Canadian Forces Cancer and Mortality Study: Causes of Death

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Canadian Forces Cancer and Mortality Study: Causes of Death

Note of appreciation

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Background

Mortality trends among both serving and released military personnel are of considerable interest to several groups including some federal departments and provincial ministries, health scientists, policymakers and the general public. Participation in both domestic and international operations may subject military personnel to unusual health risks including death. Although programs are in place to assess potential occupational and environmental exposures, it is not possible to know precisely what each military member has been exposed to throughout his/her military career.

In spite of such hazards, comparisons between military populations and the general population usually show that the former have lower rates of all-cause and disease-specific mortality than the latter. These findings are often attributed to a healthy worker effect resulting from the selection process of military personnel that tends to exclude persons with severe disabilities or serious chronic conditions.

This research is part of a larger initiative known as the Canadian Forces Cancer and Mortality Study (CF CAMS), which was initiated to examine mortality and the development of cancer for persons who served in the Canadian military. The project is a collaborative effort between Statistics Canada, the Department of National Defence (DND), and Veterans Affairs Canada (VAC). Included are individuals who enrolled in the Regular Force after January 1, 1972 with follow-up until December 31, 2006 for mortality and December 31, 2007 for cancer. The start date reflects the availability of DND electronic administrative information.

The Present Study

This report focuses specifically on mortality among the dynamic 35-year cohort of Canadian Forces (CF) personnel who enrolled between 1972 and 2006, inclusively. The first objective of this report was to examine causes of death for persons with a history of military service (still serving/released). Additionally, there was an interest from VAC to examine causes of death for persons who were released from the military (see Box 1 – Released Cohort).

> **Box 1 – Released Definition**: In this study "released" personnel are individuals with some military service in Canada's Regular Force between 1972 and 2006, but not in the Canadian Forces on December 31, 2006.

Excluded from the study were: individuals who either enrolled before 1972 or enrolled after 2006, those with a missing or invalid date of birth, and those with reserve force service only. The cohort was limited to regular force personnel as historical information on reservists proved to be incomplete in DND administrative datasets.

Death registration is mandatory in Canada, with comprehensive provincial/territorial registration systems that are combined at a national level by Statistics Canada in the Canadian Mortality Data Base (CMDB). Complete death registrations of in-country deaths were available up to December 31, 2006 (see Box 2 – Out-of-Country Deaths). Therefore, all deaths occurring in Canada between 1972 and 2006 were eligible for inclusion in the mortality analysis. A total of 3,969 death records from the CMDB were matched with the entire CF CAMS cohort. Causes of death were grouped using the Tenth Revision of the World Health Organization's International Classification of Diseases (ICD-10: http://www.who.int/classifications/eng/).

> **Box 2 – Out-of-Country Deaths**: Statistics Canada does not systematically collect information on deaths of Canadian citizens that occur outside of Canada; therefore there is no baseline to compare out-of-country military deaths. Consequently, this study does not analyse CF deaths that occurred out of country such as combat related deaths.

Analyses were completed for two groups:
 - the entire CF CAMS cohort which included 188,161 persons who enrolled in the Regular Force between 1972 and 2006. This group included individuals who were released or were still serving during this time period.
 - the released CF CAMS cohort - a sub-population of 112,225 persons who enrolled in or after 1972 and released before December 31, 2006.

For each cohort, a series of analyses were conducted using standardized mortality ratios (SMR, see Box 3 - Methods and Concepts) to compare all-cause and cause-specific mortality (for both sexes and 5-year age groups) with the general Canadian population. Findings from the SMR analyses for the released CF CAMS cohort prompted further study using a proportional hazards model (see Box 3 - Methods and Concepts) to identify factors associated with the likelihood of committing suicide following release from the CF.

