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All-cause and cause-specific mortality among Nordic military veterans following international deployment: a meta-analysis

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Tables/figures: 1/4

Abstract

Objectives

To investigate all-cause and cause-specific mortality risks, including deaths from external, cardiovascular and cancer causes, among deployed Nordic military veterans in comparison to the general population in each country.

Design

Meta-analysis.

Setting

Denmark, Norway, Finland and Sweden.

Participants

Military veterans deployed between 1990 and 2010 were followed via nationwide registers and compared with age-sex-calendar-year-specific rates in the general population using pooled standardised mortality ratios (SMRs).

Main outcomes

All-cause and cause-specific mortality retrieved from each country's Causes of Death Register, including deaths from external, cardiovascular and cancer causes.

Results

Among 83 584 veterans 1152 deaths occurred of which 343 were from external causes (including 203 suicides and 129 traffic/transport accidents), 134 from cardiovascular causes and 297 from neoplasms. Veterans had a lower risk of death from any cause (pooled SMR 0.58, 95%CI 0.52-0.64), external causes (0.71, 95%CI 0.64-0.79), suicide (0.77, 95%CI 0.67-0.89), cardiovascular causes (0.54, 95%CI 0.46-0.64), and neoplasms (0.78, 95%CI 0.70-0.88). There was no difference regarding traffic/transport accidents for the whole period (1.10, 95%CI 0.75-1.10) but the pooled point estimate was elevated, though not statistically significant, during the first 5 years (1.17, 95%CI 0.89-1.53) but not thereafter (1.01, 95%CI 0.77-1.34). For all other causes of death, except suicide, statistically significantly lower risk among veterans was observed both during the first 5 years and thereafter. For suicide, no difference was observed beyond 5 years. Judged from the country-specific SMR-estimates, there was a high degree of consistency although statistically significant heterogeneity was found for all-cause mortality.

Conclusions

Nordic military veterans had lower overall and cause-specific mortality than the general population for most outcomes, as expected given the pre-deployment selection process. Though uncommon, fatal traffic/transport accidents were an exception with no difference between deployed military veterans and the general population.

Strengths and limitations of this study

- The problem of low statistical power in country-specific analyses of rare mortality outcomes among deployed military veterans was addressed by combining data from several Nordic countries
- Using the unique personal identity number of each Nordic resident and linking data to nationwide registers on mortality outcomes, follow-up was complete regarding mortality
- The generalisability of the results outside the Nordic context may be limited by recruitment practices, deployment areas, deployment duration, and combat exposure

Background

The Nordic countries Denmark, Finland, Norway and Sweden have contributed with military personnel to conflict zones during the last 30 years, primarily to the Balkans in the 1990s and to Afghanistan between 2002 and 2014. Controversy remains regarding several cause-specific mortality outcomes among deployed Nordic military veterans, as country-specific analyses are few and may suffer from insufficient statistical power given the low mortality rates among the relatively young veteran populations.

Suicide among military veterans has received the most attention, and although country-specific estimates exist, [1-6] no study has been adequately powered to investigate whether the suicide risk varies over time after return from deployment. Another rare outcome is cancer deaths, where the risk could be elevated due to, for example, exposure to chemicals or biological agents during deployment,[7-9] but the number of cases in each country is generally too small to generate meaningful statistics. There is also uncertainty regarding the risk of fatal traffic accidents, where data from the US and UK indicate that risks are elevated immediately after return from deployment.[10-16]

The similarities between the Nordic countries in terms of population, military engagements and health care systems, as well as access to health data via nationwide registers, offer a unique opportunity to synthesize data from the different countries in order to, for the first time, pool Nordic deployed military veterans to address post-deployment outcomes with considerably greater statistical power than what is achieved by single country studies.

The purpose of this study was to investigate all-cause and cause-specific mortality risks, including deaths from external, cardiovascular and cancer causes among Nordic military veterans in comparison to the general population in each country.

Methods

This is a meta-analysis based on individual data on military veterans and mortality outcomes from Denmark, Finland, Norway, and Sweden compared to the general population in each country. The cohorts were created and outcome data collected by linking individual veterans to nationwide registers by use of the unique personal identity number assigned to each resident in the respective countries. Estimates for Denmark, Norway and Sweden were derived specifically for this meta-analysis, while the mortality estimates for Finland were taken from a publication.[2] The STROBE reporting guidelines for cohort studies were used for this study.[17]

Ethics statement

Regarding the Swedish data, the study was approved by the regional ethics committee at Karolinska Institutet, Stockholm, Sweden (2012/1439-31/5, 2014/797-32). According to Danish law, studies based exclusively on register data require no approval by a research ethics committee. Data from Norway used in this study were analysed in accordance with the regulations and procedures of the Norwegian Armed Forces Health Registry, which stipulates that approval by the Committee for Medical Health Research Ethics is not required.

Study population

Nordic military veterans who had served on any international military deployment between 1990 (Finland) or 1992 (Denmark, Norway, Sweden) and 2010 were identified from the Armed Forces registers of international deployments in each country, resulting in a total cohort of 83 584 veterans. Calendar year-specific mortality data from the general population in each country, stratified by age and sex, were retrieved from government statistics.

Follow-up and outcomes

Veterans were followed until death, emigration, or last date of register-based follow-up (December 31st 2016 for Denmark, Norway and Sweden; December 31st 2013 for Finland), whichever came first. The dates and causes of death for the veterans were retrieved from the government agency managing the Causes of Death Register in each country.

The mortality outcomes were death from any cause, external causes (International Classification of Diseases 9th and 10th revision [ICD9; ICD10] codes: ICD9: E800-E999; ICD10: V01-Y89), cardiovascular causes (390-459; I00-I99), and from neoplasms (140-239; C00-D48). The specific external causes suicide (E950-E959, E980-E989; X60-X84, Y10-Y34, Y87.0) and traffic/transport accidents (E800-E849; V01-V99, Y85) were also analysed. Finnish data were available only for the outcomes death from any cause, suicide and traffic/transport accidents.

Statistical analysis

The mortality outcomes among deployed military veterans were compared to the general population in each country using age-, sex- and calendar year-specific data to estimate standardised mortality ratios (SMRs). The SMR in each cause of death category and for each country was calculated as the ratio of the observed number and expected number of deaths. The cause of death-specific expected number of deaths in each sex, age (5-year age bands) and calendar year stratum was calculated by multiplying the number of person-years in that stratum by the cause of death specific mortality rate in the control population in the respective stratum. The 95% confidence intervals (95%CI) were estimated assuming a Poisson distribution of the observed number of deaths.

Country-specific SMRs for each outcome in veterans compared to the general population were pooled using inverse variance-weighted random effects meta-analyses. The analyses were performed

for the whole follow-up period, as well as separately for less or equal to 5 years and more than 5 years after return from deployment. Heterogeneity between countries was assessed using the I^2 statistic.[18]

Data were analysed using SAS version 9.4 (SAS Institute) and Stata version 13.0.

Patient and Public Involvement

No patient involved.

Results

Cohort characteristics

A total of 83 584 deployed Nordic military veterans were included (**Table 1**). The mean age at deployment was 27 years and men represented 95% in the pooled cohort. Danish and Swedish veterans had similar mean deployment duration of 6 months while Norwegians had a mean of 4 months. The areas of operation for military deployment are shown in **Figure 1** for Denmark, Norway and Sweden.

All-cause mortality

During follow-up, 1152 military veterans died (Denmark n=394; Finland n=212; Norway n=412; Sweden n=134). Deployed military veterans had lower mortality than the general population over the full study period (pooled SMR 0.58, 95%CI 0.52-0.64), during the first 5 years (0.50, 95%CI 0.41-0.60) and beyond 5 years after returning from deployment (0.61, 95%CI 0.56-0.67; **Figure 2**).

External cause mortality

Among military veterans from Denmark, Norway and Sweden there were a total of 343 deaths from external causes, while data from Finland were not available. The pooled SMR for the whole study period was 0.71 (95%CI 0.64-0.79; **Figure 3**). The pooled SMR for the first 5 years (0.70, 95%CI 0.55-0.91) was similar to the pooled SMR for follow-up beyond 5 years after returning from deployment (0.72, 95%CI 0.63-0.82).

Death by suicide

Based on 203 suicides, all 4 countries showed lower risk estimates among veterans than the general population resulting in a pooled SMR of 0.77 (95%CI 0.67-0.89; Figure 3). During the first 5 years after returning from deployment there were 39 suicides resulting in a pooled SMR of 0.56 (95%CI 0.41-0.78). Beyond 5 years there were 111 suicides with no statistically significant difference versus the general population (pooled SMR 0.91, 95%CI 0.75-1.10).

Fatal traffic/transport accidents

With a total of 129 fatal traffic/transport accidents, no statistically significant difference was observed between veterans and the general population (pooled SMR 1.10, 95%CI 0.92-1.31; Figure 3). The small risk increases were driven by accidents during the first 5 years following end of deployment, with point estimates of about 1.30 for Norwegian and Swedish, but not Danish veterans (data for Finnish veterans were not available) but the pooled SMR was not statistically significant (1.17, 95%CI 0.89-1.53). Beyond 5 years after return from deployment, the pooled point estimate was near the null (pooled SMR 1.01, 95%CI 0.77-1.34).

Cardiovascular deaths & fatal neoplasms

A total of 134 cardiovascular deaths occurred among the veterans resulting in a pooled SMR of 0.54 (95%CI 0.46-0.64; **Figure 4**). The lower risk for the veterans was especially pronounced during the first 5 years (0.33, 95%CI 0.18-0.61) but remained lower also beyond 5 years (0.61, 95%CI 0.51-0.74).

