Veterans Affairs   Anciens Combattants
Canada   Canada

2021 Veteran Suicide Mortality Study:
Follow-up period from 1975 to 2016.

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Research Directorate Technical Report

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Executive Summary

Suicide in Canadian Veterans is a top public health concern for Veterans Affairs Canada. Collaboration between Veterans Affairs Canada, the Department of National Defence, and Statistics Canada has led to a series of reports under the Veteran Suicide Mortality Study (VSMS). In 2017 and 2019, VSMS examined the magnitude of suicide risk in Canadian Veterans.

In this report, the 2021 VSMS updates the Veteran cohort to include releases since 1975, and adds two more years of mortality data (2015 and 2016) to the mortality linkage study. Suicides were identified by cause of death classification from provincial and territorial death certificates. Age-adjusted rates were calculated to examine trends over time. Standardised Mortality Ratios were calculated to compare the magnitude of suicide risk in Veterans to that of the Canadian general population.

The 2021 VSMS has three key findings:
1. Over the entire 42-year observation period, the risk of suicide for both male and female Veterans was observed to be consistently higher than in the Canadian general population. The risk observed in the additional two years of recent data available (2015 and 2016) was similar to previous time periods. The observed risk of suicide has neither increased nor decreased significantly over this 42 year period.
2. Male Veterans overall had a 1.5 times higher risk of dying by suicide compared to the male Canadian general population, with those under 30 at highest risk.
3. Female Veterans overall had a 2 times higher risk of dying by suicide compared to the female Canadian general population, and this risk was relatively consistent across age groups.

These findings are consistent with earlier VSMS reports, as well as with similar studies from Australia. The stable Canadian trend is in contrast to the decreasing trend described in the UK, and the increasing trend described in the US. Findings from the 2021 VSMS will be used to inform suicide prevention activities for Canadian Veterans in conjunction with other research from Veterans Affairs Canada and Department of National Defence. Future statistical reports will be released every five years with a focus on exploring other variables related to Veteran suicide.

Introduction

Suicide surveillance and research is a public health priority for Veterans Affairs Canada (VAC). The monitoring and analysis of Veteran suicides, to help understand trends over time and potential risk factors, is part of the broader strategy to support ongoing suicide prevention activities.

The Veteran Suicide Mortality Study (VSMS) is a collaborative effort between VAC, the Department of National Defence (DND), and Statistics Canada (STC). The VSMS has the following aims: to enhance the understanding of factors associated with suicide in Canadian Armed Forces Veterans, to provide updates on suicide trends over time, to inform suicide prevention activities, and to align with public expectations of timely reporting of Veteran health indicators.

Efforts to study the risk of suicide in Canadian Armed Forces Veterans have historically been challenged by limited data availability, specifically concerning the identification of Veterans in Canadian health and vital statistics databases. To address this obstacle, VAC and DND worked together to identify a large cohort of serving and released military personnel. Statistics Canada linked this information with death records obtained from Vital Statistics in all provinces and territories. The resulting data linkage was first used in 2010 (Statistics Canada, 2011). In 2017, the data and epidemiological methods were improved (Rolland-Harris, 2018).

Past VSMS reports found that both male and female Veterans were at higher risk of suicide compared to the Canadian general population. These elevated suicide risks remained fairly constant over the approximately 40 year study period (Simkus, 2017; Simkus, 2019).

In 2021, the Veteran cohort was updated to include releases since 1975 (additional year added to prior linkages that started with 1976), and two more recent years of mortality data (2015 and 2016) that became available for linkage to the Veteran cohort. The current report updates the observed trends in suicide risk over time, and by age and sex.

Methods

A series of steps are described in this methodology section. They include:
- Approval
- Methods to Protect Confidentiality
- Data Sources used for the Linkage
- Linkage Methodology
- Analysis
- Release of Findings

A timeline of the methodology steps is provided in Appendix A.

Approval
Initiation of a data linkage project at Statistics Canada results in a formal Memorandum of Understanding. STC and VAC signed an interdepartmental version called a Letter of Agreement in February 2021. This documented the requirements for approval to link, the linkage responsibilities, the limited access to the analytical file, and the release of findings.

Microdata linkage is an internationally recognized statistical method that maximizes the use of information to shed light on societal and economic questions. Statistics Canada conducts this activity in accordance with their Directive on Microdata Linkage, which has been in place since 1986. Microdata linkages must serve a public good, and undergo a prescribed review and approval process. The Centre for Population Health Data submitted a proposal to link, which documented the requirement for this linkage and the data sources. Final approval was signed by the Chief Statistician, and a summary of the approved CFCAMS and VSMS linkage 005-2021 was posted on the website (Statistics Canada, 2021).

Methods to Protect Confidentiality
Statistics Canada's commitment to keeping the confidentiality of the information obtained from the Canadian public is enshrined in the *Statistics Act* and the Agency's various policies and practices related to data collection, analysis and dissemination activities as well as the *Privacy Act*. The policies and tools that ensure compliance to the privacy principles embedded in these Acts is described in Statistics Canada's privacy framework (https://www.statcan.gc.ca/en/reference/privacy/framework).