Description of the CF CAMS cohort

Table 1 gives an overview of the main characteristics of the entire CF CAMS cohort, as well as of the released subpopulation. In the entire CF CAMS cohort, about 87% were males and 80% were non-commissioned members (NCM), their median age at enrolment was 20 years, and 51% had service between the period 1997 and 2006. Individuals in the released CF CAMS cohort joined at younger ages, had shorter periods of service, and only 19% had service between 1997 and 2006. This study followed the released CF CAMS cohort for a median duration of 18 years after release from military service. Reason for release was categorised into voluntary (61%), involuntary (29%), and medical (9%) (see Box 3 - Methods and Concepts).

Of the 188,161 personnel in the entire cohort, there were a total of 3,969 deaths over the 35 year period; only 294 were females, whereas 3,675 were males. In the released cohort (112,225 personnel), there were 2,824 deaths (204 females, 2,620 males). The median age at death was 34 in the entire CF CAMS cohort and 37 in the released CF CAMS cohort.

Table 1
Description of entire CF CAMS cohort and its released subpopulation

	Entire CFCAMS Cohort		Released CFCAMS Cohort	
	Number	**%**	**Number**	**%**
N	188,161	100.0	112,225	59.6
Sex				
Female	25,394	13.5	15,439	13.8
Male	162,767	86.5	96,786	86.2
Age at enrolment				
16 to 19	85,346	45.4	59,057	52.6
20 to 24	78,771	41.9	44,691	39.8
25 to 29	16,845	9.0	6,501	5.8
30 to 59	7,199	3.8	1,976	1.7
Median (yrs)	20	...	19	...
Age at release				
16 to 19	N/A	...	18,242	16.3
20 to 24	N/A	...	43,354	38.6
25 to 29	N/A	...	21,950	19.6
30 to 69	N/A	...	28,679	25.6
Median (yrs)		...	24	...
Last rank				
NCM[1]	150,536	80.0	92,590	82.5
Officer	31,727	16.9	14,590	13.0
Unknown	5,898	3.1	5,045	4.5
Years of service				
Less than 1	23,256	12.4	17,958	16.0
1 to 2 yrs	38,166	20.3	30,947	27.6
3 to 9 yrs	57,708	30.7	38,152	34.0
10 to 19 yrs	33,477	17.8	15,183	13.5
20 or more	35,554	18.9	9,985	8.9
Median (yrs)	5	...	3	...
Reason for release[2]				
Voluntary	N/A	...	68,211	60.8
Involuntary	N/A	...	32,841	29.3
Medical	N/A	...	10,297	9.2
Unknown	N/A	...	876	0.8
Period of service[3]				
1972 to 1986	109,558	...	83,276	...
1987 to 1996	98,845	...	54,761	...
1997 to 2006	96,435	...	21,250	...

1. Non-commissioned members.
2. See text box for description of categories.
3. Individuals may have served in multiple periods; categories are not mutually exclusive.
Source: Department of National Defence.

Key Findings

Entire CF CAMS cohort compared with the general Canadian population
Table 2 describes the age-adjusted causes of mortality for males and females for the entire CF CAMS cohort. Table 3 describes age -specific analyses for injury and suicide. All reported differences are statistically significant at the 95% confidence level.

- In both the male and female CF CAMS study group, there was a statistically significant lower risk of death (36% lower for males, 33% for females) from all causes compared with the general population.

- In the male CF CAMS cohort, the risk of dying from injury, cancer, cardiovascular disease and other diseases was significantly lower than in the general population.

- In the female CF CAMS cohort, the risk of death from cancer and cardiovascular disease was significantly lower than in the general population.

- Males in the entire CF CAMS study group had a significantly higher risk of dying in an air and space transport accident compared with males in the general population.

- For both males and females in the entire CF CAMS cohort, when all ages were considered, the risk of dying from suicide was not significantly different from that of the general population.

- Age-specific analyses indicated that females aged 20 to 24 in the CF CAMS population had almost twice the risk of death from unintentional injury compared with women of similar age in the general population. These findings were statistically significant.

