and many others ~~international~~ studies are limited by their inability to ~~cannot~~ make direct comparisons with a similar civilian cohort or to adjust for established risk factors and potential confounders such as socioeconomic status or rurality.

The primary aim of this paper was to describe and compare the rates of death by suicide in Canadian male veterans living in Ontario with age- and sex- matched civilians, adjusting for key confounders.

Methods

Study Design

This was a retrospective, cohort study using provincial, routinely collected data and set in Ontario [16-19]. Ontario is home to eight of the thirty-eight Canadian federal military bases, including the major operational bases Canadian Forces Base Kingston and Petawawa, the Royal Military College of Canada, the Department of National Defence (DND) Headquarters, and national headquarters for the RCMP. In Ontario, universal healthcare planning and delivery is separated into fourteen distinct geographic regions [www.lhins.ca]. With 13.7 million inhabitants, Ontario is also the most populous province in Canada, making it an ideal province to study rare outcomes such as death by suicide. This study received ethics approval from the Queen's University Health Sciences Research Ethics Board. The authors followed the STROBE reporting guidelines [20].

Patient and Public Involvement

Patients and/or the public were not involved in the design or analysis of this study.

Study Population

Veterans were defined as previous Canadian Armed Forces (CAF) and RCMP members who provided evidence to the Ontario Ministry of Health and Long-Term Care (MOHLTC) of their career history, typically at the time of Ontario Health Insurance Plan (OHIP) provincial healthcare registration. The MOHLTC provided an anonymized list of people with an administrative CAF and RCMP service code linked to their health card number to ICES, as well as career start and end dates. At the time of service departure, health insurance coverage is switched from federal to provincial oversight and waiting periods for provincial health insurance are waived which has resulted in a population-based cohort of veterans in Ontario. Data anonymization and linkage including the addition of the unique encoded identified (ICES Key Number) and removal of the health card number was performed according to standard ICES protocol by the ICES Data Acquisition team and identifying information was removed from the cohort prior to access by the authors.

VAC estimated that 31% of veterans —approximately 1,050 individuals— transition from the military to civilian residence in Ontario each year [21]. We do not know the true denominator of veterans living in Ontario during our study timeframe; however, the number of veterans entering our cohort per year was similar to the expected number. We found a similar age, sex, and length of service distribution in our cohort as reported by VAC. Our cohort has fewer younger veterans (<25 years old) and a larger number of older veterans (50 and older) than expected; however, this is likely explained by our inclusion of RCMP veterans [18]. We are unable to separately study CAF and RCMP veterans as the MOHLTC includes both under a single veteran status identifier variable. The large majority of our cohort are likely to be CAF veterans, rather than RCMP [18] as less than 200 RCMP retire to Ontario per year (personal communication, Drouin). We therefore estimate that 80% or more of the cohort are CAF veterans.

We included male ex-serving members in this study if they registered for OHIP between January 1, 1990 and March 31, 2013. Female veterans were not included given the small percentage of the military who are female (~15%)[22] and the rarity of suicide. We excluded individuals with OHIP coverage while still engaged in CAF or RCMP service, as indicated by OHIP billing record dates. Individuals were followed until death, OHIP coverage ended (e.g., moved out of province), or until the end of the study period (December 31, 2015). The date of OHIP registration is a close approximation of the veterans release date from the CAF or RCMP [18].

Two civilian comparator groups were created by matching at a ratio of four civilians for one veteran: 1) on age (using birth year) and sex; and 2) on age, sex, and residential geography in the year following transition. Geographic region of residence was determined by Local Health Integration Networks (LHIN). Fourteen LHINs manage the financial planning and provision of healthcare in Ontario. Individuals were assigned to a LHIN based on their postal code. Our previous work demonstrated temporal stability for the majority demographic details and that veterans are most likely to live within three regions of Ontario with close proximity to major bases and governmental departments [18]. The two reference groups were chosen to be most comparable with other Canadian studies (age and sex alone [15]) and a study from Scotland that applied matching (age, sex, and geography [8]). The OHIP registration date of the veteran was used as the index date for entry into the cohort for both the veteran and the matched civilian reference groups. Eligible civilian controls had to be alive at the study index date.