Linked analysis files are deemed sensitive statistical information and subject to the confidentiality requirements of the Statistics Act. To reduce the risk of privacy intrusiveness and to minimize the risk of disclosure, source files in Statistics Canada's Social Data Linkage Environment (SDLE) are separated into source index files and source data files. As well, the record linkage production environment that uses the source index files is separated from the data integration and analysis environment that uses the source data files. That is, Statistics Canada employees performing the record linkages in SDLE have access to only the basic personal identifiers needed for linkage. Employees who build the analytical files for research have access only to the data stripped of personal identifiers. Anonymous keys are used to integrate the data from the various sources into a linked analysis data file. Further, only Statistics Canada employees who have an approved need to access the data for their analytical

work are allowed access to the linked analysis file. The Privacy Impact Assessment conducted by Statistics Canada found these processes acceptable to reduce the risk of privacy intrusiveness and to minimize the risk of disclosure (http://www.statcan.gc.ca/eng/sdle/index).

Data Sources Used for the Linkage
The 2021 VSMS follows a cohort of Veterans who released from the Canadian Armed Forces between 1975 and 2016 with service in the Regular Force and Reserve Class C (Appendix B).

Canadian mortality data is obtained from provincial and territorial Vital Statistics databases, and maintained by Statistics Canada (Appendix C). At the time of linkage, finalized mortality data was available to the end of 2016. Statistics Canada recommended that this study not include the preliminary data for 2017, 2018, and 2019, since this data is subject to revision and increases of more than 10% are expected for suicide deaths (Park, 2021).

Linkage Methodology
The linkage was overseen by Social Data Linkage Environment (SDLE) at Statistics Canada. The CAF cohort file was linked to the Derived Record Depository (DRD). DRD is a national longitudinal data base of individuals derived from multiple STC sources and containing only basic personal identifiers. The sources include Census, T1 tax files, landed immigrants, and Canadian births and deaths. SDLE regularly links the DRD with data files of Canadian deaths. Overall, 99.5% of the 1970 to 2016 Canadian death file linked to the DRD (St-Jean, 2018). The linkage rate of the CAF cohort to DRD was 99.9%, and the associated keys were stored in the Key Registry of the SDLE (SDLE, 2021). Subsequent linkage of all unique CAF cohort records to the death file was completed either deterministically using Social Insurance Number (92% of records) or probabilistically using a combination of other identifiers (8% of records). Details on the process used for both linkage types are provided by Statistics Canada (Park, 2021).

Statistics Canada created a mortality output file that contained the randomly-assigned Statistics Canada identifier number and mortality information for those cohort members found to be deceased in Canada. Identifying variables were dropped for confidentiality. The mortality output file was validated, and no concerning issues were found following examination the data variables. Several irregularities were identified that provided direction to study investigators to define exclusion of records (Park 2021).

Analysis
The complete linked dataset was anonymized and held in a secure area at Statistics Canada, where access to the analytical file was limited to Statistics Canada employees or identified deemed employees inside the Federal Research Data Centre, under STC's Directive on the Use of Deemed Employees. Analyses were conducted by a VAC senior epidemiologist, and supported by an analyst at Statistics Canada.

The analysis was done in multiple steps (see Appendix D), with the start delayed by COVID restrictions. The first step is usually described as "data cleaning", that deals with the irregularities found in administrative data.

Analyses were done separately for males and females. This was done since the distribution by sex of the Veteran population and the Canadian general population (CGP) are quite different, and the distribution of suicides for males and females differs in both populations. Analyses combined Regular Force and Primary Reserve Force Class C Veterans, since they had similar risk of suicide (VanTil, 2021).

Age-adjusted suicide rates were calculated for both Veterans and the CGP. The numerator included suicide deaths as defined by the cause of death classification codes reported by Statistics Canada (Navaneelan, 2012). The denominator was calculated as person-years. The 42-year study period required that the rates be adjusted to a standard age distribution; this study updated this to the 2011 Canadian population. Indirect standardization was deemed the most appropriate for this study (Smolenski, 2021). Age group categories were by 5-year intervals, and 95% confidence intervals were calculated (see Appendix D).

Standardized Mortality Ratios (SMRs) were calculated by age group to compare the risk of suicide in Veterans to the CGP (Kapur, 2009). Their 95% confidence intervals (boundaries are listed in the tables as Lower CI, Upper CI) were also calculated to illustrate the amount of random error in the estimates; CIs that overlap 1.0 indicate that the SMR is not statistically significant from the CGP (see Appendix D).

Release of Findings
The numbers in this report replace earlier reports. Updated release dates (usually due to re-enlistment in the cohort) and improvements in processing and methodology led to the revision of some findings compared to those previously published.

Only aggregate tabular statistics that conform to the confidentiality provisions of the *Statistics Act* are released outside of Statistics Canada. This is supported by disclosure guidelines available to the researchers. This included the following measures:
- Counts are rounded to an adjacent multiple of 5;
- All counts less than 10 must be suppressed; this includes the potential to identify these small counts by comparing to release of the prior report;
- Rates per 100 000 and bounds of the confidence interval are rounded;
- Age group categories and time period categories are collapsed as required to maintain confidentiality.

Several findings in this report are based on calculations using small numbers, contributing to wide confidence intervals. In compliance with Statistics Canada reporting requirements, many categories in this report were collapsed.

Results

Cohort Summary

The final linked VSMS cohort included over 250,000 Canadian Veterans by the end of the study period in 2016 (Appendix B). The Veteran cohort was 89% male, with 60% of all cohort members released at a Junior Non-Commissioned Member (NCM) rank, and 29% released since 2000. Some cohort members had a combination of service experience in both the Regular Force and Reserve Class C during their careers. The majority of the cohort (95%) had belonged to the Regular Force at some point in their military careers; 17% had belonged to Reserve Class C at some point. Analyses combined Veterans of both Regular Force and Reserve Class C, since they had similar risk of suicide (VanTil, 2021).

