BMJ Open

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

Carl-Martin Pethrus,[1] Mia Sadowa Vedtofte,[2] Kristian Neovius ,[3] Einar K Borud,[4,5] Martin Neovius[1]

To cite: Pethrus C-M, Vedtofte MS, Neovius K, *et al*. Pooled analysis of all-cause and cause-specific mortality among Nordic military veterans following international deployment. *BMJ Open* 2022;**12**:e052313. doi:10.1136/bmjopen-2021-052313

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2021-052313).

Received 19 April 2021
Accepted 17 March 2022

[1]Clinical Epidemiology Division, Department of Medicine (Solna), Karolinska Institutet, Stockholm, Sweden
[2]Research and Knowledge Centre, Danish Veteran Centre, Ringsted, Denmark
[3]Cyclo AB, Stockholm, Sweden
[4]Norwegian Armed Forces Joint Medical Services, Oslo, Norway
[5]Department of Community Medicine, UiT The Arctic University of Norway, Tromsø, Norway

Correspondence to
Dr Martin Neovius;
martin.neovius@ki.se

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 Pooled 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 to 0.64), external causes (0.71, 95% CI 0.64 to 0.79), suicide (0.77, 95% CI 0.67 to 0.89), cardiovascular causes (0.54, 95% CI 0.46 to 0.64) and neoplasms (0.78, 95% CI 0.70 to 0.88). There was no difference regarding traffic/transport accidents for the whole period (1.10, 95% CI 0.92 to 1.31) but the pooled point estimate was elevated, though not statistically significant, during the first 5 years (1.17, 95% CI 0.89 to 1.53) but not thereafter (1.01, 95% CI 0.77 to 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 predeployment 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 USA 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 healthcare systems, as well as access to health data via nationwide registers, offer a unique opportunity to synthesise data from the different countries in order to, for the first time, pool Nordic deployed military veterans to address postdeployment 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 with 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 Strengthening the Reporting of Observational Studies in Epidemiology reporting guidelines for cohort studies were used for this study.[17]

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 (31 December 2016 for Denmark, Norway and Sweden; 31 December 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 with the general population in each country using age-specific, sex-specific 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% CIs were estimated assuming a Poisson distribution of the observed number of deaths.

Country-specific SMRs for each outcome in veterans compared with 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 V.9.4 (SAS Institute) and Stata V.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 years 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).

Table 1 Participant characteristics of deployed Nordic military veterans

	Denmark	Finland*	Norway	Sweden
No 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 (SD)	27.9 (8.6)	Not reported	27.3 (8.0)	26.7 (6.5)
Median (IQR)	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	18–66	19–58
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 (SD)	5.6 (1.98)	Not reported	3.9 (2.9)	6.0 (2.0)
Median (IQR)	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† (years)				
Mean (SD)		14.8 (5.8)	17.0 (5.5)	13.5 (5.9)
Median (IQR)		15.1 (9.4–20.4)	17.5 (12.6–21.9)	13.6 (8.1–19.2)
Range		0–24	0–25	0–23

*Data from the publication by Laukkala *et al*.[2]
†Follow-up started the day of return from first deployment.

Deployed military veterans had lower mortality than the general population over the full study period (pooled SMR 0.58, 95% CI 0.52 to 0.64), during the first 5 years (0.50, 95% CI 0.41 to 0.60) and beyond 5 years after returning from deployment (0.61, 95% CI 0.56 to 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 to 0.79; figure 3). The pooled SMR for the first 5 years (0.70, 95% CI 0.55 to 0.91) was similar to the pooled SMR for follow-up beyond 5 years after returning from deployment (0.72, 95% CI 0.63 to 0.82).

Death by suicide

Based on 203 suicides, all 4 countries showed lower risk estimates among veterans than the general population

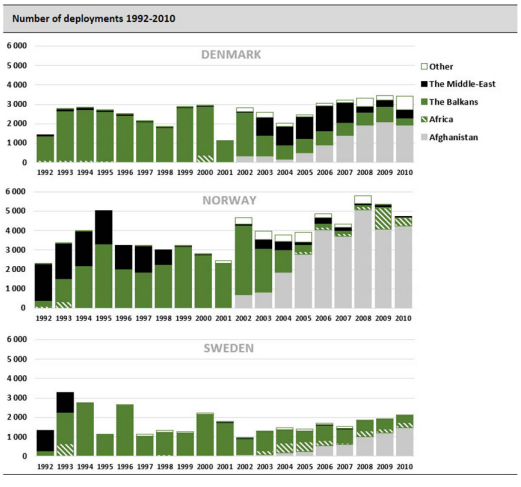

Figure 1 Number of deployments by year and region in Denmark (top panel), Norway (middle panel) and Sweden (bottom panel) between 1992 and 2010. No data were reported for Finland.