Data Sources

The study linked multiple administrative datasets held at ICES (formerly known as the Institute for Clinical Evaluative Sciences). ICES is a prescribed entity under section 45 of PHIPA and may collect data and conduct analyses to improve health and healthcare without individual consent. These datasets were linked at the individual level using unique encoded identifiers and analyzed at ICES. The Registered Persons Database provided sociodemographic data on age, sex, region, and rurality of residence in Ontario, as well as aggregate community-level median income. The OHIP database provided information on eligibility for provincial health services and was used to identify major physical and mental comorbidities. The Canadian Institute of Health Information Discharge Abstract Database (CIHI-DAD) provided information on hospitalizations and was also used to identify physical and mental health comorbidities. The National Ambulatory Care Reporting System (NACRS) provided diagnostic and service information on ED visits and was also used to identify physical and mental comorbidities. The Ontario Registrar General (ORG) database provided information on vital status and cause of death.

Identifying Deaths by Suicide

Death by suicide was the primary outcome of this study. We identified deaths using the ORG database which contains mandatory reported information from provincial death certificates. Deaths occurring between January 1, 1990 and December 31, 2015 were captured using an established method that uses the underlying cause of death diagnoses related to suicide as per the International Classification of Disease (9th edition) classification system (E950-E959) and a manner of death equal to suicide for deaths occurring in 2013 and later. This method has 97%

sensitivity in identifying suicides from the ORG database [23]. All other deaths were classified as being due to other causes.

Covariates

Covariates were selected from known predictors of suicide risk that were not along the causal pathway[1] and measured in the first year of provincial health insurance eligibility: age (matching), sex (matching), geography (matching, sensitivity analysis only), physical illness, socioeconomic status, and rurality of residence. Potential explanatory variables, such as mental illness, trauma, or operational experiences (e.g., deployment) were considered to occur along the causal pathway from military career to death by suicide and were not included as potential confounders. The presence of major comorbidities was classified using the John's Hopkins Aggregate Diagnosis Groups (ADGs) [24]. A score was used to reduce the number of individual variables in the model, rather than including the presence of particular physical health diagnoses specifically and to ensure only validated measures of such conditions were included. The aggregate diagnosis groups are created using hospitalization (CIHI-DAD), ED visits (NACRS), and physician billing (OHIP) data in Ontario in the two years following the index date. Information on health status while the veteran was still serving was not available, as this is captured in a separate, military healthcare system. By focusing on major ADGs we hoped to decrease the likelihood of capturing new diagnoses that would not have existed the year previous to the transition from military to civilian life. Using information on the type, diagnoses, and number of encounters, six ADGs are classified as 'major' and summed [24]. Major ADGs included time-limited: major, time limited: major-primary infections, likely to recur: progressive, chronic medical: unstable, chronic specialty: unstable orthopedics, injuries/adverse effects: major, and malignancy. The major psychosocial ADG was not included in the measure of comorbidity used to adjust for confounding in the comparison of suicide risk between veterans and non-veterans as differences in the occurrence of mental disorders could explain differences in suicide risk between veterans and civilians. Categories of 0, 1, and 2+ major comorbidities were used in the analysis based on the distribution of data. Socioeconomic status was defined according to median community income quintile using census data linked to postal codes (1 = lowest to 5 = highest). Rurality of residence was defined according to the Rurality Index of Ontario, in which municipalities are assigned a score (0-100) based on total population, population density, and travel times to healthcare centres [25]. Individuals were assigned to a municipality using their postal code.

Statistical Analysis

Descriptive statistics compared demographic characteristics between the veteran and civilian populations using Chi square tests for independence and t-tests for categorical and continuous data respectively. Crude death by suicide incidence rates, incidence rate ratios, and 95% confidence limits were calculated using the gamma distribution. Incidence rates were further stratified by age at release (<30, 30-39, 40-49, 50+), calendar year of release (1990-1999, 2000-2013), length of service (<5 years, 5-9 years, 10-19 years, 20+ years), and in five-year time intervals following release (0-5 years, 5-10 years, 10-15 years, and 15-20 years) to explore temporal and service-related patterns. Statistical comparisons of these strata were not completed given small sample sizes.

Multivariable competing risks analysis was completed using the Fine and Grey sub-distribution hazards regression to compare the risk of death by suicide and death by other causes between veterans and civilians [26]. Individuals were censored at the end of the follow-up period if they had not experienced the event of interest for the analysis. Hazard ratios and 95% confidence intervals were presented, further adjusted for baseline age (continuous), presence of major comorbidities (0, 1, 2+), median community income (quintiles), and rurality of residence (Rurality Index of Ontario, 0-9 (most Urban), 10-30, 31-50, 51-70, 70+ (most rural)). Confounders were selected because their values differ between veterans and civilians and are associated with suicide risk. Individuals with complete data (97.7% of the cohort) were included in the multivariable analyses. P-values less than 0.05 were considered statistically significant; 2-sided hypothesis tests were completed. All analyses were performed using SAS 9.3 Copyright 2008 (Cary, NC, USA).