Table 1 provides additional details on this cohort's military characteristics, by sex.

Era of first enrolment demonstrates that 33% of the male cohort and 11% of females enrolled prior to 1975, and therefore this study does not have a full record of their occupation and rank changes over their careers.

Era of release demonstrates the starting point of this cohort with the earliest releases in 1975. Almost half of the cohort (49% of males, 39% of females) released prior to 1990 indicating their military experience was during the era of United Nations peacekeeping. Approximately a quarter of the cohort released 1990 to 2000 during the era of escalating peacekeeping conflicts in Somalia, the Balkans, and the Persian Gulf. Approximately a quarter of the cohort (24% of males, 31% of females) released 2001 to 2014 during the era of the Afghanistan conflict. Almost 5% of the cohort released in the 2 years (2015 and 2016) since the last VSMS report.

Environmental uniform at release was missing for 40% of the cohort, and an additional 20% were recorded as the non-specific "Canadian Forces"; therefore no further analysis was done by environment at release.

Deployment during military service was recorded in this study for 28% of males in the cohort and 23% of females; this is much lower than reported by Life After Service Survey. The survey findings reported 76% of Veterans deployed; 79% of male Veterans, 58% of female Veterans (Sweet 2020). If future analyses are to examine deployment, the investigators will need to partner with DND to seek additional data sources and expertise for deployments.

Table 1. Military characteristics of the 1975-2016 VSMS cohort.

	Male		Female	
	N	%	N	%
Total in cohort	226,415		27,230	
Still alive Dec 31, 2016	196,085	87%	26,220	96%
Died during study period	30,330	13%	1,010	4%
Rank at release				
Junior NCM	133,275	59%	18,430	69%
Senior NCM	51,110	22%	3,135	11%
Officer	40,210	18%	5,515	20%
Missing	1,820	1%	150	0%
Total	226,415	100%	27,230	100%
Component				
Regular Force only	190,225	84%	20,915	77%
Both Reg and Res C Force	25,490	11%	4,085	15%
Reserve C Force only	10,700	5%	2,230	8%
Total	226,415	100%	27,230	100%
Era of first enrolment				
Pre-1975	75,605	33%	2,885	11%
1975-1989	107,950	48%	17,015	63%
1990-2000	19,685	9%	3,615	13%
2001-2016	23,175	10%	3,715	13%
Total	226,415	100%	27,230	100%
Era of release				
1975-1989	110,650	49%	10,660	39%
1990-2000	51,075	23%	6,470	24%
2001-2014	54,720	24%	8,310	31%
2015-2016	9,970	4%	1,790	6%
Total	226,415	100%	27,230	100%
Environment at release				
Sea	21,420	9%	2,700	10%
Land	41,690	19%	3,950	14%
Air	22,500	10%	2,920	11%
Canadian Forces	49,340	22%	6,030	22%
Missing	91,465	40%	11,630	43%
Total	226,415	100%	27,230	100%
Deployment				
Deployed	63,435	28%	6,160	23%
Not deployed	162,980	72%	21,070	77%
Total	226,415	100%	27,230	100%

Male Suicide Mortality Over Time

Veteran males overall had a 1.5 times higher risk of suicide death than the male Canadian General Population, when adjusted for age differences. This risk was higher than the Canadian General Population in all time periods examined, and did not change significantly across time periods. The suicide risk of male Veterans was lowest during the 2005 to 2009 period, however this was not significantly different from the other time periods (Table 2 and Figure 1).

Table 2. Comparison of male Veteran and Canadian suicide risks using Standardised Mortality Ratios (SMR) by time period, 1975 to 2016.

Time period*	N	Suicide SMR	Lower CI	Upper CI
1975-1979	70	2.14	1.67	2.70
1980-1984	145	1.62	1.37	1.90
1985-1989	200	1.61	1.40	1.85
1990-1994	250	1.61	1.42	1.82
1995-1999	290	1.57	1.40	1.76
2000-2004	250	1.44	1.27	1.63
2005-2009	235	1.34	1.18	1.52
2010-2014	290	1.49	1.33	1.67
2015-2016	125	1.45	1.21	1.73
Total	1,855	1.47	1.40	1.54

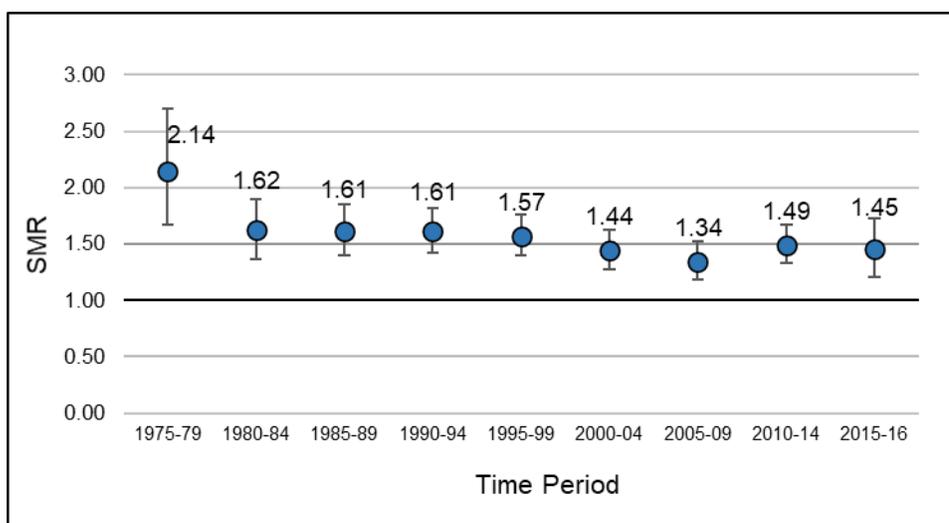*standardized to the 2011 Canadian age distribution

Figure 1. Comparison of male Veteran and Canadian suicide risks using Standardised Mortality Ratios (SMR) by time period, 1975 to 2016.