There were 297 deaths among the veterans due to neoplasms resulting in a pooled SMR of 0.78 (95%CI 0.70-0.88; Figure 4). As for cardiovascular deaths, the lower risk was especially pronounced during the first 5 years (0.50, 95%CI 0.37-0.68) but remained lower also beyond 5 years (0.86, 95%CI 0.76-0.97).

Heterogeneity

The statistical power for analysing heterogeneity was high for all-cause mortality but low for the cause-specific mortality outcomes.

For all-cause mortality the I^2 was 73% for the whole study period (P=0.01). The heterogeneity reflected the high precision of the estimates, rather than major numerical differences in country-specific SMRs, which ranged from 0.55 to 0.64. For the first 5 years the I^2 was 66% (P=0.03) with the estimate for Denmark at 0.40 (95%CI 0.33-0.45) while the other countries had SMRs higher than 0.50. Beyond 5 years the I^2 was 36% (P=0.20) and country-specific estimates ranged from 0.55 to 0.66.

For the cause-specific analyses the I^2 estimate was 0% for all outcomes for the whole time period as well as beyond 5 years of follow-up. During the first 5 years estimates were also 0%, except that the I^2 was 47% (P=0.15) for external cause mortality and 27% (P=0.26) for cardiovascular mortality.

Discussion

Main findings

In this study of 83 584 deployed Nordic military veterans followed for up to 25 years, veterans had lower mortality compared with the general population. For the whole follow-up period as well as the first 5 years after return from deployment, the pooled SMRs were lower for death from any cause, as well as for external causes, suicide, cardiovascular causes and neoplasms, while no statistically significant difference was found for fatal traffic/transport accidents. Beyond 5 years, no differences were found for suicide or fatal/traffic transport accidents. Judged from the SMR estimates for each country, there was a high degree of consistency although statistically significant heterogeneity was found for all-cause mortality due to the large sample size, resulting in high precision.

Previous research

Lower all-cause mortality among veterans compared to the general population is a typical finding in this field given the physical and mental health screening prior to military deployment, a selection bias referred to as "the healthy soldier effect."[19-21] For Swedish veterans, we have previously shown that when accounting for differences in, for example, cognitive ability, psychological evaluation test scores and pre-deployment mental health, there is no difference in either suicide or all-cause mortality between deployed military veterans and non-deployed tightly matched comparators.[5]

Although reporting a lower overall mortality among veterans in comparison to civilian or non-deployed military control groups, several major studies investigating US and British veterans from the Vietnam War and Gulf War have found increased cause-specific mortality risks among these veterans from external causes, mainly death by suicide and motor vehicle accidents, during the first years following deployment.[10-16] The Nordic veterans in the present study had lower risk than the general population for all outcomes during the first 5 years, except for fatal traffic/transport accidents where no difference was found. The point estimate indicated a potentially elevated risk although it was based on merely 56 deaths and the effect estimate was 1.17. This outcome will require further investigation when also accounting for the healthy soldier effect and including non-fatal accidents, as a potentially increased risk may reflect higher degrees of risk-taking behaviour after military deployment.[22] Another explanation could be that the intention of some of these accidents were in fact suicide. However, it must also be remembered that fatal traffic/transport accidents were uncommon, with a total of 129 events over the whole period despite pooling approximately 20 years of deployments from the four Nordic countries, and following more than 80 000 veterans for up to 25 years.

Implications

Mortality in Nordic deployed military veterans does not appear to be a public health problem, neither during the first 5 years after return from deployment nor thereafter, as their death rates were lower than the rates in the general population. However, deployed Nordic military veterans are a group that have gone through physical and mental health tests resulting in them having a better pre-deployment prognosis than the general population as a whole. Therefor more research is needed on specific mortality outcomes, especially fatal traffic and transport accidents, when also accounting for these baseline differences. In the meantime, veterans returning from deployment could be informed about the potential risk elevation for traffic/transport accidents, however small, and a discussion about risk-taking behaviour may be warranted prior to discharge.

Strengths and limitations

The main strength of this study was the combination of data from Denmark, Finland, Norway and Sweden including deployments spanning two decades and including up to 25 years follow-up using nationwide registers resulting in virtually no losses to follow-up. This provided more statistical power than country-specific studies, where estimates on the national level would have been associated with more uncertainty. We also designed the study so that each country used a similar study deployment period, follow-up time, and type of outcome ascertainment mechanism, resulting in greater similarity between countries than is often the case in meta-analyses combining only published estimates. By doing this, major areas of operation for each country were similar, although Denmark and Norway included deployments to Iraq while this was not the case for Sweden and Finland.

Despite the size of the study and the length of follow-up, estimates regarding fatal traffic/transport accidents were imprecise. Future studies could be expanded by also including non-fatal traffic/transport accidents to gain power, but still reflect the same underlying mechanism. Further, this study compared deployed military veterans with the general population of the same age and sex to assess whether any of the investigated types of post-deployment mortality could be of public health concern. However, in order to approach causal interpretation of the effect of military deployment on mortality, the healthy soldier effect must be addressed by carefully accounting for pre-deployment differences in mental and physical health, as well as psychological resources. Finally, the generalisability outside the Nordic context may be limited by recruitment practices, deployment areas, deployment duration, and combat exposure.

Conclusions

Nordic military veterans were found to have lower mortality after deployment compared to the general population, as expected given the selection process preceding military deployment. Though uncommon, fatal traffic/transport accidents during the first years following return from deployment, was an exception with point estimates indicating higher rather than lower risk. This warrants further investigation.

Contributorship statement

MN is the principal investigator. MSV was responsible for the preparation of Danish data. EKB was responsible for the preparation of Norwegian data. JS was responsible for the preparation of Swedish data. KN performed the statistical analyses. CMP and MN wrote the first draft of the manuscript. All the authors undertook revisions and contributed intellectually to the development of this paper. MN and CMP are the study guarantors.

Competing interests

The funders of the study had no role in study design, data analysis, data interpretation, or writing of the report. The corresponding author had final responsibility for the decision to submit for publication.

Funding

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Data sharing statement

No additional data available.

References

1. Hansen-Schwartz J, Jessen G, Andersen K, Jorgensen HO. Suicide after deployment in UN peacekeeping missions--a Danish pilot study. *Crisis* 2002; **23**: 55-8.

2. Laukkala T, Parkkola K, Henriksson M, et al. Total and cause-specific mortality of Finnish military personnel following service in international peacekeeping operations 1990-2010: a comprehensive register-based cohort study. *BMJ Open* 2016; **6**: e012146.

3. Lyk-Jensen SV, Heideman J, Glad A, Dohlmann Weatherall C. *Danske hjemvendte soldater (12:24)*: Det Nationale Forskningscenter for Velfærd; 2012.

4. Michel PO, Lundin T, Larsson G. Suicide rate among former Swedish peacekeeping personnel. *Military medicine* 2007; **172**: 278-82.

5. Pethrus CM, Johansson K, Neovius K, Reutfors J, Sundstrom J, Neovius M. Suicide and all-cause mortality in Swedish deployed military veterans: a population-based matched cohort study. *BMJ Open* 2017; **7**: e014034.

6. Thoresen S, Mehlum L, Moller B. Suicide in peacekeepers--a cohort study of mortality from suicide in 22,275 Norwegian veterans from international peacekeeping operations. *Social psychiatry and psychiatric epidemiology* 2003; **38**: 605-10.

7. McBride D, Cox B, Broughton J, Tong D. The mortality and cancer experience of New Zealand Vietnam war veterans: a cohort study. *BMJ Open* 2013; **3**: e003379.

8. Stone R. Environmental radioactivity. New findings allay concerns over depleted uranium. *Science* 2002; **297**: 1801.

9. Yi SW, Ryu SY, Ohrr H, Hong JS. Agent Orange exposure and risk of death in Korean Vietnam veterans: Korean Veterans Health Study. *Int J Epidemiol* 2014.

10. Knapik JJ1 MR, Grier TL, Jones BH. A systematic review of post-deployment injury-related mortality among military personnel deployed to conflict zones. *BMC Public Health* 2009; **13**: 231.

11. Macfarlane GJ, Thomas E, Cherry N. Mortality among UK Gulf War veterans. *Lancet* 2000; **356**: 17-21.

12. Kang HK, Bullman TA. Mortality among U.S. veterans of the Persian Gulf War. *N Engl J Med* 1996; **335**: 1498-504.

13. Postservice mortality among Vietnam veterans. The Centers for Disease Control Vietnam Experience Study. *JAMA* 1987; **257**: 790-5.

14. Boehmer TK, Flanders WD, McGeehin MA, Boyle C, Barrett DH. Postservice mortality in Vietnam veterans: 30-year follow-up. *Arch Intern Med* 2004; **164**: 1908-16.

15. Kang HK BT, Macfarlane GJ, Gray GC. Mortality among US and UK veterans of the Persian Gulf War: a review. *Occup Environ Med* 2002; **59**: 794-9.

16. Kang HK, Bullman TA. Mortality among US veterans of the Persian Gulf War: 7-year follow-up. *Am J Epidemiol* 2001; **154**: 399-405.

17. von Elm E, Altman D, Egger M, Pocock S, Gotzsche P, Vandenbroucke J. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

18. Higgins JP, Thompson SG. Quantifying heterogeneity in a meta-analysis. *Stat Med* 2002; **21**: 1539-58.

19. McLaughlin R, Nielsen L, Waller M. An evaluation of the effect of military service on mortality: quantifying the healthy soldier effect. *Ann Epidemiol* 2008; **18**: 928-36.