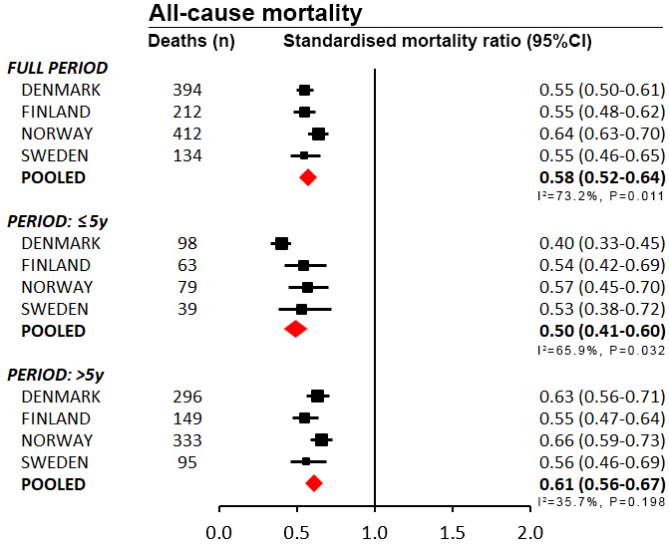

Figure 2 Forest plot of all-cause mortality in military veterans from Denmark, Finland, Norway and Sweden compared with the general population.

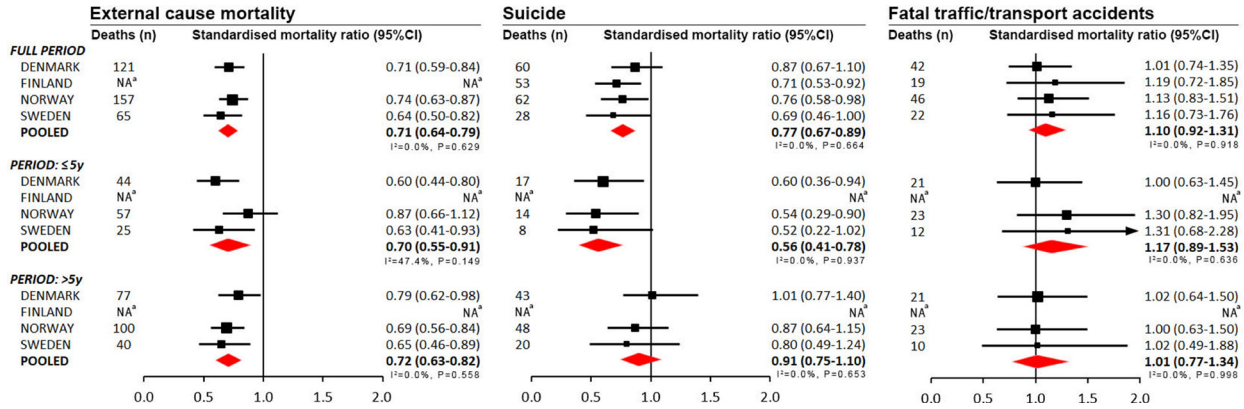

Figure 3 Forest plot of external cause mortality overall (left), suicide (middle) and fatal traffic/transport accidents (right) in military veterans from Denmark, Finland, Norway and Sweden compared with the general population. [a]NA=not available.

resulting in a pooled SMR of 0.77 (95% CI 0.67 to 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 to 0.78). Beyond 5 years, there were 111 suicides with no statistically significant difference vs the general population (pooled SMR 0.91, 95% CI 0.75 to 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 to 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 to 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 to 1.34).