Results

20,397 veterans releasing to Ontario between 1990 and 2013 and 81,559 age-matched non-veterans were included in this analysis (Figure 1). Together they contributed over one million person-years of follow-up. Median follow-up from index was 10 years in veterans and 12 years in civilians. Almost half of veterans left the CAF or RCMP before 2001, and half released in 2001 or later. Length of service varied; 19.5% served less than five years, 16.4% served for five to nineteen years, and 54.1% served twenty or more years. Table 1 compares characteristics of the veteran and age-matched civilian cohorts. Veterans had significantly fewer major or minor physical and mental health conditions, were significantly less likely to live in communities with the lowest median income, and were more likely to live in rural areas than the civilian cohort. Supplementary Table S1 compares demographic characteristics between the civilian and age, sex and geography- matched cohorts.

Over the study period, 4.2% of the male veteran cohort died (n=854) compared with 6.5% of the non-veteran cohort (n= 5,294). 52% of deaths in male veterans occurred in those under the age of 50 years, compared to 43% of deaths in male civilians. The most common causes of death in both groups were cancer or diseases of the circulatory system. Overall, veterans had an 18% lower adjusted risk of dying from causes other than suicide, compared to age-matched civilians (HR 0.82, 95% CI 0.76-0.89; p<0.0001).

Death by suicide was rare in both cohorts; 4.6% of deaths in the veteran cohort (n=39) and 3.6% of deaths in the non-veteran cohort (n=189) respectively. The crude incidence rate of death by suicide in the veteran cohort was 16.1 per 100,000 person-years (95% CI 11.2-22.2) and 17.7 per 100,000 person-years in the non-veteran cohort (95% CI 15.2-20.6). Veterans and non-veterans had a similar risk of dying by suicide during the study period (Table 2). The adjusted hazard ratio (HR) of death by suicide for veterans was 1.01 (95% CI 0.71-1.43) compared to the age-matched non-veteran comparator group. The conclusions did not change when the civilian cohort was matched on both age and geography (Supplementary Table S2).

Table 3 describes the incidence rates of suicide within the veteran cohort by age at release, length of service and calendar year of release. The patterns in crude incidence rates suggest that veterans aged 30-49 years at the time of release and veterans who released after 2000 have a

higher rate of death by suicide compared to other veterans. Veterans serving 5-9 years also appeared to have a higher rate of suicide, compared to other veterans. However 95% confidence limits are wide and overlapped for all estimates, owing to small absolute numbers within each category.

Discussion

In our study we found a similar risk of suicide among Canadian veterans compared to civilians. Patterns in suicide incidence rates suggest that veterans aged 30-49 years at the time of release, veterans who released after 2000, and veterans who served 5-9 years have the highest risk within the veteran population; however, these were not statistically significant. Our findings of a similar risk of death by suicide in the veteran and civilian population is consistent with contemporary studies comparing ex-serving veteran populations and the general population in the United Kingdom[8 11 27 28], deployed veterans in Sweden[13], and deployed veterans in the United States prior to 2009[10].

Our study is inconsistent with suicide rates and comparisons with the general population reported by the Canadian[15] and Australian governments[9], and the American peer-reviewed literature published since 2009 for veterans of the Afghanistan and Iraq conflicts[12]. The VAC report concluded the age-adjusted suicide standardized mortality ratio in male veterans was 1.36 (95% CI 1.30-1.44) times higher than in the general population when standardized to the 1991 Canadian population, and their reported crude rates were double those described in our study for both the veteran and civilian groups although we used the same data sources and definitions to identify death by suicide [15]. Differences in study time frames, how the veteran populations were selected and who was included (e.g., Canadian population versus Ontario alone), and differences in analytic approaches between our study and the VAC report may explain discordant findings. Differences between our study findings and the American and Australian experiences may be explained by variation in the underlying prevalence of post traumatic stress disorder or suicide across military or general populations, or different combat and deployment experiences[29].