20. Waller M, McGuire AC. Changes over time in the "healthy soldier effect". *Population health metrics* 2011; **9**: 7.

21. Seltzer CC, Jablon S. Effects of selection on mortality. *Am J Epidemiol* 1974; **100**: 367-72.

22. Killgore WD, Cotting DI, Thomas JL, et al. Post-combat invincibility: violent combat experiences are associated with increased risk-taking propensity following deployment. *Journal of psychiatric research* 2008; **42**: 1112-21.

Tables & Figures

Table 1 Participant characteristics of deployed Nordic military veterans

	Denmark	Finland[a]	Norway	Sweden
Number of participants	27 442	15 002	23 422	17 718
Deployment years	1992-2010	1990-2010	1992-2010	1992-2010
Age at first deployment (years)				
Mean (standard deviation)	27.9 (8.6)	*Not reported*	27..3 (8.0)	26.7 (6.5)
Median (interquartile range)	24.2 (22.1-30.3)	*Not reported*	24.5 (-)	24.5 (22.1-28.7)
Range	18-66	*Not reported*	18.2-65.5	19.0-58.3
Sex				
Men, n (%)	26 011 (95%)	14 584 (97%)	22 004 (94%)	17 216 (97%)
Women, n (%)	1431 (5%)	418 (3%)	1418 (6%)	502 (3%)
Deployment duration for all deployments (months)				
Mean (standard deviation)	5.6 (1.98)	*Not reported*	3.9 (2.9)	6.0 (2.0)
Median (interquartile range)	6.1 (5.7-6.1)	*Not reported*	3.5 (-)	6.1 (5.7-6.8)
Range	0.2-49.7	*Not reported*	0.03-39.5	0.03-30.3

[a] Data from the publication by Laukkala et al[2]

Figure 1 Number of deployments by year and region in Denmark (top panel), Norway (middle panel) and Sweden (bottom panel) between 1992 and 2010. No data were reported for Finland.

Figure 2 Forest plot of all-cause mortality in military veterans from Denmark, Finland, Norway and Sweden compared to the general population

Figure 3 Forest plot of external cause mortality overall (left), suicide (middle) and fatal traffic/transport accidents (right) in military veterans from Denmark, Finland, Norway and Sweden compared to the general population

[a] NA = Not available

Figure 4 Forest plot of cardiovascular deaths (left) and fatal neoplasms (right) in military veterans from Denmark, Norway and Sweden compared to the general population

[a] NA = Not available

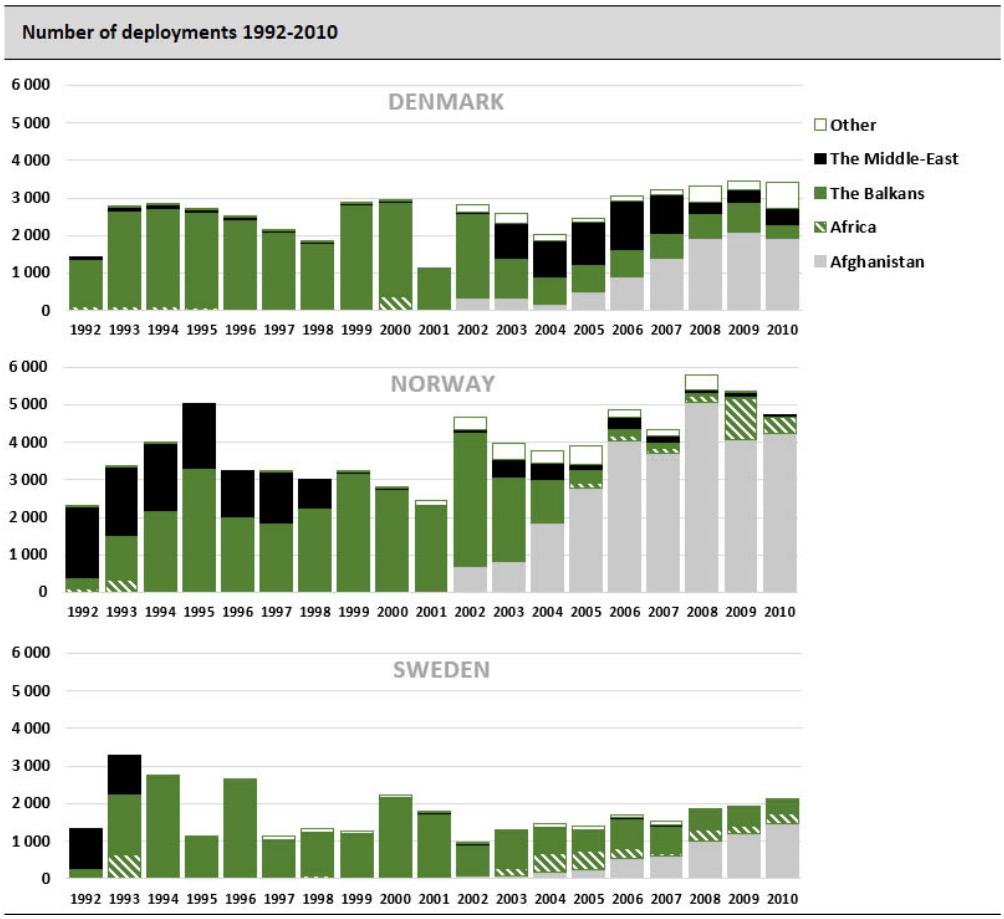

Figure 1 Number of deployments by year and region in Denmark (top panel), Norway (middle panel) and Sweden (bottom panel) between 1992 and 2010. No data were reported for Finland.

68x62mm (300 x 300 DPI)

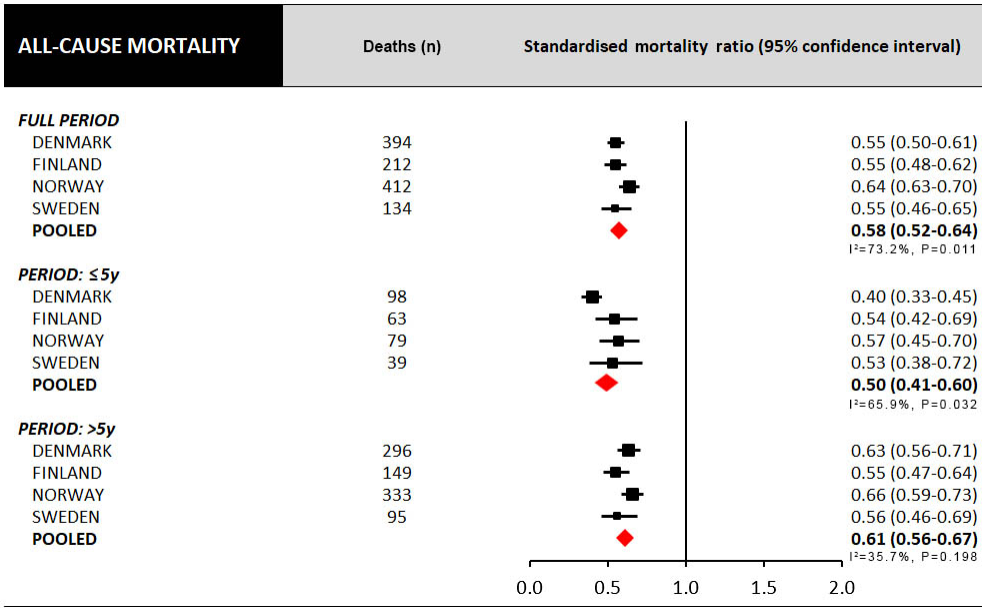

Figure 2 Forest plot of all-cause mortality in military veterans from Denmark, Finland, Norway and Sweden compared to the general population

352x219mm (72 x 72 DPI)

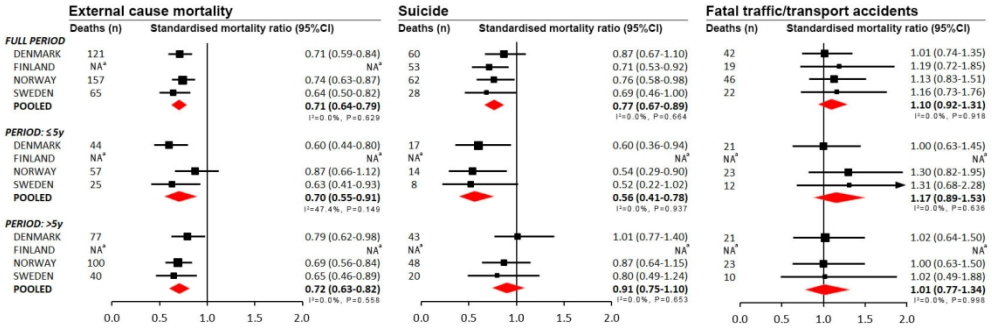

Figure 3 Forest plot of external cause mortality overall (left), suicide (middle) and fatal traffic/transport accidents (right) in military veterans from Denmark, Finland, Norway and Sweden compared to the general population a NA = Not available

595x202mm (72 x 72 DPI)

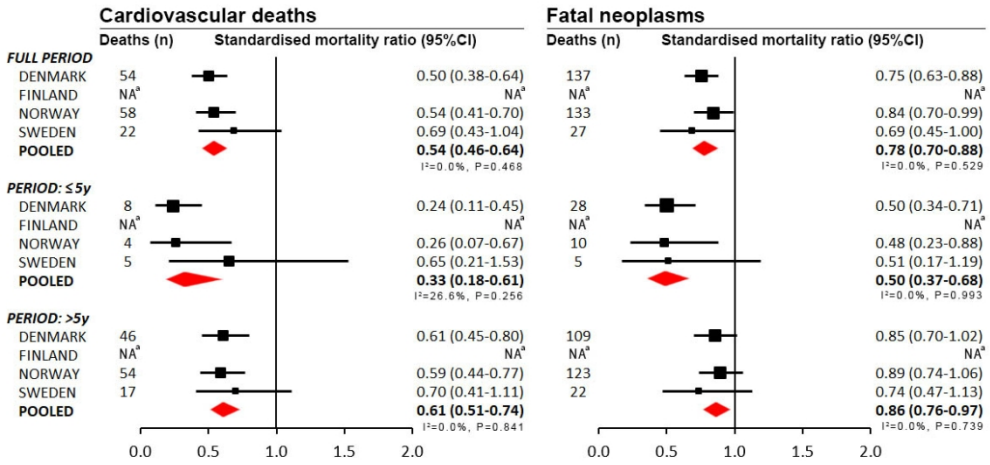

Figure 4 Forest plot of cardiovascular deaths (left) and fatal neoplasms (right) in military veterans from Denmark, Norway and Sweden compared to the general population a NA = Not available

416x203mm (72 x 72 DPI)

Reporting checklist for cohort study.