Male Suicide Mortality by Age Group

Although Veteran males overall had a 1.5 times higher risk of suicide death than the male Canadian General Population, the risk was highest in the youngest age group, and decreased with age (age analysis described in Appendix D). Males under 30 years of age had a 2.5 times higher risk compared to males of the same age in the Canadian General Population. In contrast, male Veterans aged 50 to 59 years had a similar risk of suicide compared to the CGP, and those aged 60 years and older had a 42% lower risk (Table 3 and Figure 2).

Table 3. Comparison of male Veteran and Canadian suicide risks using Standardised Mortality Ratios (SMR) by age group, 1975 to 2016.

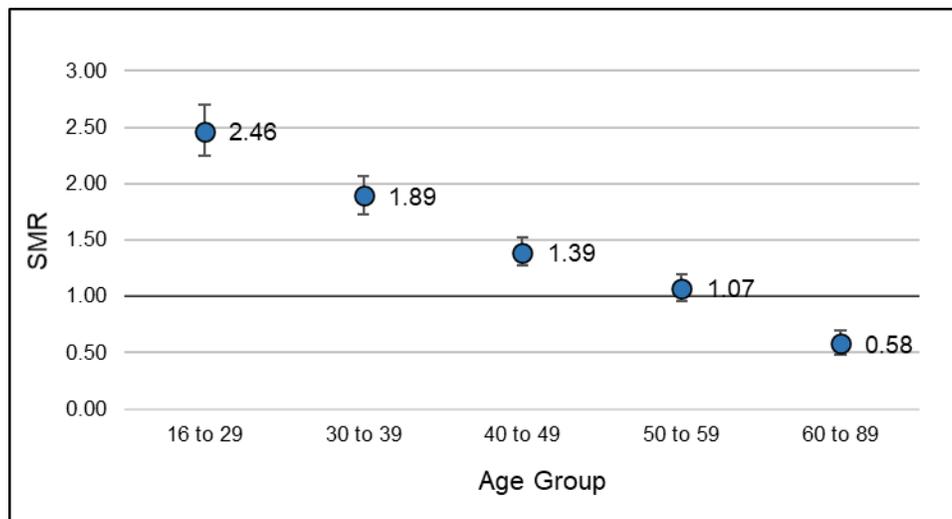| Age group	N	Suicide SMR	Lower CI	Upper CI
16 to 29	455	2.46	2.25	2.70
30 to 39	495	1.89	1.73	2.06
40 to 49	480	1.39	1.27	1.52
50 to 59	315	1.07	0.96	1.19
60 to 89	110	0.58	0.48	0.70
Total	1,855	1.47	1.40	1.54

Figure 2. Comparison of male Veteran and Canadian suicide risks using Standardised Mortality Ratios (SMR) by age group, 1975 to 2016.

Female Suicide Mortality Over Time

Female Veterans overall had a 2 times higher risk of suicide death than the female Canadian General Population, when adjusted for age differences. This risk did not change significantly across time periods (Table 4 and Figure 3).

Table 4. Comparison of female Veteran and Canadian suicide risks using Standardised Mortality Ratios (SMR) by time period, 1975 to 2016.

Time period*	N	Suicide SMR	Lower CI	Upper CI
1975-1989	15	2.21	1.27	3.60
1990-1999	15	1.64	0.92	2.71
2000-2009	35	2.95	2.05	4.10
2010-2016	30	2.40	1.60	3.47
Total	95	2.15	1.74	2.64

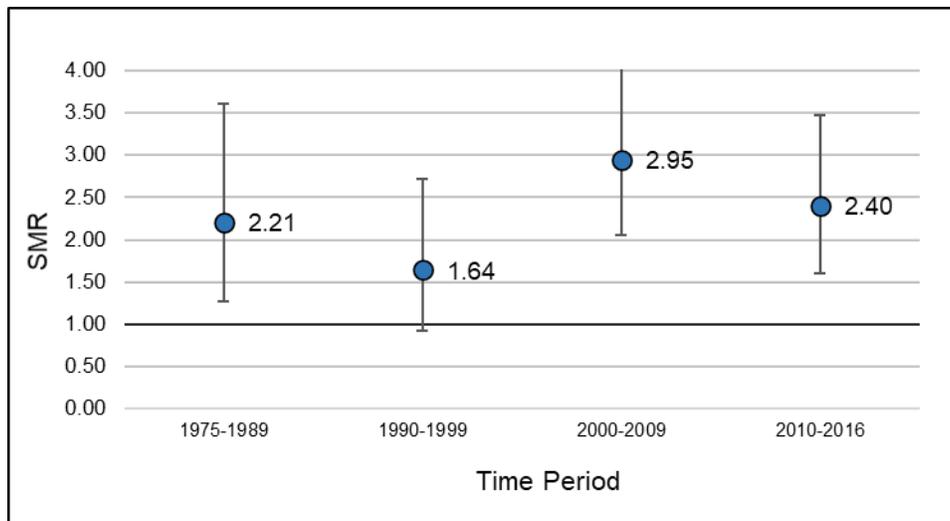*standardized to the 2011 Canadian age distribution

Figure 3. Comparison of female Veteran and Canadian suicide risks using Standardised Mortality Ratios (SMR) by time period, 1975 to 2016.

