Road Traffic Accidents in Scottish Military Veterans

Short running title: RTA in veterans

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ABSTRACT

Road traffic accidents (RTA) are recognised to be an important cause of death and injury in serving military personnel but little is known about the risk in veterans. We used data from the Scottish Veterans Health Study to examine the risk of RTA in a large national cohort of veterans, in comparison with people who had never served. We conducted a retrospective cohort study of 57,000 veterans and 173,000 non-veterans, followed up for up to 30 years, using survival analysis to compare risk of RTA injury. Subgroup analysis was used to explore trends by birth cohort and length of service. Overall, veterans had a higher risk of RTA (Cox proportional hazard ratio (HR) 1.17, 95% confidence intervals (CI) 1.14-1.20). The risk was highest in the veterans with the shortest service (early service leavers), including those who did not complete initial military training (HR 1.31, 95% CI 1.23-1.40). The mean age at first RTA was 34 years, irrespective of age at leaving service, and the greatest increase in risk was in veterans born in the 1960s, but veterans born after 1970 showed no increase in risk. We have therefore demonstrated that the increased risk of RTA observed in serving military personnel persists in veterans through the fourth decade of life. The high risk in early service leavers is likely to be related to risk factors other than military service, including previous childhood adversity. Recent Ministry of Defence road safety programmes may now be reducing the long-term risk of RTA injury.

KEYWORDS

Road traffic accidents

Land transport accidents

Risk factors

Military veterans

Retrospective cohort studies

HIGHLIGHTS

- Serving personnel are known to be at increased risk of RTA, and are more likely to be risky drivers, but there is little information on whether the increased risk continues into veteran life.
- The Scottish Veterans Health Study has shown that veterans are at increased risk of RTA and that the risk persists into the fourth decade of life, irrespective of time elapsed since leaving service.
- The excess risk has disappeared in veterans born after 1970, suggesting that recent Ministry of Defence road safety initiatives are proving effective.

ABBREVIATIONS & ACRONYMS

CI	Confidence intervals
ESL	Early service leaver
HR	Hazard ratio
ICD	International Classification of Diseases
ISD	Information Services Division, NHS Scotland
LTA	Land transport accident
MOD	Ministry of Defence (UK)
NHS	National Health Service (UK)
NHSCR	National Health Service Central Registry (Scotland)
RTA	Road traffic accident
SES	Socio-economic status
SIMD	Scottish Index of Multiple Deprivation
SMR	Standardised mortality ratio
SMRnn	Scottish Morbidity Record [number]
US	United States (of America)

1. INTRODUCTION

Road traffic accidents (RTA) were the commonest cause of death in serving UK military personnel until 2007, when the percentage was first exceeded by deaths due to hostile action, notwithstanding the increase in operational tempo in Iraq and Afghanistan which had been ongoing since 2001 (Defence Statistics (Health), 2011). The majority of the deaths were in off-duty personnel and predominantly in male soldiers under the age of 30 years. Injuries due to RTA were also a major contributor to medical retirement from the Armed Forces. A number of road safety initiatives aimed at serving personnel were introduced from 2006, and the rate of RTA death has been falling since 2004-2006, from a peak of 28 per 100,000 across all three Services (Naval Service, Army, and Royal Air Force) in 1991-1993 to 10 per 100,000 in 2013-2015. Army rates have always been highest, reaching 38 per 100,000 in 1989-1991 and falling to 12 per 100,000 in 2013-2015. Despite this improvement, the overall risk of death from RTA in military personnel remains elevated in comparison with the UK population, standardised mortality ratio (SMR) 174. For comparison the highest risk is in pedestrians with SMR being equal to 271, followed by motorcycle accidents where the SMR is 234 and motor vehicle accidents with an SMR of 137 (Defence Statistics (Health), 2016).

Armed Forces personnel have been shown to exhibit risk-taking behaviour in a range of settings (Fear et al., 2007; Thandi et al., 2015), and in a randomly-selected cohort of military personnel surveyed between 2004 and 2006, 19% of personnel were classified as risky drivers (Fear et al., 2008), although there is evidence that this is now reducing (Sheriff et al., 2015). Risk factors included being young, male, in the Army, having a combat role, and having a history of childhood adversity (Fear et al., 2008). The risk of RTA has been shown

to increase after operational deployment (Lincoln et al., 2006), although it declines with time elapsed since return (Macfarlane et al., 2005). The UK Ministry of Defence (MOD) has implemented a programme of road safety education for personnel returning from deployment since 2006.