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		Reporting Item	Page Number
Title and abstract			1
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	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	4
Objectives	#3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	#4	Present key elements of study design early in the paper	5
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up.	5
Eligibility criteria	#6b	For matched studies, give matching criteria and number of exposed and unexposed	5
Variables	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
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. Give information separately for for	5

		exposed and unexposed groups if applicable.	
Bias	#9	Describe any efforts to address potential sources of bias	9, 10
Study size	#10	Explain how the study size was arrived at	N/A this was a meta analysis
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	5, 6
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	5, 6
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	N/A this was a meta analysis
Statistical methods	#12c	Explain how missing data were addressed	N/A this was a meta analysis
Statistical methods	#12d	If applicable, explain how loss to follow-up was addressed	N/A this was a meta analysis
Statistical methods	#12e	Describe any sensitivity analyses	6
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing	7

		follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	
Participants	#13b	Give reasons for non-participation at each stage	N/A this was a meta analysis
Participants	#13c	Consider use of a flow diagram	N/A this was a meta analysis
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	14
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	N/A no missing mortality data in the registers
Descriptive data	#14c	Summarise follow-up time (eg, average and total amount)	N/A this was a meta analysis
Outcome data	#15	Report numbers of outcome events or summary measures over time. Give information separately for exposed and unexposed groups if applicable.	7, 8
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95%	N/A this was a meta analysis

		confidence interval). Make clear which confounders were adjusted for and why they were included	
Main results	#16b	Report category boundaries when continuous variables were categorized	N/A this was a meta analysis
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	See Figures
Other analyses	#17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8
Discussion			
Key results	#18	Summarise key results with reference to study objectives	9
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.	9, 10
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	9, 10
Generalisability	#21	Discuss the generalisability (external validity) of the study results	10
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	1

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Pooled Analysis of all-cause and cause-specific mortality among Nordic military veterans following international deployment

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Pooled Analysis of all-cause and cause-specific mortality among Nordic military veterans following international deployment

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Abstract

Objectives

To investigate all-cause and cause-specific mortality risks, including deaths from external, cardiovascular and cancer causes, among deployed Nordic military veterans in comparison to the general population in each country.

Design

Meta-analysis.

Setting

Denmark, Norway, Finland and Sweden.

Participants

Military veterans deployed between 1990 and 2010 were followed via nationwide registers and compared with age-sex-calendar-year-specific rates in the general population using pooled standardised mortality ratios (SMRs).

Main outcomes

All-cause and cause-specific mortality retrieved from each country's Causes of Death Register, including deaths from external, cardiovascular and cancer causes.

Results

Among 83 584 veterans 1152 deaths occurred of which 343 were from external causes (including 203 suicides and 129 traffic/transport accidents), 134 from cardiovascular causes and 297 from neoplasms. Veterans had a lower risk of death from any cause (pooled SMR 0.58, 95%CI 0.52-0.64), external causes (0.71, 95%CI 0.64-0.79), suicide (0.77, 95%CI 0.67-0.89), cardiovascular causes (0.54, 95%CI 0.46-0.64), and neoplasms (0.78, 95%CI 0.70-0.88). There was no difference regarding traffic/transport accidents for the whole period (1.10, 95%CI 0.75-1.10) but the pooled point estimate was elevated, though not statistically significant, during the first 5 years (1.17, 95%CI 0.89-1.53) but not thereafter (1.01, 95%CI 0.77-1.34). For all other causes of death, except suicide, statistically significantly lower risk among veterans was observed both during the first 5 years and thereafter. For suicide, no difference was observed beyond 5 years. Judged from the country-specific SMR-estimates, there was a high degree of consistency although statistically significant heterogeneity was found for all-cause mortality.

Conclusions

Nordic military veterans had lower overall and cause-specific mortality than the general population for most outcomes, as expected given the pre-deployment selection process. Though uncommon, fatal traffic/transport accidents were an exception with no difference between deployed military veterans and the general population.

Strengths and limitations of this study

- The problem of low statistical power in country-specific analyses of rare mortality outcomes among deployed military veterans was addressed by combining data from several Nordic countries
- Using the unique personal identity number of each Nordic resident and linking data to nationwide registers on mortality outcomes, follow-up was complete regarding mortality
- The generalisability of the results outside the Nordic context may be limited by recruitment practices, deployment areas, deployment duration, and combat exposure

Background

The Nordic countries Denmark, Finland, Norway and Sweden have contributed with military personnel to conflict zones during the last 30 years, primarily to the Balkans in the 1990s and to Afghanistan between 2002 and 2014. Controversy remains regarding several cause-specific mortality outcomes among deployed Nordic military veterans, as country-specific analyses are few and may suffer from insufficient statistical power given the low mortality rates among the relatively young veteran populations.

Suicide among military veterans has received the most attention due to it arguably being the most serious manifestation of psychiatric problems, and its strong association with post-traumatic stress disorder among military veterans. Although country-specific estimates exist,[1-6] no study has been adequately powered to investigate whether the suicide risk varies over time after return from deployment. Another rare outcome is cancer deaths, where the risk could be elevated due to, for example, exposure to chemicals or biological agents during deployment,[7-9] but the number of cases in each country is generally too small to generate meaningful statistics. There is also uncertainty regarding the risk of fatal traffic accidents, where data from the US and UK indicate that risks are elevated immediately after return from deployment.[10-16]

The similarities between the Nordic countries in terms of population, military engagements and health care systems, as well as access to health data via nationwide registers, offer a unique opportunity to synthesize data from the different countries in order to, for the first time, pool Nordic deployed military veterans to address post-deployment outcomes with considerably greater statistical power than what is achieved by single country studies.

The purpose of this study was to investigate all-cause and cause-specific mortality risks, including deaths from external, cardiovascular and cancer causes among Nordic military veterans in comparison to the general population in each country.

Methods

This is a pooled analysis based on country-specific individual data on military veterans and mortality outcomes from Denmark, Finland, Norway, and Sweden compared to the general population in each country. The cohorts were created and outcome data collected by linking individual veterans to nationwide registers by use of the unique personal identity number assigned to each resident in the respective countries. The linkage was performed by Statistic Denmark (Denmark), Statistics Finland (Finland), The Norwegian Armed Forces Health Registry (Norway) and National Board of Health and Welfare (Sweden). Estimates for Denmark, Norway and Sweden were derived specifically for this pooled analysis, while the mortality estimates for Finland were taken from a publication.[2] The STROBE reporting guidelines for cohort studies were used for this study.[17]

Ethics statement

Regarding the Swedish data, the study was approved by the regional ethics committee at Karolinska Institutet, Stockholm, Sweden (2012/1439-31/5, 2014/797-32). According to Danish law, studies based exclusively on register data require no approval by a research ethics committee. Data from Norway used in this study were analysed in accordance with the regulations and procedures of the Norwegian Armed Forces Health Registry, which stipulates that approval by the Committee for Medical Health Research Ethics is not required.

Study population

Nordic military veterans who had served on any international military deployment between 1990 (Finland) or 1992 (Denmark, Norway, Sweden) and 2010 were identified from the Armed Forces registers of international deployments in each country, resulting in a total cohort of 83 584 veterans (Denmark: n=27 442; Finland: 15 002; Norway: n=23 422; Sweden: n=17 718). Calendar year-specific mortality data from the general population in each country, stratified by age and sex, were retrieved from government statistics.

Follow-up and outcomes

Veterans were followed from the date of return from first deployment until death, emigration, or last date of register-based follow-up (December 31st 2016 for Denmark, Norway and Sweden; December 31st 2013 for Finland), whichever came first. The dates and causes of death for the veterans were retrieved from the government agency managing the Causes of Death Register in each country.

The mortality outcomes were death from any cause, external causes (International Classification of Diseases 9th and 10th revision [ICD9; ICD10] codes: ICD9: E800-E999; ICD10: V01-Y89), cardiovascular causes (390-459; I00-I99), and from neoplasms (140-239; C00-D48). The specific external causes suicide (E950-E959, E980-E989; X60-X84, Y10-Y34, Y87.0) and traffic/transport accidents (E800-E849; V01-V99, Y85) were also analysed. Finnish data were available only for the outcomes death from any cause, suicide and traffic/transport accidents.