- Age-specific analyses indicated that CF CAMS females aged 40 to 44 were more than twice as likely to die from suicide as their same-age counterparts in the general population. These differences were statistically significant.

Table 2

Causes of mortality – entire CF CAMS cohort

	Males		Females	
	Number of deaths	**SMR (95% CI)**	**Number of deaths**	**SMR (95% CI)**
All causes	3,675	0.64 (0.62 to 0.66)*	294	0.67 (0.59 to 0.75)*
External causes				
Injury[1]	1,263	0.77 (0.72 to 0.81)*	74	1.00 (0.78 to 1.25)
Suicide	897	1.01 (0.94 to 1.07)	37	0.99 (0.69 to 1.37)
Airspace accident	97	2.59 (2.10 to 3.16)*	x	–
Cancer	525	0.58 (0.53 to 0.63)*	124	0.75 (0.62 to 0.88)*
Cardiovascular disease	429	0.44 (0.40 to 0.49)*	30	0.40 (0.27 to 0.58)*
Infectious diseases	119	0.53 (0.44 to 0.63)*	x	–
Digestive diseases	62	0.63 (0.48 to 0.81)*	x	–
Endocrine diseases	45	0.41 (0.30 to 0.55)*	x	–
Nervous system	46	0.38 (0.28 to 0.51)*	x	–
Respiratory diseases	34	0.34 (0.22 to 0.48)*	x	–
Mental disorders	28	0.35 (0.23 to 0.51)*	x	–

* SMR significantly different than 1.

1. Injuries, poisoning and certain other external causes (excluding suicide and airspace).

x suppressed to meet the confidentiality requirements of the *Statistics Act*.

Sources: Department of National Defence and Canadian Mortality Data Base.

Table 3

Age–specific external causes of mortality – entire CF CAMS cohort

		Male		Female	
	Age at death	Number of deaths	SMR (95% CI)	Number of deaths	SMR (95% CI)
Injury[1]	16 to 19	89	0.89 (0.71 to 1.09)	x	–
	20 to 24	415	1.06 (0.95 to 1.16)	27	1.85 (1.22 to 2.69)*
	25 to 29	256	0.77 (0.68 to 0.87)*	16	1.18 (0.67 to 1.91)
	30 to 34	189	0.68 (0.59 to 0.78)*	x	–
	35 to 39	129	0.56 (0.46 to 0.65)*	x	–
	40 to 44	106	0.60 (0.48 to 0.71)*	x	–
	45 to 49	55	0.54 (0.41 to 0.70)*	x	–
	50 to 54	22	0.78 (0.49 to 1.18)	x	–
	55 +	x	–	x	–
Suicide	16 to 19	21	0.69 (0.43 to 1.05)	x	–
	20 to 24	181	1.10 (0.94 to 1.26)	x	–
	25 to 29	172	0.98 (0.83 to 1.13)	x	–
	30 to 34	152	0.92 (0.78 to 1.07)	x	–
	35 to 39	148	0.99 (0.83 to 1.15)	x	–
	40 to 44	132	1.12 (0.93 to 1.31)	13	2.14 (1.14 to 3.67)*
	45 to 49	73	1.09 (0.85 to 1.37)	x	–
	50 to 54	17	0.94 (0.55 to 1.51)	x	–
	55 +	x	–	x	–

* SMR significantly different than 1.

1. Injuries, poisoning and certain other external causes (excluding suicide and airspace).

x suppressed to meet the confidentiality requirements of the *Statistics Act*.

Sources: Department of National Defence and Canadian Mortality Data Base.

Released cohort compared with the general Canadian population

Table 4 describes the age-adjusted causes of mortality for the released CF CAMS cohort for males and females. Table 5 describes the age-specific analyses for injury and suicide. All reported differences are statistically significant at the 95% confidence level.