In our study, age, length of service, era of release, and the period following release appeared to modify the risk of death by suicide although our study was underpowered to identify significant differences. These results are situated within ~~previous~~ work performed in other countries; however, they differ in detail. Whereas some authors have found a higher risk in young male serving and ex-serving military members [11 15], as well as in older veterans [8 9], others identified significantly lower rates for older veterans compared to the general population [9 15]. Many studies highlight a higher risk in early service leavers: those who spend the least amount of time in the military, who may be medically released for mental health reasons, and who may have less access to support [11 15]. Our study may not adequately capture those who serve the least amount of time if they are less likely to identify with the provincial health system as a veteran. In additional to military-specific differences and underlying suicide rates, these studies may reach different conclusions given their choice of referent population or due to statistical uncertainty.

Many factors may explain why suicide rates could be similar in the veteran and general populations, even if exposure to trauma and rates of mental disorders differ. The presence of positive psychological factors, such as resiliency[1], exposure to mental health training and suicide

prevention efforts within the CAF and public safety occupations may mitigate the risk of suicide in the veteran population. Canadian serving members had higher odds of experiencing mental health-related stigma than the general population but were more likely to report seeking care [30]. Many civilians in the general population do not have access to the same level of training, supports, or resources that are available to serving and ex-serving personnel, and so, although exposure to trauma or stressful conditions may be higher and stigma may still exist, Canadian military members, veterans, and their networks may be better prepared to deal with them.

The healthy worker effect, defined as the bias that exists when comparing an occupational cohort to a general population that includes those unable to work due to illness or disability [31], and possible misclassification of veteran status are two key limitations of this study. We addressed the healthy worker effect by adjusting for comorbidity which resulted in an attenuation of the observed difference between veterans and non-veterans, and the difference in respect of suicide remained non-significant. In addition, comorbidity may change over time resulting in residual confounding. However, we do not anticipate this would occur differently between the veteran and civilian population. Given these limitations, similar rates of death by suicide may be as meaningful as identifying an elevated risk. In addition, our means of identifying veterans in publicly funded health data is subject to limitations. A national registry of Canadian Armed Forces or RCMP veterans does not exist. Our process of ascertainment requires self-identification of military or RCMP service history to the provincial ministry of health in order to access the provincial healthcare system. Therefore, while we are confident that those included in the study are truly military and RCMP veterans, as they must provide regulated documentation of their service history, we cannot be certain that all veterans disclose their status, in particular if they are not ill or do not require health services. However, instructions for switching to provincial health services are included and recommended to military personnel during the military-to-civilian transition. Our study observations may not be generalizable to young veterans who serve a short period of time prior to release as they may be less likely to identify as a veteran on provincial health insurance.

We would have preferred to study risk within reservist and female veteran populations, or by service experience (e.g., deployments, locations of service, combat experiences) or account for previous trauma experience or childhood adversity [8 15]; however, we were unable to do so given data availability. We were also unable to study the risk of death by suicide separately for CAF and RCMP veterans and this may over or underestimate the effect in CAF personnel. A recent survey of mental health disorders among public safety personnel suggests many RCMP screen positive for trauma exposure and various mental health problems [32], although there are no data on suicide risk. In addition, RCMP personnel do not have the same access to mental health training and support as those in the CAF. In depth analyses of other-cause death, such as cancer or motor vehicle accidents were outside the scope of our study. Future studies investigating differences in other-cause deaths are needed to create a more comprehensive picture of the impact of a military career on overall mortality.

Conclusions

Our study observed a similar suicide risk among veterans compared to a matched general population cohort. Our study's primary strength is its population-based design, including rigorous adjustment for confounding. Our observations are consistent with research in the United

Kingdom and diverge from the only other Canadian study, as well as studies from the United States. Therefore, given the international focus on the issue of suicide amongst individuals serving or who have served in the military, this work raises a need to conduct further high quality research on the topic of suicide in the military, including veteran populations. Similar rates of suicide-related mortality highlight the need and opportunity for earlier intervention. We recommend continued efforts around help-seeking for mental health conditions, increased focus on mental health and suicide prevention in the defence community, and further suicide prevention strategy development.

Author Contributions: AM, AK, MW, and PK contributed to the conception and design of the work. AM, MW, and PK contributed to the acquisition of data. AM and MW contributed to the analysis of the work. All authors (AM, AK, MW, HT, HC, NF, PK) contributed to the interpretation of data, drafting and revising the manuscript critically for important intellectual content, approve the final version to be published and agree to be accountable for all aspects of the work.