Cardiovascular deaths and fatal neoplasms

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

There were 297 deaths among the veterans due to neoplasms resulting in a pooled SMR of 0.78 (95% CI 0.70 to 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 to 0.68) but remained lower also beyond 5 years (0.86, 95% CI 0.76 to 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

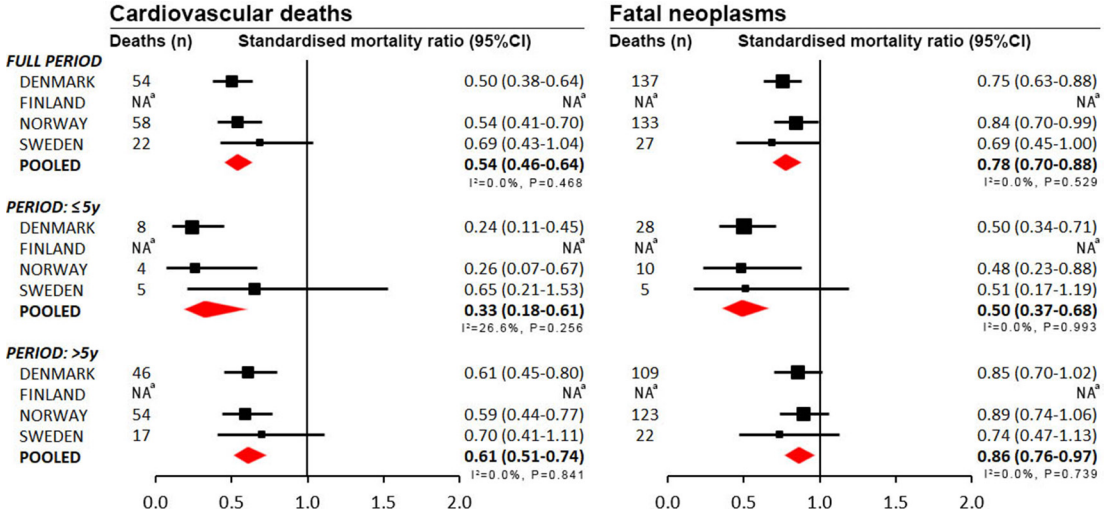

Figure 4 Forest plot of cardiovascular deaths (left) and fatal neoplasms (right) in military veterans from Denmark, Norway and Sweden compared with the general population. [a]NA=not available.

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 to 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 with 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 predeployment 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 this 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 predeployment prognosis than the general population as a whole. Therefore, 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 postdeployment 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 predeployment 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 healthcare systems, covering both the veterans and the controls in this 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 online supplemental appendix 1 for details).

CONCLUSIONS

Nordic military veterans were found to have lower mortality after deployment compared with 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.

Contributors MN is the principal investigator. MSV was responsible for the preparation of Danish data. EKB was responsible for the preparation of Norwegian data. MN 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.

Funding This work was supported by The Royal Fund (Kungafonden) in Sweden (funding for doctoral student and lead author CMP) and the Swedish Armed Forces (costs associated with Swedish register linkage). MSV is employed by the Danish Veteran Centre, which is a part of the Danish Armed Forces, and EKB is employed by the Norwegian Armed Forces Joint Medical Services.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval 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.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available.

ORCID iD

Kristian Neovius http://orcid.org/0000-0003-1819-1530

REFERENCES

1 Hansen-Schwartz J, Jessen G, Andersen K, *et al*. 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, *et al*. Danske hjemvendte soldater (*12:24*): Det Nationale Forskningscenter for Velfærd 2012.
4 Michel P-O, Lundin T, Larsson G. Suicide rate among former Swedish peacekeeping personnel. *Mil Med* 2007;172:278–82.
5 Pethrus C-M, Johansson K, Neovius K, *et al*. 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. *Soc Psychiatry Psychiatr Epidemiol* 2003;38:605–10.
7 McBride D, Cox B, Broughton J, *et al*. 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;297:297.
9 Yi S-W, Ryu S-Y, Ohrr H, *et al*. Agent orange exposure and risk of death in Korean Vietnam veterans: Korean Veterans health study. *Int J Epidemiol* 2014;43:1825–34.
10 Knapik JJ, Marin RE, Grier TL, *et al*. A systematic review of post-deployment injury-related mortality among military personnel deployed to conflict zones. *BMC Public Health* 2009;9:231.
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 TKC, Flanders WD, McGeehin MA, *et al*. Postservice mortality in Vietnam veterans: 30-year follow-up. *Arch Intern Med* 2004;164:1908–16.
15 Kang HK, Bullman TA, Macfarlane GJ, *et al*. 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 DG, Egger M, *et al*. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *Epidemiology* 2007;18:800–4.
18 Higgins JPT, 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". *Popul Health Metr* 2011;9:7.
21 Seltzer CC, Jablon S. Effects of selection on mortality. *Am J Epidemiol* 1974;100:367–72.
22 Killgore WDS, Cotting DI, Thomas JL, *et al*. Post-combat invincibility: violent combat experiences are associated with increased risk-taking propensity following deployment. *J Psychiatr Res* 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.