- In both the male and female released CF CAMS populations, there was a statistically significant lower risk of death (23% lower for males, 30% for females) from all causes compared with the general population.

- In the male released CF CAMS population, there was a significantly lower risk of death from disease-related causes including cancer, cardiovascular disease and several other diseases compared with the general population.

- In the female released CF CAMS population, risk of death from cancer and cardiovascular disease was lower than in the general population. These findings were statistically significant.

- In both the male and female released CF CAMS populations, the risk of death from unintentional injury was not significantly different from that in the general population.

- In the female released CF CAMS population, when all ages were considered, the risk of suicide was not significantly different from that in the general female population.

- In the male released CF CAMS population, the risk of suicide was about one and a half times higher than in the general male population. This difference was statistically significant.

- Age-specific analyses indicated that released CF CAMS males aged 20 to 24 had a 42% higher risk of death from unintentional injury (excluding suicide) and males aged 16 to 44 had a higher risk of death from suicide when compared with corresponding age groups in the general male population. These findings were statistically significant.

- Age-specific analyses indicated that among released CF CAMS females aged 40 to 44, the risk of suicide was about two and a half times higher compared with the corresponding age group in the general female population. This difference was statistically significant.

Table 4

Causes of mortality – released CF CAMS cohort

	Males		Females	
	Number of deaths	**SMR (95% CI)**	**Number of deaths**	**SMR (95% CI)**
All causes	2,620	0.77 (0.74 to 0.80)*	204	0.70 (0.60 to 0.80)*
External causes				
Injury[1]	826	1.00 (0.93 to 1.07)	38	0.96 (0.68 to 1.31)
Suicide	696	1.46 (1.35 to 4.56)*	29	1.32 (0.88 to 1.89)
Cancer	375	0.62 (0.55 to 0.68)*	89	0.74 (0.89 to 0.91)*
Cardiovascular disease	331	0.49 (0.44 to 0.55)*	25	0.46 (0.30 to 0.68)*
Infectious diseases	103	0.75 (0.60 to 0.89)*	x	-
Digestive diseases	57	0.92 (0.69 to 1.19)	x	-
Endocrine diseases	41	0.58 (0.42 to 0.79)*	x	-
Nervous system	38	0.54 (0.38 to 0.74)*	x	-
Respiratory diseases	27	0.73 (0.22 to 0.63)*	x	-
Mental disorders	26	0.50 (0.33 to 0.74)*	x	-

* SMR significantly different than 1.

1. Injuries, poisoning and certain other external causes (excluding suicide and airspace).

x suppressed to meet the confidentiality requirements of the *Statistics Act*.

Sources: Department of National Defence and Canadian Mortality Data Base.

Table 5
Age–specific external causes of mortality – released CF CAMS cohort

	Age at death	Males		Females	
		Number of deaths	SMR (95% CI)	Number of deaths	SMR (95% CI)
Injury[1]	16 to 19	25	1.41 (0.91 to 2.08)	x	-
	20 to 24	183	1.42 (1.21 to 1.62)*	x	-
	25 to 29	169	1.11 (0.94 to 1.28)	x	-
	30 to 34	159	1.05 (0.89 to 1.22)	x	-
	35 to 39	116	0.81 (0.66 to 0.95)*	x	-
	40 to 44	103	0.82 (0.66 to 0.97)*	x	-
	45 to 49	48	0.61 (0.45 to 0.80)*	x	-
	50 to 54	21	0.96 (0.59 to 1.46)	x	-
	55 +	x	-	x	-
Suicide	16 to 19	12	2.12 (1.09 to 3.70)*	x	-
	20 to 24	118	2.11 (1.73 to 2.50)*	x	-
	25 to 29	132	1.63 (1.35 to 1.91)*	x	-
	30 to 34	117	1.29 (1.05 to 1.52)*	x	-
	35 to 39	118	1.28 (1.05 to 1.51)*	x	-
	40 to 44	117	1.41 (1.15 to 1.66)*	12	2.66 (1.37 to 4.64)*
	45 to 49	65	1.25 (0.96 to 1.59)	x	-
	50 to 54	16	1.15 (0.66 to 1.87)	x	-
	55 +	x	-	x	-

* SMR significantly different than 1.
1. Injuries, poisoning and certain other external causes (excluding suicide and airspace).
x suppressed to meet the confidentiality requirements of the *Statistics Act*.