Statistical analysis

The mortality outcomes among deployed military veterans were compared to the general population in each country using age-, sex- and calendar year-specific data to estimate standardised mortality ratios (SMRs). The SMR in each cause of death category and for each country was calculated as the ratio of the observed number and expected number of deaths. The cause of death-specific expected number of deaths in each sex, age (5-year age bands) and calendar year stratum was calculated by multiplying the number of person-years in that stratum by the cause of death specific mortality rate in the control population in the respective stratum. The 95% confidence intervals (95%CI) were estimated assuming a Poisson distribution of the observed number of deaths.

Country-specific SMRs for each outcome in veterans compared to the general population were pooled using inverse variance-weighted random effects meta-analyses. The analyses were performed for the whole follow-up period, as well as separately for less or equal to 5 years and more than 5 years after return from deployment. Heterogeneity between countries was assessed using the I^2 statistic.[18]

Data were analysed using SAS version 9.4 (SAS Institute) and Stata version 13.0.

Patient and Public Involvement

No patient involved.

Results

Cohort characteristics

A total of 83 584 deployed Nordic military veterans were included (**Table 1**). The mean age at deployment was 27 years and men represented 95% in the pooled cohort. Danish and Swedish veterans had similar mean deployment duration of 6 months while Norwegians had a mean of 4 months. The areas of operation for military deployment are shown in **Figure 1** for Denmark, Norway and Sweden. The mean follow-up was 14.8, 17.0 and 13.5 for Denmark, Norway and Sweden, respectively.

All-cause mortality

During follow-up, 1152 military veterans died (Denmark n=394; Finland n=212; Norway n=412; Sweden n=134). Deployed military veterans had lower mortality than the general population over the full study period (pooled SMR 0.58, 95%CI 0.52-0.64), during the first 5 years (0.50, 95%CI 0.41-0.60) and beyond 5 years after returning from deployment (0.61, 95%CI 0.56-0.67; **Figure 2**).

External cause mortality

Among military veterans from Denmark, Norway and Sweden there were a total of 343 deaths from external causes, while data from Finland were not available. The pooled SMR for the whole study period was 0.71 (95%CI 0.64-0.79; **Figure 3**). The pooled SMR for the first 5 years (0.70, 95%CI 0.55-0.91) was similar to the pooled SMR for follow-up beyond 5 years after returning from deployment (0.72, 95%CI 0.63-0.82).

Death by suicide

Based on 203 suicides, all 4 countries showed lower risk estimates among veterans than the general population resulting in a pooled SMR of 0.77 (95%CI 0.67-0.89; Figure 3). During the first 5 years after returning from deployment there were 39 suicides resulting in a pooled SMR of 0.56 (95%CI 0.41-0.78). Beyond 5 years there were 111 suicides with no statistically significant difference versus the general population (pooled SMR 0.91, 95%CI 0.75-1.10).

Fatal traffic/transport accidents

With a total of 129 fatal traffic/transport accidents, no statistically significant difference was observed between veterans and the general population (pooled SMR 1.10, 95%CI 0.92-1.31; Figure 3). The small risk increases were driven by accidents during the first 5 years following end of deployment, with point estimates of about 1.30 for Norwegian and Swedish, but not Danish veterans (data for Finnish veterans were not available) but the pooled SMR was not statistically significant (1.17, 95%CI 0.89-1.53). Beyond 5 years after return from deployment, the pooled point estimate was near the null (pooled SMR 1.01, 95%CI 0.77-1.34).

Cardiovascular deaths & fatal neoplasms

A total of 134 cardiovascular deaths occurred among the veterans resulting in a pooled SMR of 0.54 (95%CI 0.46-0.64; **Figure 4**). The lower risk for the veterans was especially pronounced during the first 5 years (0.33, 95%CI 0.18-0.61) but remained lower also beyond 5 years (0.61, 95%CI 0.51-0.74).

There were 297 deaths among the veterans due to neoplasms resulting in a pooled SMR of 0.78 (95%CI 0.70-0.88; Figure 4). As for cardiovascular deaths, the lower risk was especially pronounced during the first 5 years (0.50, 95%CI 0.37-0.68) but remained lower also beyond 5 years (0.86, 95%CI 0.76-0.97).

Heterogeneity

The statistical power for analysing heterogeneity was high for all-cause mortality but low for the cause-specific mortality outcomes.

For all-cause mortality the I^2 was 73% for the whole study period (P=0.01). The heterogeneity reflected the high precision of the estimates, rather than major numerical differences in country-specific SMRs, which ranged from 0.55 to 0.64. For the first 5 years the I^2 was 66% (P=0.03) with the estimate for Denmark at 0.40 (95%CI 0.33-0.45) while the other countries had SMRs higher than 0.50. Beyond 5 years the I^2 was 36% (P=0.20) and country-specific estimates ranged from 0.55 to 0.66.

For the cause-specific analyses the I^2 estimate was 0% for all outcomes for the whole time period as well as beyond 5 years of follow-up. During the first 5 years estimates were also 0%, except that the I^2 was 47% (P=0.15) for external cause mortality and 27% (P=0.26) for cardiovascular mortality.

Discussion

Main findings

In this study of 83 584 deployed Nordic military veterans followed for up to 25 years, veterans had lower mortality compared with the general population. For the whole follow-up period as well as the first 5 years after return from deployment, the pooled SMRs were lower for death from any cause, as well as for external causes, suicide, cardiovascular causes and neoplasms, while no statistically significant difference was found for fatal traffic/transport accidents. Beyond 5 years, no differences were found for suicide or fatal/traffic transport accidents. Judged from the SMR estimates for each country, there was a high degree of consistency although statistically significant heterogeneity was found for all-cause mortality due to the large sample size, resulting in high precision.

Previous research

Lower all-cause mortality among veterans compared to the general population is a typical finding in this field given the physical and mental health screening prior to military deployment, a selection bias referred to as "the healthy soldier effect."[19-21] For Swedish veterans, we have previously shown that when accounting for differences in, for example, cognitive ability, psychological evaluation test scores and pre-deployment mental health, there is no difference in either suicide or all-cause mortality between deployed military veterans and non-deployed tightly matched comparators.[5]

Although reporting a lower overall mortality among veterans in comparison to civilian or non-deployed military control groups, several major studies investigating US and British veterans from the Vietnam War and Gulf War have found increased cause-specific mortality risks among these veterans from external causes, mainly death by suicide and motor vehicle accidents, during the first years following deployment.[10-16] The Nordic veterans in the present study had lower risk than the general population for all outcomes during the first 5 years, except for fatal traffic/transport accidents where no difference was found. The point estimate indicated a potentially elevated risk although it was based on merely 56 deaths and the effect estimate was 1.17. This outcome will require further investigation when also accounting for the healthy soldier effect and including non-fatal accidents, as a potentially increased risk may reflect higher degrees of risk-taking behaviour after military deployment.[22] Another explanation could be that the intention of some of these accidents were in fact suicide. However, it must also be remembered that fatal traffic/transport accidents were uncommon, with a total of 129 events over the whole period despite pooling approximately 20 years of deployments from the four Nordic countries, and following more than 80 000 veterans for up to 25 years.

Implications

Mortality in Nordic deployed military veterans does not appear to be a public health problem, neither during the first 5 years after return from deployment nor thereafter, as their death rates were lower than the rates in the general population. However, deployed Nordic military veterans are a group that have gone through physical and mental health tests resulting in them having a better pre-deployment prognosis than the general population as a whole. Therefor more research is needed on specific mortality outcomes, especially fatal traffic and transport accidents, when also accounting for these baseline differences. In the meantime, veterans returning from deployment could be informed about the potential risk elevation for traffic/transport accidents, however small, and a discussion about risk-taking behaviour may be warranted prior to discharge.

Strengths and limitations

The main strength of this study was the combination of data from Denmark, Finland, Norway and Sweden including deployments spanning two decades and including up to 25 years follow-up using nationwide registers resulting in virtually no losses to follow-up. This provided more statistical power than country-specific studies, where estimates on the national level would have been associated with more uncertainty. We also designed the study so that each country used a similar study deployment period, follow-up time, and type of outcome ascertainment mechanism, resulting in greater similarity between countries than is often the case in meta-analyses combining only published estimates. By doing this, major areas of operation for each country were similar, although Denmark and Norway included deployments to Iraq while this was not the case for Sweden and Finland.

Despite the size of the study and the length of follow-up, estimates regarding fatal traffic/transport accidents were imprecise. Future studies could be expanded by also including non-fatal traffic/transport accidents to gain power, but still reflect the same underlying mechanism. Further, this study compared deployed military veterans with the general population of the same age and sex to assess whether any of the investigated types of post-deployment mortality could be of public health concern. However, in order to approach causal interpretation of the effect of military deployment on mortality, the healthy soldier effect must be addressed by carefully accounting for pre-deployment differences in mental and physical health, as well as psychological resources. It should also be noted that the generalisability outside the Nordic context may be limited by recruitment practices, deployment areas, deployment duration, and combat exposure. Finally, while Nordic data on all cause mortality are described as precise and valid, cause-specific mortality data have more limitations as the quality is dependent on the responsible physician certifying the death, autopsy rates (which currently are low and declining), and while completeness is high the validity of specific causes may vary by age (less valid in the elderly), cause, calendar period and country.[23]

All four Nordic countries have universal health care systems, covering both the veterans and the controls in the present study. In addition, however, there are Veteran Centres in Denmark and Norway providing some additional support after deployment regarding identification of illness and also treatment (see Appendix for details).

Conclusions

Nordic military veterans were found to have lower mortality after deployment compared to the general population, as expected given the selection process preceding military deployment. Though uncommon, fatal traffic/transport accidents during the first years following return from deployment, was an exception with point estimates indicating higher rather than lower risk. This warrants further investigation.