Table 1: Demographic characteristics of the veteran and age-matched civilian cohorts

	Veterans (n=20,397)	Civilians (n=81,559)	p-value[1]
Age at index (mean, SD)	42.1 (10.1)	42.1 (10.1)	0.88
# Major ADGs			<0.001
0	12,095 (59.3%)	45,328 (55.6%)	
1	5,428 (26.6%)	22,476 (27.6%)	
2+	2,874 (14.1%)	13,755 (16.9%)	
# Minor ADGs			<0.001
0	4,248 (20.8%)	14,896 (18.3%)	
1	3,129 (15.3%)	11,112 (13.6%)	
2	3,213 (15.8%)	11,870 (14.6%)	
3+	9,807 (48.1%)	43,681 (53.6%)	
Socioeconomic Status			<0.001
Lowest	2,090 (10.2%)	16,017 (19.6%)	
2	3,439 (16.9%)	15,929 (19.5%)	
3	4,196 (20.6%)	15,950 (19.6%)	
4	5,225 (25.6%)	16,121 (19.8%)	
Highest	4,519 (22.2%)	16,119 (19.8%)	
Missing	928 (4.5%)	1,423 (1.7%)	
Rurality			<0.001
Most Urban	11,619 (57.0%)	58,447 (71.7%)	
10-30	3,812 (18.7%)	11,300 (13.9%)	
31-50	2,483 (12.2%)	7,093 (8.7%)	
51-70	1,381 (6.8%)	1,803 (2.2%)	
Most Rural	197 (1.0%)	1,222 (1.5%)	
Missing	905 (4.4%)	1,694 (2.1%)	

ADG= John[2]s Hopkins adjusted diagnostic groups; SD= standard deviation; Socioeconomic status=median community income quintiles, Rurality=Rurality Index of Ontario score, 0-100. [1]p-value from Kruskal-Wallis test (continuous) and chi-square test (categorical)

Table 2: Risk of death in male veterans residing in Ontario (n=20,397, median follow-up time 10 years), compared to age-, sex-matched civilians (n=81,559, median follow-up time 12 years)

	# deaths	Unadjusted Hazard Ratio (95% CI)	p-value[1]	Adjusted[2] Hazard Ratio (95% CI)	p-value[1]
Death by suicide					
Veteran Status					
Civilian	189 (0.23%)	1.00 (reference)	0.41	1.00 (reference)	0.96
Veteran	39 (0.19%)	0.86 (0.62-1.22)		1.01 (0.71-1.43)	
Death from other causes					
Veteran Status					
Civilian	5,105 (6.3%)	1.00 (reference)	<0.001	1.00 (reference)	<0.001
Veteran	815 (4.0%)	0.68 (0.63-0.74)		0.82 (0.76-0.89)	

[1]p-value from the Fine & Gray modified Wald statistic; [2]Adjusted for age, number of major physical and mental comorbidities (0, 1, 2+), socioeconomic status (quintiles of median community income), rurality (rurality index of Ontario score, 0-9, 10-30, 31-50, 51-70, 70+); CI= confidence interval

Table 3: Incidence rates of suicide in male veterans releasing between 1990 and 2013[1]

	Rate of deaths by suicide per 100,000 person-years (n=20,397)
Age at release	
<30	18.2 (6.7-39.6)
30-39	29.7 (17.0-48.3)
40-49	18.7 (10.7-30.3)
50+	1.5 (0.04-8.2)
Calendar year of release	
1990-1999	13.9 (8.5-21.4)
2000-2013	19.7 (11.9-30.8)
Length of service	
<5 years	10.1 (3.3-23.5)
5-9 years	32.3 (15.5-59.4)
10-19 years	23.5 (10.7-44.5)
20+ years	12.3 (6.9-20.4)
Time period following release	
0-5 years	21.3 (13.5-32.0)
6-10 years	12.5 (5.4-24.6)
11-15 years	9.4 (2.6-24.0)

[1]Absolute numbers of suicides are not reported due to small cell sizes and privacy restrictions

Figure 1: Selection of study cohort

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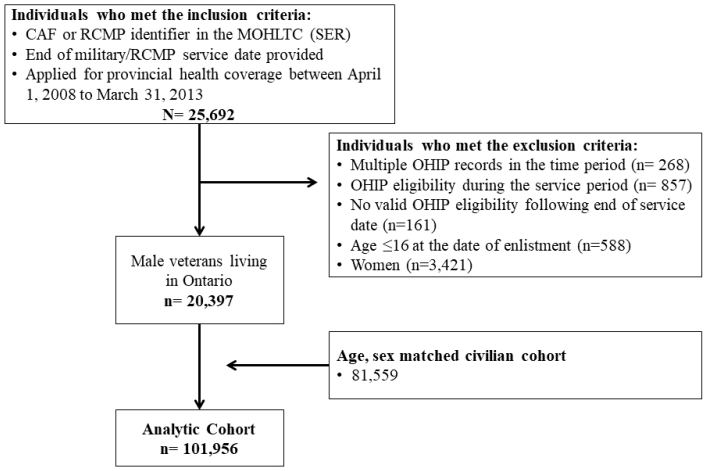