Sources: Department of National Defence and Canadian Mortality Data Base.

Factors associated with the risk of death from suicide in the released CF CAMS cohort

Table 6 describes the factors associated with the likelihood of committing suicide in the released CF CAMS cohort using a proportional hazards model (see Box 3 - Methods and Concepts). The model controlled for several risk factors at the same time including sex, rank, age at release, reason for release, years of service, and period of military service. The model demonstrated that taking into account all the above factors, the risk of suicide was:

- Almost three and a half times higher for males compared with females;
- Two and a half times higher for Non-Commissioned Members (NCMs) compared with officers;
- Over two times higher for individuals with less than 10 years of military service compared with those who had 10 or more years of service;
- Two times higher for individuals with a medical release and one and a half times higher for those individuals who released involuntarily compared with those who took a voluntary release;
- One and a half times higher for persons who served during the period 1972 to 1986 compared with persons who did not serve during this time period.

Table 6

Cox proportional hazards model for suicide: released CF CAMS cohort

Risk Factor	Hazard Ratio	P value
Sex		
Female	reference	...
Male	3.45 *	0.000
Age at release		
16 to 19	0.62 *	0.034
20 to 24	0.58 *	0.010
25 to 29	0.62 *	0.023
30 to 69	reference	...
Last rank		
NCM[1]	2.50 *	0.000
Officer	reference	...
Years of service		
Less than 3 yrs	2.68 *	0.000
3 to 9 yrs	2.16 *	0.001
10 or more yrs	reference	...
Reason for release[2]		
Voluntary	reference	...
Involuntary	1.55 *	0.000
Medical	2.03 *	0.000
Period of service[3]		
1972 to 1986 Yes	1.63*	0.004
No	reference	...
1987 to 1996 Yes	0.94	0.678
No	reference	...
1997 to 2006 Yes	1.26	0.249
No	reference	...

* Hazard ratio significantly different than 1.

1. Non-commissioned members.

2. see text box for description of categories.

3. categories are not mutually exclusive; reference is "did not serve in this period".

Sources: Department of National Defence and Canadian Mortality Data Base.

Summary

Consistent with the findings of other studies, the results show that all-cause and disease-related mortality was lower among individuals with a history of military service compared with the general Canadian population. These findings may be partially accounted for by the "healthy worker" effect resulting from the selection process at enrolment.

Air and space transport accidents were more frequent among males with military service than in the general population. This finding is likely attributable to the higher representation of flying-related occupations in the CF compared with the general population and the intrinsic risks of military aviation.

Elevated risk of dying was noted for females in the military from injuries among those aged 20 to 24, and from suicide for those aged 40 to 44, compared with the same age groups in the general population.

Among the released cohort (military personnel that enrolled and released between 1972 and 2006), there was a higher risk of suicide in males aged 16 to 44, and in women aged 40 to 44, when compared to the general population. These findings prompted the need for a closer examination of factors potentially related to suicide among the released CF CAMS cohort.

Findings from the proportional hazards model showed that the risk of suicide in the released group of military personnel was highest among male non-commissioned members with short periods of service who were released for non-voluntary reasons. Furthermore, the risk of suicide was higher for personnel with military service during the 1972 to 1986 time period.