Contributorship statement

MN is the principal investigator. MSV was responsible for the preparation of Danish data. EKB was responsible for the preparation of Norwegian data. JS was responsible for the preparation of Swedish data. KN performed the statistical analyses. CMP and MN wrote the first draft of the manuscript. All the authors undertook revisions and contributed intellectually to the development of this paper. MN and CMP are the study guarantors.

Competing interests

The funders of the study had no role in study design, data analysis, data interpretation, or writing of the report. The corresponding author had final responsibility for the decision to submit for publication.

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Data sharing statement

No additional data available.

References

1. Hansen-Schwartz J, Jessen G, Andersen K, Jorgensen HO. Suicide after deployment in UN peacekeeping missions--a Danish pilot study. *Crisis* 2002; **23**: 55-8.

2. Laukkala T, Parkkola K, Henriksson M, et al. Total and cause-specific mortality of Finnish military personnel following service in international peacekeeping operations 1990-2010: a comprehensive register-based cohort study. *BMJ Open* 2016; **6**: e012146.

3. Lyk-Jensen SV, Heideman J, Glad A, Dohlmann Weatherall C. *Danske hjemvendte soldater (12:24)*: Det Nationale Forskningscenter for Velfærd; 2012.

4. Michel PO, Lundin T, Larsson G. Suicide rate among former Swedish peacekeeping personnel. *Military medicine* 2007; **172**: 278-82.

5. Pethrus CM, Johansson K, Neovius K, Reutfors J, Sundstrom J, Neovius M. Suicide and all-cause mortality in Swedish deployed military veterans: a population-based matched cohort study. *BMJ Open* 2017; **7**: e014034.

6. Thoresen S, Mehlum L, Moller B. Suicide in peacekeepers--a cohort study of mortality from suicide in 22,275 Norwegian veterans from international peacekeeping operations. *Social psychiatry and psychiatric epidemiology* 2003; **38**: 605-10.

7. McBride D, Cox B, Broughton J, Tong D. The mortality and cancer experience of New Zealand Vietnam war veterans: a cohort study. *BMJ Open* 2013; **3**: e003379.

8. Stone R. Environmental radioactivity. New findings allay concerns over depleted uranium. *Science* 2002; **297**: 1801.

9. Yi SW, Ryu SY, Ohrr H, Hong JS. Agent Orange exposure and risk of death in Korean Vietnam veterans: Korean Veterans Health Study. *Int J Epidemiol* 2014.

10. Knapik JJ1 MR, Grier TL, Jones BH. A systematic review of post-deployment injury-related mortality among military personnel deployed to conflict zones. *BMC Public Health* 2009; **13**: 231.

11. Macfarlane GJ, Thomas E, Cherry N. Mortality among UK Gulf War veterans. *Lancet* 2000; **356**: 17-21.

12. Kang HK, Bullman TA. Mortality among U.S. veterans of the Persian Gulf War. *N Engl J Med* 1996; **335**: 1498-504.

13. Postservice mortality among Vietnam veterans. The Centers for Disease Control Vietnam Experience Study. *JAMA* 1987; **257**: 790-5.

14. Boehmer TK, Flanders WD, McGeehin MA, Boyle C, Barrett DH. Postservice mortality in Vietnam veterans: 30-year follow-up. *Arch Intern Med* 2004; **164**: 1908-16.

15. Kang HK BT, Macfarlane GJ, Gray GC. Mortality among US and UK veterans of the Persian Gulf War: a review. *Occup Environ Med* 2002; **59**: 794-9.

16. Kang HK, Bullman TA. Mortality among US veterans of the Persian Gulf War: 7-year follow-up. *Am J Epidemiol* 2001; **154**: 399-405.

17. von Elm E, Altman D, Egger M, Pocock S, Gotzsche P, Vandenbroucke J. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

18. Higgins JP, Thompson SG. Quantifying heterogeneity in a meta-analysis. *Stat Med* 2002; **21**: 1539-58.

19. McLaughlin R, Nielsen L, Waller M. An evaluation of the effect of military service on mortality: quantifying the healthy soldier effect. *Ann Epidemiol* 2008; **18**: 928-36.

20. Waller M, McGuire AC. Changes over time in the "healthy soldier effect". *Population health metrics* 2011; **9**: 7.

21. Seltzer CC, Jablon S. Effects of selection on mortality. *Am J Epidemiol* 1974; **100**: 367-72.

22. Killgore WD, Cotting DI, Thomas JL, et al. Post-combat invincibility: violent combat experiences are associated with increased risk-taking propensity following deployment. *Journal of psychiatric research* 2008; **42**: 1112-21.

23. Laugesen K, Ludvigsson JF, Schmidt M, et al. Nordic Health Registry-Based Research: A Review of Health Care Systems and Key Registries. *Clin Epidemiol* 2021; **13**: 533-54.

Tables & Figures

Table 1 Participant characteristics of deployed Nordic military veterans

	Denmark	Finland[a]	Norway	Sweden
Number of participants	27 442	15 002	23 422	17 718
Deployment years	1992-2010	1990-2010	1992-2010	1992-2010
Age at first deployment (years)				
Mean (standard deviation)	27.9 (8.6)	*Not reported*	27.3 (8.0)	26.7 (6.5)
Median (interquartile range)	24.2 (22.1-30.3)	*Not reported*	24.5 (21.5-30.3)	24.5 (22.1-28.7)
Range	18-66	*Not reported*	18.2-65.5	19.0-58.3
Sex				
Men, n (%)	26 011 (95%)	14 584 (97%)	22 004 (94%)	17 216 (97%)
Women, n (%)	1431 (5%)	418 (3%)	1418 (6%)	502 (3%)
Deployment duration for all deployments (months)				
Mean (standard deviation)	5.6 (1.98)	*Not reported*	3.9 (2.9)	6.0 (2.0)
Median (interquartile range)	6.1 (5.7-6.1)	*Not reported*	3.5 (1.0-6.3)	6.1 (5.7-6.8)
Range	0.2-49.7	*Not reported*	0.03-39.5	0.03-30.3
Follow-up[b] (years)				
Mean (standard deviation)		14.8 (5.8)	17.0 (5.5)	13.5 (5.9)
Median (interquartile range)		15.1 (9.4-20.4)	17.5 (12.6-21.9)	13.6 (8.1-19.2)
Range		0-24	0.1-25.0	0-23

[a] Data from the publication by Laukkala et al[2]

[b] Follow-up started the day of return from first deployment

Figure 1 Number of deployments by year and region in Denmark (top panel), Norway (middle panel) and Sweden (bottom panel) between 1992 and 2010. No data were reported for Finland.

Figure 2 Forest plot of all-cause mortality in military veterans from Denmark, Finland, Norway and Sweden compared to the general population

Figure 3 Forest plot of external cause mortality overall (left), suicide (middle) and fatal traffic/transport accidents (right) in military veterans from Denmark, Finland, Norway and Sweden compared to the general population

[a] NA = Not available

Figure 4 Forest plot of cardiovascular deaths (left) and fatal neoplasms (right) in military veterans from Denmark, Norway and Sweden compared to the general population

[a] NA = Not available

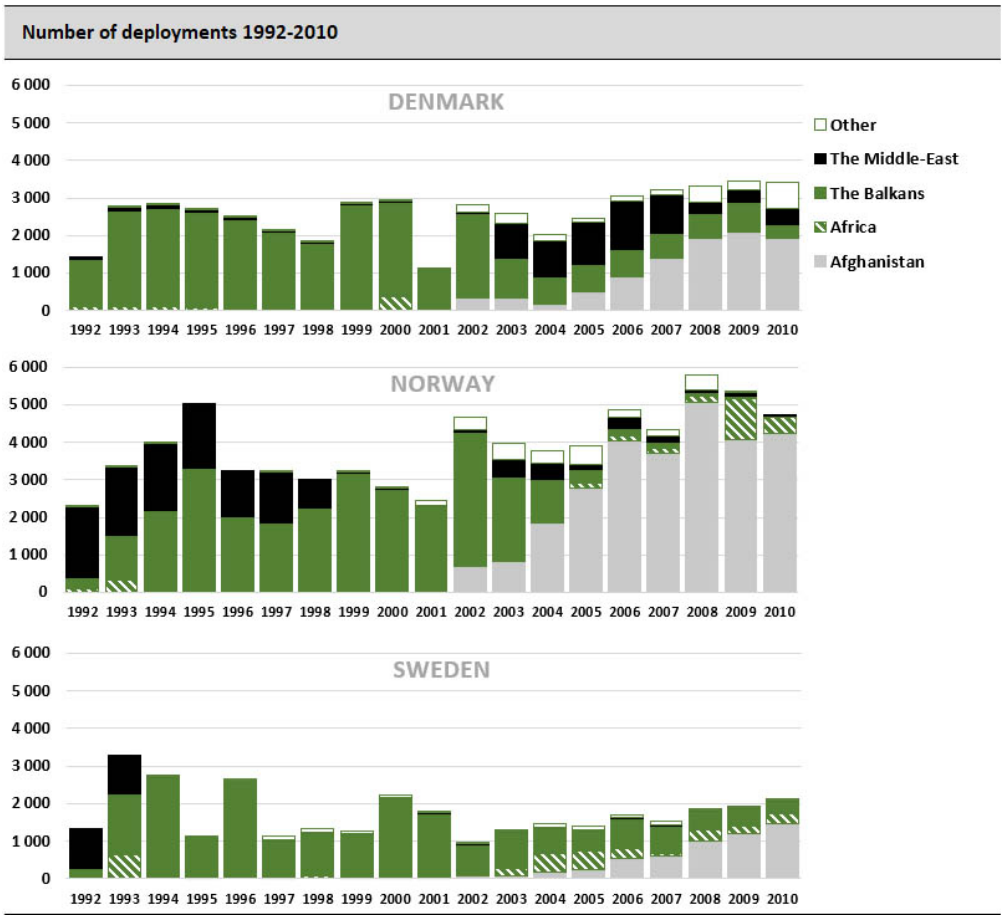

Figure 1 Number of deployments by year and region in Denmark (top panel), Norway (middle panel) and Sweden (bottom panel) between 1992 and 2010. No data were reported for Finland.