Female Suicide Mortality by Age Group

Overall, female Veterans had a 2 times higher risk of dying by suicide compared to the female Canadian General Population, and the risk was consistently elevated in all three age groups. The small number of female suicides overall restricted the analysis to three age groups (Table 5 and Figure 4).

Table 5. Comparison of female Veteran and Canadian suicide risks using Standardised Mortality Ratios (SMR) by age group, 1975 to 2016.

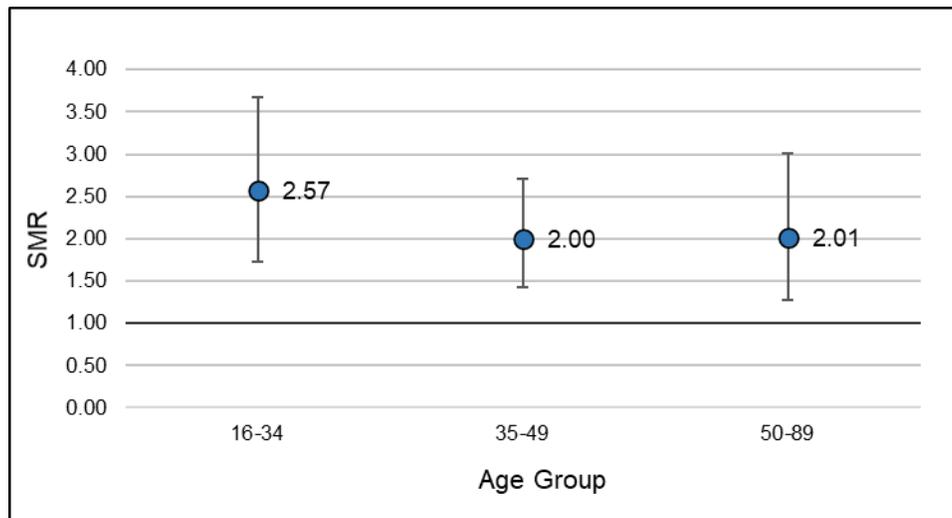| Age Group	N	Suicide SMR	Lower CI	Upper CI
16 to 34	30	2.57	1.73	3.67
35 to 49	40	2.00	1.43	2.71
50 to 89	25	2.01	1.27	3.01
Total	95	2.15	1.74	2.64

Figure 4. Comparison of female Veteran and Canadian suicide risks using Standardised Mortality Ratios (SMR) by age group, 1975 to 2016.

Comparison of Male and Female Suicide Mortality

Overall, age-adjusted suicide rates per 100,000 person-years for male and female Veterans were higher than in the Canadian General Population. The Veteran male suicide rate was 2 times higher than that of Veteran females (Figure 5).
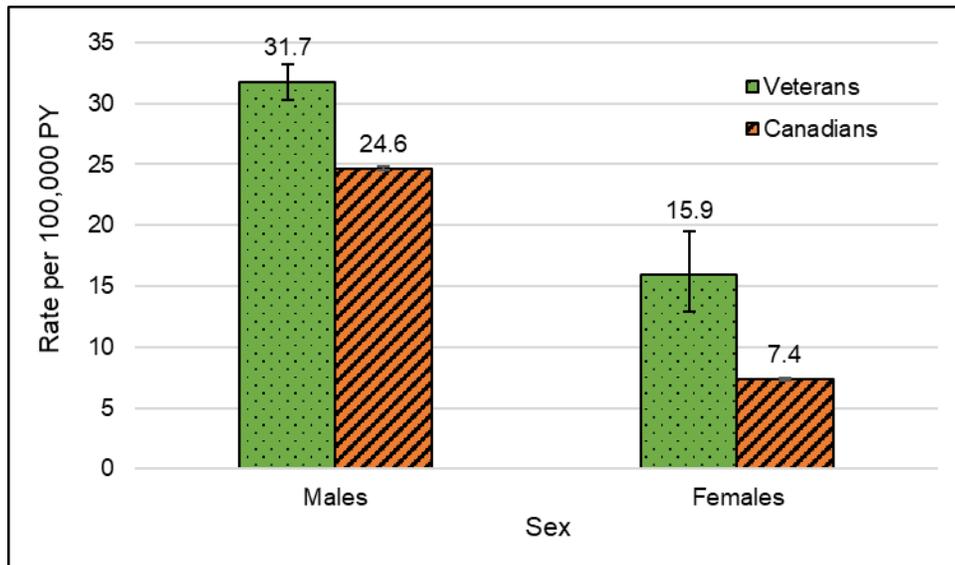

Figure 5. Age-adjusted suicide rates for Veterans and Canadians, 1975 to 2016; rates standardized to the 2011 Canadian age distribution.

Discussion

Suicide is a critical public health concern for VAC. With assistance from DND and Statistics Canada, VAC has conducted analyses of the largest available dataset with cause of death and military service information for Canadian Armed Forces Veterans. The 2021 Veteran Suicide Mortality Study's key findings are as follows:

1. Over the entire 42-year observation period, the risk of suicide for both male and female Veterans was observed to be consistently higher than in the Canadian general population. The risk observed in the additional two years of recent data available (2015 and 2016) was similar to previous time periods. The observed risk of suicide has neither increased nor decreased significantly over this 42 year period.