Limitations
The reliance of this study on administrative data represents both an advantage and a limitation. On the positive side, it provided a large sample size and an observation period of 35 years that would be difficult to attain with survey data. Unfortunately, interpretation of the study findings was limited as information relating to individuals' socio-demographic profile, medical and psychological history, deployment to areas of conflict and other potentially relevant variables were not accessible at the time of the study. As it is the case with every record linkage study, the probabilistic linkage of administrative data from two different sources might have also led to the inadvertent inclusion of false positives and false negatives in the final linked database (i.e. individuals still alive who are counted as dead after linkage or, conversely, dead individuals that show up as alive; see Box 3 – Methods and Concepts).

This study was limited in scope by examining mortality trends only among military personnel who enrolled in the Canadian Forces between 1972 and 2006. The lack of available information on individuals who enrolled before 1972 necessitated their exclusion from the CF CAMS cohort resulting in a younger cohort (and subsequent fewer deaths) than expected of a full history of Canadians with Regular Force military service. Consequently, the released component of the cohort was not representative of the entire population that released from 1972 to 2006. The findings of this study therefore apply to a subgroup of the released population and should not be generalized to the overall population of veterans.

Box 3 - Methods and Concepts
Record linkage:
The final linked database containing both human resources information on CF personnel and causes of death was obtained through probabilistic record linkage of the combined DND historical (1972 to 1997) and current (1998 to 2006) administrative databases, to the Canadian Mortality Data Base (CMDB) records of death that occurred between January 1, 1972 and December 31, 2006. Prior to the CMDB linkage, the DND administrative records were also linked to the Historical Tax Summary File. This file contains information about the years individuals have filed an income tax report, whether there was notification of the death of the filer or whether the filer moved out of the country. The pre-match to tax filer information provided some indication as to the vital status of the individuals at the end of the follow-up period and aided in the identification and confirmation of deaths.

Standardized Mortality Ratios (SMR):
Standardized Mortality Ratios (SMR) were used to compare the mortality of the CF CAMS cohort with that of the general Canadian population. All-cause and cause-specific mortality rates were calculated separately for males and females, each year of follow-up, and each age group in the CF CAMS cohort and compared with the corresponding group in the general population using indirect standardization methods. In compliance with the requirements of the Statistics Act, all counts of deaths < 10 were suppressed. Therefore, SMRs were reported only for causes (by ICD chapter) if the sex specific counts of deaths across the 35 year study were greater than ten. Deaths were reported using three different versions of the World Health Organization's International Classification of Diseases (ICD) throughout the 35 year study. For consistency, all deaths classified using ICD-8 and ICD-9 where mapped onto ICD-10 categories prior to SMR analysis.

An SMR value of 1.0 indicates that the observed mortality in the cohort was the same as that observed in the Canadian population. Values less than 1.0 suggest lower mortality in the cohort while values greater than 1.0 suggest higher than expected mortality in the cohort. In addition to the point estimate, 95% confidence intervals were calculated using either normal approximation (count of deaths ≥ 100) or the exact Poisson method (count of deaths < 100).

Proportional hazards model:
Cox's semiparametric proportional hazards model was used to identify risk factors associated with suicide in the released CF CAMS cohort. The exponentiated coefficients of a Cox regression are hazard ratios and can be interpreted in terms of relative risk compared to a reference category. If, for instance, women were the reference category, a hazard ratio of 2.0 for men would imply that the relative risk of death was twice as high among men as it was among women. Conversely, a hazard ratio of 0.5 for men would mean that men's risk of death was half that of women. A hazard ratio of 1.0 would indicate that the risks were identical for both men and women.
Reasons for release:
Reasons for release were classified into three categories (voluntary, involuntary, medical). Voluntary reasons included service completed, immediate annuity, fixed service duration, retirement age. Involuntary reasons included not advantageously employed, unsuitable for further service, unsatisfactory conduct or performance, irregular or fraudulent enrolment, illegally absent, misconduct, dismissal, and reduction in strength. Medical reasons are the result of an administrative decision to release an individual owing to medical employment limitations.