68x62mm (300 x 300 DPI)

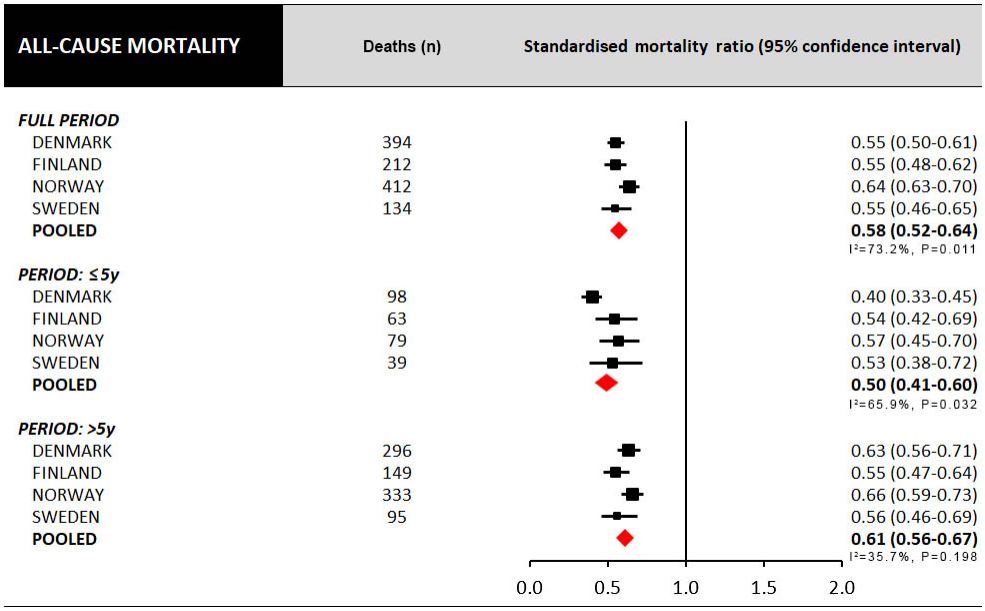

Figure 2 Forest plot of all-cause mortality in military veterans from Denmark, Finland, Norway and Sweden compared to the general population

352x219mm (72 x 72 DPI)

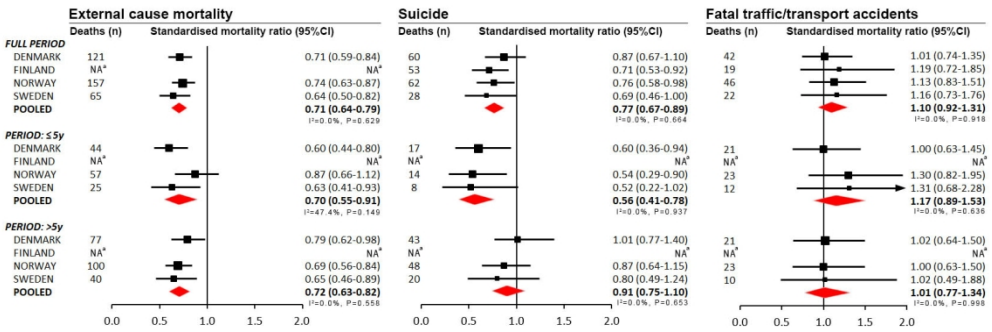

Figure 3 Forest plot of external cause mortality overall (left), suicide (middle) and fatal traffic/transport accidents (right) in military veterans from Denmark, Finland, Norway and Sweden compared to the general population a NA = Not available

595x202mm (72 x 72 DPI)

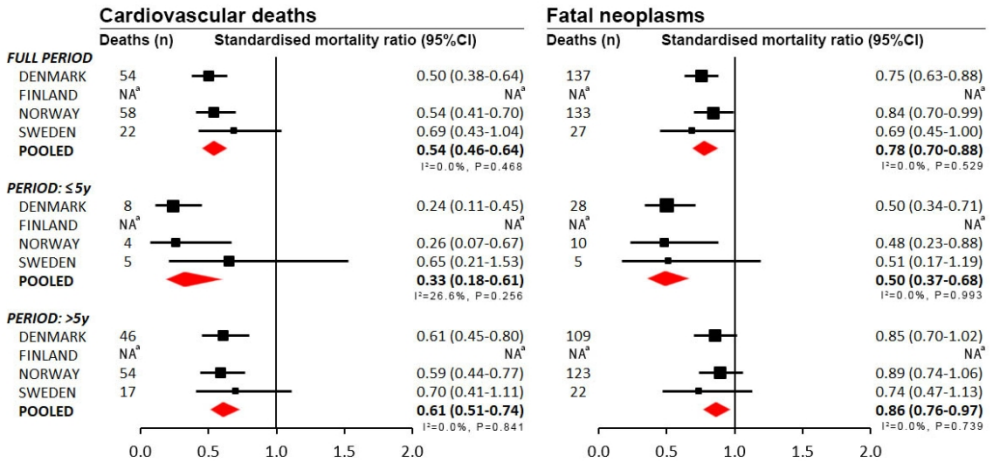

Figure 4 Forest plot of cardiovascular deaths (left) and fatal neoplasms (right) in military veterans from Denmark, Norway and Sweden compared to the general population a NA = Not available

416x203mm (72 x 72 DPI)

APPENDIX

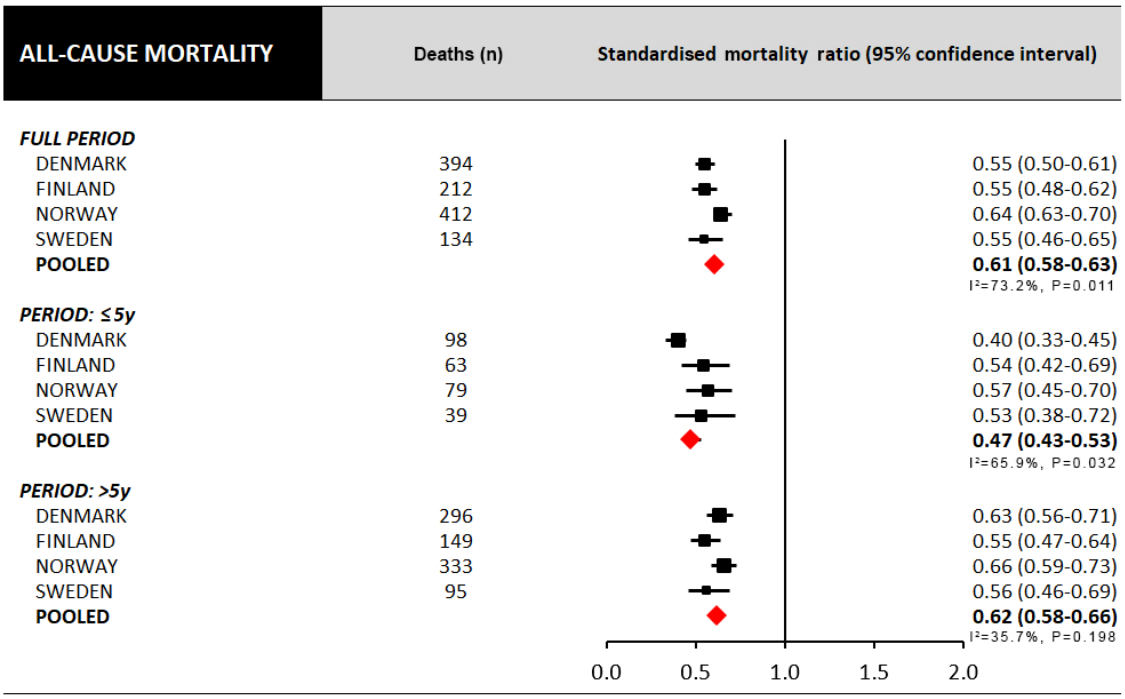

Figure A1 Forest plot of all-cause mortality in military veterans from Denmark, Finland, Norway and Sweden compared to the general population (fixed-effect model)

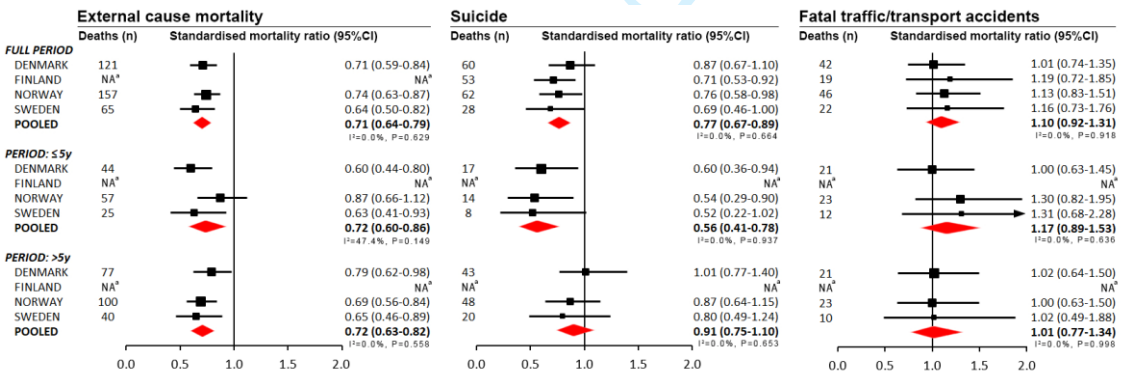

Figure A2 Forest plot of external cause mortality overall (left), suicide (middle) and fatal traffic/transport accidents (right) in military veterans from Denmark, Finland, Norway and Sweden compared to the general population (fixed-effect model)