2. Male Veterans overall had a 1.5 times higher risk of dying by suicide compared to the male Canadian general population, with those under 30 at highest risk.

3. Female Veterans overall had a 2 times higher risk of dying by suicide compared to the female Canadian general population, and this risk was relatively consistent across age groups.

The standardised mortality ratios presented in this report indicate that Veterans have an increased risk of suicide compared to the Canadian General Population. Overall, the age-adjusted suicide rate for male Veterans was 32 per 100,000 person-years; this was 1.5 times higher risk of death by suicide compared to the male Canadian General Population. For female Veterans, the age-adjusted suicide rate was 16 per 100,000 person-years; this was 2 times higher risk of suicide death compared to the female Canadian General Population. Similar to what has been observed in the general population (Navaneelan, 2012), the Veteran Suicide Mortality Study found that male Veterans had a higher rate of suicide than female Veterans. The risk of suicide overall for male and female Veterans in Canada has remained stable over the 42 year study period, including the most recent period of 2015 and 2016. These findings are consistent with earlier findings (Simkus 2017; VanTil 2018; Simkus 2019).

For male Veterans, the risk of suicide was highest in the youngest group of Veterans. This age distribution contrasts with the peak in middle age (40 to 59) reported for Canadian male suicide rates (Navaneelan, 2012). Veterans aged less than 30 years had 2.6 times higher risk of suicide than Canadian males of comparable age, and those under 40 years had 1.9 times higher risk. The higher risk in young male Veterans is consistent with earlier findings of highest suicide risk for NCM ranks approximately 4 years after release (VanTil, 2021).

For female Veterans, the risk of suicide did not change with age. This age distribution is similar to the age distribution reported for Canadian female suicide rates (Navaneelan, 2012). In all age groups, the risk was consistently higher than Canadian females of comparable age.

The longstanding increased risk of suicide for Veterans (both male and female) compared to the Canadian general population underscores the importance of the Canadian Armed Forces and Veterans Affairs Canada Joint Suicide Prevention Strategy (CAF-VAC 2017). The differing patterns of suicide risk by age for males and females suggest that risk factors may differ between the sexes. While current Canadian strategies may be appropriate for most groups of

Veterans, the rates and numbers for male Veterans under 40 suggest the need for a targeted strategy for this group, particularly for the first years after NCM release. Prevention and treatment efforts should take sex differences into account, while avoiding a sole focus on only males or females.

Studies of Veteran suicide in other countries have also observed higher risk for young male Veterans (AIHW 2021, MOD 2020, USDVA 2019), similar to the VSMS. Higher male Veteran suicide rates in comparison with general populations in Australia (24% higher, AIHW 2021) and the US (30% higher, USDVA 2019), are also similar to the VSMS. However, UK male Veterans are consistently lower (SMR=0.56, MOD 2020). Higher female Veteran suicide rates in comparison with general populations in Australia (twice as likely, AIHW 2021) and the US (2.2 times higher, USVA 2019), are similar to the VSMS. The stable Veteran suicide rates over many years in Canada are similar to stable trends reported in Australia (AIHW 2021). This finding is in contrast to the declining trend in the UK (MOD 2020), and the increasing rates in the US over the period of 2001 to 2018 (USDVA 2021).

Strengths and Limitations

One of the key strengths of this study is the comprehensiveness of its data sources. The use of pay data ensures that all persons that had military pay were included in the cohort, and the use of official death records ensures that Veterans' suicide deaths are equally likely to be reported as suicide deaths in the Canadian General Population. The large cohort numbers and lengthy follow-up period provide the best available picture of the risk of death by suicide for both male and female Canadian Veterans.

However, these data sources do not characterize the full military career of Veterans, nor their experiences following release from the military. There is always public interest in findings by deployment, such as Afghanistan. However, such analysis excludes the 35% of Veterans who did not deploy, and comparisons are influenced by the healthy worker effect (VanTil 2019). The findings from VSMS should therefore be considered in conjunction with other forms of research that examines the broader concept of suicidality (ideation, attempts and suicide death) and a longer list of military characteristics.

Small numbers of female Veterans have restricted reporting for confidentiality (Park 2021), and their rates are greatly affected by small differences in suicide counts (Hoffmire 2020).

Suicide mortality data are not available for the most recent years of 2017 to 2019, due to the status of Canadian mortality data as preliminary and not finalized (Park 2021). Although the US was able to report on these years, and reported that the rates fell in 2019 (USDVA 2021), the Canadian numbers are too small to report any statistically significant change in trend over a single year. The Canadian practice is consistent with Australia's report that did not provide suicide rates for 2017 to 2019, and noted the data for these most recent years are subject to change (AIHW 2021).

Future VSMS Reports

Over a single year, changes in Canadian numbers are too small to report a statistically significant change in trend, which challenges the feasibility and confidentiality of annual VSMS reports. Going forward, reporting of Veteran suicide will occur every five years, with an examination of new variables related to Veteran suicide to support the Joint Suicide Prevention Strategy.

The next topic to be examined could be other causes of death, since certifying a death by suicide requires a high burden of proof due to medicolegal implications that underestimate counts by approximately 30%; a more inclusive examination of accidents, suicides or undetermined intent could be more informative for prevention efforts (Katz 2016). Another topic could be the mechanism of suicide death, that has been a focus of US studies (Hoffmire 2014, McCarten 2015).