Figure 1: Selection of study cohort

Mahar et al, Supplementary Tables

Table S1: Demographic characteristics of the veteran and age-matched civilian cohorts

	Veterans (n=19,585)	Civilians (n=78,318)	p-value[1]
Age at index (mean, SD)	42.2 (10.1)	42.2 (10.0)	0.89
# Major ADGs			
0	11,427 (58.3%)	43,041 (55.0%)	<0.001
1	5,317 (27.1%)	21,727 (27.7%)	
2+	2,841 (14.5%)	13,550 (17.3%)	
# Minor ADGs			
0	3,765 (19.2%)	14,374 (18.4%)	<0.001
1	2,986 (15.2%)	11,372 (14.5%)	
2	3,145 (16.1%)	12,283 (15.7%)	
3+	9,689 (49.5%)	40,289 (51.4%)	
Socioeconomic Status			
Lowest	2,086 (10.7%)	15,507 (19.8%)	<0.001
2	3,434 (17.5%)	15,341 (19.6%)	
3	4,188 (21.4%)	15,472 (19.8%)	
4	5,220 (26.7%)	15,779 (20.1%)	
Highest	4,513 (23.0%)	15,706 (20.1%)	
Missing	144 (0.7%)	513 (0.7%)	
Rurality			
Most Urban	11,589 (59.2%)	45,553 (58.2%)	<0.001
10-30	3,808 (19.4%)	11,000 (14.0%)	
31-50	2,480 (12.7%)	16,383 (20.9%)	
51-70	1,381 (7.1%)	3,902 (5.0%)	
Most Rural	197 (1.0%)	901 (1.2%)	
Missing	130 (0.7%)	579 (0.7%)	

ADG= Johns Hopkins adjusted diagnostic groups; SD= standard deviation; Socioeconomic status=median community income quintiles, Rurality=Rurality Index of Ontario score, 0-100. [1]p-value from Kruskal-Wallis test (continuous) and chi-square test (categorical)

Table S2: Risk of death in male veterans residing in Ontario (n=20,397, median follow-up time 10 years), compared to age- sex, and geography matched civilians (n=78,318, median follow-up time 12 years)

	# deaths	Unadjusted Hazard Ratio (95% CI)	p-value[1]	Adjusted[2] Hazard Ratio (95% CI)	p-value[1]
Death by suicide					
Veteran Status					
Civilian	174 (0.22%)	1.00 (reference)	0.47	1.00 (reference)	0.58
Veteran	39 (0.19%)	0.88 (0.62-1.25)		1.10 (0.78-1.56)	
Death from other causes					
Veteran Status					
Civilian	5,182 (6.6%)	1.00 (reference)	<0.001	1.00 (reference)	<0.001
Veteran	815 (4.0%)	0.58 (0.53-0.62)		0.77 (0.71-0.83)	

[1]p-value from the Fine & Gray modified Wald statistic; [2]Adjusted for age, number of major physical and mental comorbidities (0, 1, 2+), socioeconomic status (quintiles of median community income), rurality (rurality index of Ontario score, 0-9, 10-30, 31-50, 51-70, 70+) and geography (matching, 14 Local Health Integration Networks); CI= confidence interval

STROBE Statement

Checklist of items that should be included in reports of observational studies

Section/Topic	Item No	Recommendation	Reported on Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6/7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed	6/7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7,8
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7,8
Bias	9	Describe any efforts to address potential sources of bias	10/11
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7/8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7/8
		(*b*) Describe any methods used to examine subgroups and interactions	7/8
		(*c*) Explain how missing data were addressed	7/8
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed	7/8
		(*e*) Describe any sensitivity analyses	7/8

Section/Topic	Item No	Recommendation	Reported on Page No
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9 + Figure 1
		(b) Give reasons for non-participation at each stage	9 + Figure 1
		(c) Consider use of a flow diagram	9 + Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	9,10
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11,12
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	4

**Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.*

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.