[a] NA = Not available

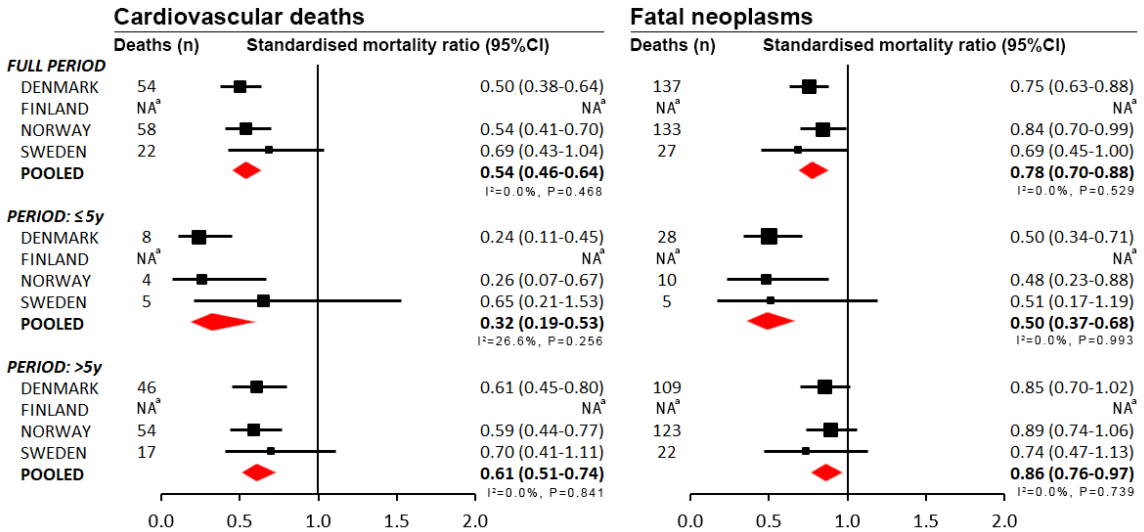

Figure A3 Forest plot of cardiovascular deaths (left) and fatal neoplasms (right) in military veterans from Denmark, Norway and Sweden compared to the general population (fixed-effect model)

[a] NA = Not available

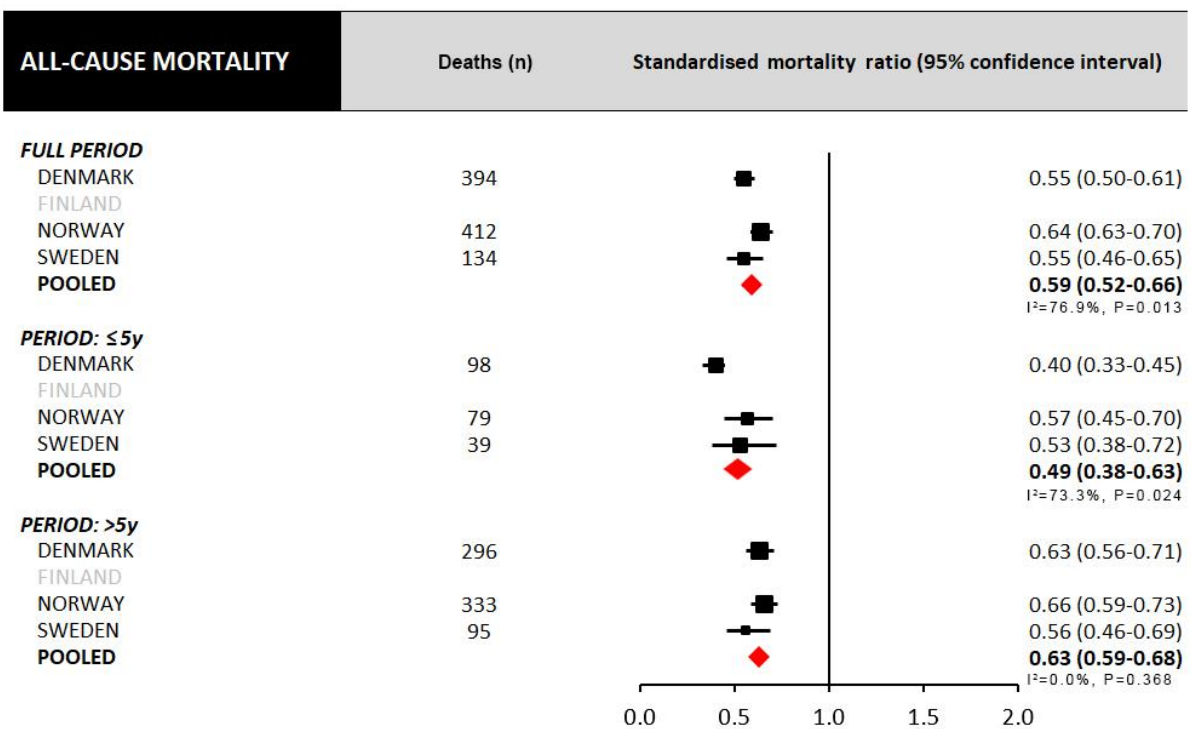

Figure A4 Forest plot of all-cause mortality in military veterans from Denmark, Norway and Sweden compared to the general population (Finland excluded)

Veterans' health promotion programs (by country)

Denmark

In Denmark the Danish Veterans Centre was founded in 2011 one year after the first Veteran policy was made by the government. As the period of the current study was from 1992 to 2010, there was no specific Government initiated veterans' health promotion programs during this period. In Denmark all citizens have access to free public health systems including psychiatric treatment. Likewise it is the municipalities that manage and is responsible for everything concerning social benefits and activities.

Thus, the Danish Veterans Centre is a supplement to the above general public services. The Danish Veterans Centre is a coordinating body organized under the Danish Ministry of Defense, working to support and treat Danish veterans and their families as well as furthering the acknowledgement of their efforts and sacrifices. The Centre operates within the Danish welfare model and the Centre's various support and treatment options for veterans complement services and treatments offered by the Danish universal healthcare system. The Danish Veteran Centre cooperates closely with government authorities, providers in the health care system, municipalities as well as a large number of voluntary organizations to support veterans and their relatives. The Centre functions as a 24/7 one-point of entry to cohesive and comprehensive support and treatment from Center's psychologists and social workers. The Centre offers treatment for deployment related psychopathology, conducts research projects within e.g. pre-deployment resilience and mental health training, post-deployment-screening and reintegration into civilian society, and furthermore the Centre offers support and advice to soldiers and veterans regarding employment and education, as well as offering e.g. PREP-courses (Prevention and Relationship Enhancement Program).

Norway

The Norwegian Government's plan of action to care for veteran personnel before, during and after serving abroad was published in 2011, with a follow-up plan in 2014. The action plan covers personnel who serve in international operations, and the objective of the action plan is to improve society's recognition of, and provision of care for, the personnel. The Norwegian Armed Forces provide psychiatric services to the veterans, and cooperate closely with the civilian health services, which is accessible for all residents.

Sweden

There were no veteran-specific health promotion programs in Sweden during the study period. The health care system in Sweden is universally accessible to all residents and veterans are generally encouraged to seek care within the existing health care structure. There is, however, a specific clinic for veterans in Uppsala, but this clinic is part of the county-driven health care system.

Reporting checklist for cohort study.

Based on the STROBE cohort guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cohortreporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title and abstract			1
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	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	4
Objectives	#3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	#4	Present key elements of study design early in the paper	5
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up.	5
Eligibility criteria	#6b	For matched studies, give matching criteria and number of exposed and unexposed	5
Variables	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
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. Give information separately for for	5

		exposed and unexposed groups if applicable.	
Bias	#9	Describe any efforts to address potential sources of bias	9, 10
Study size	#10	Explain how the study size was arrived at	N/A this was a meta analysis
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	5, 6
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	5, 6
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	N/A this was a meta analysis
Statistical methods	#12c	Explain how missing data were addressed	N/A this was a meta analysis
Statistical methods	#12d	If applicable, explain how loss to follow-up was addressed	N/A this was a meta analysis
Statistical methods	#12e	Describe any sensitivity analyses	6
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing	7

		follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	
Participants	#13b	Give reasons for non-participation at each stage	N/A this was a meta analysis
Participants	#13c	Consider use of a flow diagram	N/A this was a meta analysis
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	14
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	N/A no missing mortality data in the registers
Descriptive data	#14c	Summarise follow-up time (eg, average and total amount)	N/A this was a meta analysis
Outcome data	#15	Report numbers of outcome events or summary measures over time. Give information separately for exposed and unexposed groups if applicable.	7, 8
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95%	N/A this was a meta analysis

		confidence interval). Make clear which confounders were adjusted for and why they were included	
Main results	#16b	Report category boundaries when continuous variables were categorized	N/A this was a meta analysis
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	See Figures
Other analyses	#17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8
Discussion			
Key results	#18	Summarise key results with reference to study objectives	9
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.	9, 10
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	9, 10
Generalisability	#21	Discuss the generalisability (external validity) of the study results	10
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	1