The partnership between VAC, DND and STC is also developing a broader listing of Veterans in Canada that could include releases prior to 1975. Future publication to describe the validation of this listing will allow consideration of its use for linkage with Canadian mortality data.

Conclusions

Suicide among Canadian Veterans continues to be a top public health concern. Collaborative efforts by Veterans Affairs Canada, The Department of National Defence, and Statistics Canada continue to result in regular reports on suicide deaths among Veterans in Canada. Both male and female Canadian Veterans have a significantly higher risk of death by suicide compared to Canadians in the general population. At particular risk are the youngest male Veterans. Findings from the current study support continued suicide prevention activities for Canadian Veterans.

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Appendix A – Timeline for Methodology Steps

Timeline for the methodology steps for VSMS 2021:

- Approval
  February 2021: Letter of Agreement signed
  March 2021: Approval to link signed

- Methods to Protect Confidentiality
  November 2019: Oath to protect confidentiality

- Data Sources used for the Linkage
  May 2020: expected data retrieval at DND to ensure all updates for the calendar year 2019 were final
  November 2020: Finalized death data for years up to 2016 released by STC and available for linkage
  February 2021: actual date of data transfer from DND data to STC (delayed due to COVID)

- Linkage Methodology
  March 2021: SDLE linkage
  June 2021: Linkage documentation

- Analysis
  May 2021: options discussed for FRDC access, availability of STC analysts
  September 2021: Data cleaning
  November 2021: Calculation of age-adjusted rates and SMRs
  December 2021: Report drafted

- Release of Findings
  December 2021: Tabular data released from STC to VAC
  December 2021: VSMS report started approvals at VAC
  January 2022: VAC Research Directorate and Communications develop release products
  Late Spring 2022: expect final governmental approval for release

Appendix B – Veteran Cohort Definition

The VSMS follows Canadian Veterans who released from the Canadian Armed Forces between January 1, 1975 and December 31, 2016, with service in the Regular Force and/or Reserve Class C. The cohort was defined using pay data from DND's Central Computerised Pay System. The data retrieval at DND was in 2020 to ensure all updates for the calendar year 2019 were final. The following inclusion criteria were applied:

    a) cohort members must have released from the Canadian Armed Forces on or after 1975;

    b) cohort members must no longer be serving as of December 31, 2016, and must be surviving upon their release (i.e. did not die in service); and

    c) cohort members' age at enrolment/release and dates of death must be logical relative to their service time.

The cohort grew from 10,763 Veterans in 1975 to approximately 260,000 Veterans by the end of 2016. This includes Veterans who died during this period; the analysis removed Veterans upon their death in order to accurately calculate suicide SMRs and rates.

Because Reserve "A" and "B" personnel are paid through a different system, these Veterans were not included in this study.

The Central Computerised Pay System is an electronic DND dataset that identifies all Regular Force and Reserve Class C (who participated in international operations and/or tours of duty) who released from the Canadian Armed Forces dating back to 1975. The Central Computerised Pay System has an accuracy and precision advantage from its built-in feedback mechanism, whereby both personnel and the employer are motivated to correct pay errors as soon as possible. Salaries and pay amounts were not shared with the research team; only dates of pay changes were used to identify when each service member ended their employment with the Canadian Armed Forces ("released").

The cohort was supplemented with data from the DND Mortality Database, that captures verified out-of-country deaths while in service, since 2004.

The cohort provided by DND included 543 variables for analysis. Many dates were provided to define different periods of service by rank, deployment, military occupation, and component. Up to 92 periods had start and end dates that may be sequential or may demonstrate a gap. The "data cleaning" step prior to analysis reconciled many dates. Examples included prioritization of the confirmed date of death by Vital Statistics, and subsequent adjustment of conflicting dates of release from DND. If the date of death was within 1 week of release, the release date was adjusted to match this date. The 1 week time frame is consistent with the mid-point of a pay period, and confirmed by comparison of suicide counts with published DND data that showed these deaths occurred during service (Simkus 2017). Other dates were not possible to correct, so exclusion criteria were applied. For example, 16 years was set as the minimum age at enrolment and release, and 60 years was set as the maximum age at enrolment.

Appendix C – Canadian Mortality Data

Canadian mortality data is maintained by Statistics Canada in the Canadian Vital Statistics Death Database (CVSD). Deaths are reported by the provincial and territorial Vital Statistics Registries to Statistics Canada since 1950. The information provided includes demographic and cause of death information (https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3233).

The underlying cause of death is coded using the International Classification of Diseases (ICD). The format of these codes changes with each update:
- ICD-8 used from 1969 to 1978;
- ICD-9 used from 1979 to 1999;
- ICD-10 used from 2000 to 2019.

Few out-of-country deaths are captured by this system. Prior to 2010, some data were collected for Canadian residents who died in some American states. Such data are no longer collected starting with the reference year 2010. Data for Yukon are not available as of 2017.

Annual releases of mortality data are made at the end of November. At the time of linkage in March 2021, CVSD provided the **finalized** data for 1975 to 2016. Death data for 2017 and later are **subject to revision**, the result of delays in registration/submission, or updated cause of death after autopsy.

The Vital Statistics team at Statistics Canada notes that **preliminary** (2017, 2018, 2019) **and provisional** (2020) **deaths are subject to revision.** Any future revisions affect disproportionately the number of deaths due to suicide or other accidental or unnatural causes (ICD Chapter 20: External Causes of Morbidity) and could result in significant increase (>10%). Causes of death that take into account autopsy findings are often delayed, and preliminary reports may indicate a non-specified cause of death.

Appendix D – Data Analysis

The analysis was done in multiple steps:
- Data cleaning
- Age-adjusted suicide rates
- Standardized Mortality Ratios

Data linkages were conducted using SAS statistical software. All data cleaning, manipulation, and analyses were conducted using Stata statistical software and Microsoft Excel.

Data cleaning deals with the irregularities found in administrative data. This process included:
- Elimination of duplicate records
- Elimination of extra variables
- Amalgamation of multiple mortality sources
- Creation of consistent ICD code format across 3 ICD versions
- Reconciliation of dates from multiple sources
- Removal of records with release prior to 1975
- Adjustment of release date if within 1 week of death[1]
- Elimination of records with out-of-scope ages (death date prior to service dates, enrolment before age 16, release after age 65)
- Exclusion of military deaths
- Truncation of Cohort Data to 31 December 2016.

The mortality variables used in the VSMS are date of death and its underlying cause, as indicated by the International Classification of Diseases (ICD) code assigned at the time of death. The codes are consistent with other Canadian reports (Navaneelan, 2012). The codes for suicide deaths changed over the study period:
- ICD-8 codes E950-E959
- ICD-9 codes E950-E959
- ICD-10 codes X60-X84 and Y87.0

Analyses were done separately for males and females. This was done since the distribution by sex of the Veteran population and the Canadian general population (CGP) are quite different, as well as the differing distribution of suicides for males and females in both populations. Analyses combined Regular Force and Class C Reserve Force Veterans, since they had similar risk of suicide (VanTil, 2021).

Age-adjusted suicide rates were calculated for both Veterans and the CGP. The numerator included suicide deaths as defined above. The denominator was calculated as person-years that began from the date of release and ended with either the completion of this study on 31 December 2016 or the date of death. The 42-year study period required that the rates be adjusted to a standard age distribution; this study used the 2011 Canadian population, weighted to exclude ages 0-14 and 90+. Indirect standardization was used since it outperforms direct

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[1] Comparison of suicide counts with published DND data showed these deaths within a week after release date were still serving; consistent with mid-point of the 2 week pay period.

standardization; for rare events such as suicide deaths, the direct method with combined subgroups can produce biased estimates (Smolenski, 2021). Earlier VSMS reports used large age-subgroups that produced a lower estimate of age-adjusted suicide rates for female Veterans.

Age group categories were by 5-year intervals, and 95% confidence intervals were calculated. However, small numerators and/or small denominators can lead to statistically unstable rates. 95% confidence intervals were calculated using either normal approximation (death counts ≥ 100) or the exact Poisson method (deaths counts < 100). Canadian death data and population counts were provided by Statistics Canada.

Standardised Mortality Ratios (SMR) were used to compare risk of suicide within the VSMS cohort to those of the CGP (Kapur, 2009), calculated as the ratio of observed to expected cases. A SMR value of 1.0 indicates that the observed mortality in the Veteran cohort was the same as that observed in the CGP. Values less than 1.0 suggest lower than expected mortality in the Veteran cohort, while values greater than 1.0 suggest higher than expected mortality in the Veteran cohort. In addition to the point estimate, 95% confidence intervals (boundary range from Lower CI to Upper CI) were calculated to illustrate the amount of random error in the estimates, which is particularly valuable when dealing with small numbers of cases. The calculation of confidence intervals used either normal approximation (death counts ≥ 100) or the exact Poisson method (death counts < 100). SMR confidence intervals that overlap 1.0 are not statistically significant. See Figure A for a visual example of interpreting SMRs and their confidence intervals.
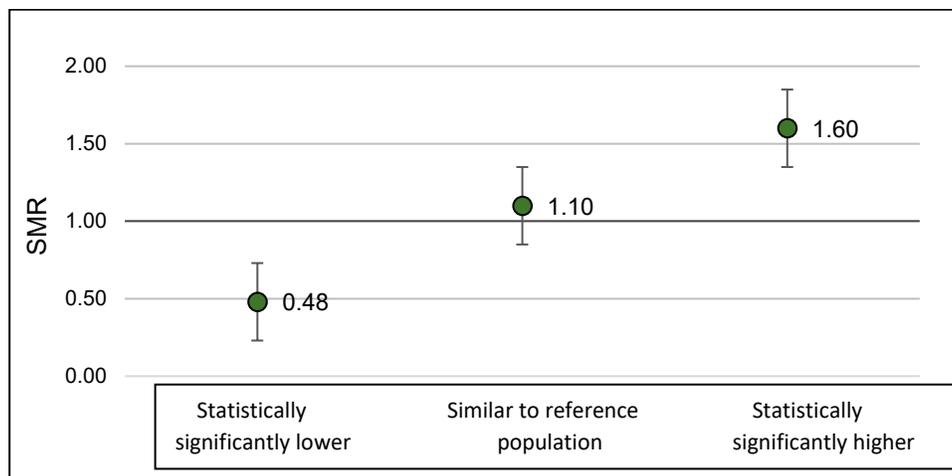

Figure A. Example on how to interpret standardised mortality ratios (SMR) and their corresponding confidence intervals (CIs).

Standardized mortality ratios provide comparisons to the Canadian General Population, and are often used in mortality studies. They are used to estimate the excess risk of death in a population of interest; this information can be applied to target public health interventions and resources. Further details on the data and linkage methodology is published under the Canadian Forces Cancer and Mortality Study 2 protocol, which uses the same source of linked data as the VSMS (Rolland-Harris, 2018).