Despite extensive data on the risk of RTA in serving personnel, little is known about the level of risk in veterans. Furthermore most studies on RTA have examined deaths, and data on non-fatal injuries are more sparse. We used data from the Scottish Veterans Health Study to examine the risk of injury and death from RTA in a large cohort of veterans drawn from the full range of backgrounds and covering a wide range of periods and lengths of service, in comparison with the general Scottish population.

2. METHODS

2.1 General

The Scottish Veterans Health Study is a retrospective cohort study, conducted by the authors, which examines long-term health outcomes in military veterans in comparison with non-veterans. The study population includes all 56,570 military veterans resident in Scotland who were born between 1945 and 1985 and who were registered with National Health Service (NHS) Scotland both before and after service, and a comparison group of 172,753 individuals having no record of service. The comparison group was selected from NHS central records by matching on age, sex and postcode sector of residence (mean population 5,000) to select three non-veterans for each veteran. The demographic characteristics of the study cohort have been reported elsewhere (Bergman et al., 2014).

The current study focussed on fatal and injury RTA. Demographic data were obtained from electronic NHS registration records and were linked at an individual level to routine acute hospital data (Scottish Morbidity Record SMR01) and death certificates to provide information on injury and death due to RTA. The electronic NHS record provided dates of entering and leaving the Armed Forces for veterans. The maximum period of follow-up was from 1 January 1981 (or date of leaving the Armed Forces, for veterans, if later) to 31 December 2012. The data extract was pseudo-anonymised, and approval for the study was given by the Privacy Advisory Committee of the Information Services Division, NHS Scotland.

2.2 Socio-economic status

SIMD is an area-based measure of deprivation derived from measures across a number of domains encompassing income, employment, health, education (including skills and

training), housing, crime, and access to services. The data are derived from a wide range of sources including benefits claims, criminal justice statistics, healthcare data, and educational performance records. The SIMD has been used to derive quintiles of socioeconomic status (SES) for the Scottish population; ranging from 1 (most deprived) to 5 (least deprived). Details of the Scottish Index of Multiple Deprivation (SIMD) are published by the Scottish Government (Scottish Government, 2012). SIMD is calculated for 6,505 datazones (mean population 800) in Scotland, based on postcode of residence. We categorised the cohort participants according to these quintiles using the postcode of residence.

2.3 Definitions

Injury or death due to RTA was defined as ICD-10 code V00-V99, or ICD-9 code E810-E819 or E820-E825, at any position in the hospital record or in the death record. Only the first occurrence in the hospital record was captured in order to avoid confounding arising from repeated admissions arising from the same accident. 'Early Service Leavers' (ESL) were tightly defined as veterans having 2.5 years' service or less in order not to incorrectly classify those who had completed the earlier minimum term of 3 years, whilst those having 0.4 years' service or less were categorised as not having completed initial training (Bergman et al., 2016).

2.4 Statistical analysis

Cox proportional hazard models were used to examine the association between veteran status and cumulative risk of injury or death from RTA, using age as the time dependent variable, age at first recorded occurrence of RTA as the event time and age at death (if no RTA) as the censor time. Cox proportionality assumptions were tested using methodology

based on Schoenfeld residuals (Grambsch & Therneau, 1994). A landmark analysis was performed using age 18 years as the starting point in order to prevent confounding by childhood RTAs which precluded military service among the comparison group. The *a priori* rejection level was set at 0.05. The models were run univariately and then repeated adjusting for the potential confounding effect of SES quintile. The analyses were repeated stratifying by grouped year of birth to examine potential birth cohort effects. All analyses were performed using Stata v12.1 (©1985-2011 StataCorp).

3. RESULTS

3.1 *Main findings*

After data cleansing to remove records with incomplete or invalid data, 56,205 (99.3%) veterans and 172,741 (99.9%) non-veterans were included in the analyses. The veterans included 5,235 (9.2%) women, reflecting the male/female ratio of the military population. The mean period of follow-up was 29.3 years, and there was a total of 6.7 million person-years of follow-up (measured in years) among veterans and non-veterans combined.

Over the period of follow-up, there were 7,702 (13.70%) road traffic accident casualties among the veterans, compared with 23,907 (13.84%) in non-veterans. The overall risk was higher in veterans taking into account their generally shorter follow-up time, from the conclusion of their military service, as demonstrated by the Cox proportional hazard ratio (Table 1). The risk was similar after adjusting for SES. Non-proportionality of the hazards was significant; the Nelson-Aalen plot showed that the risk in veterans increased more steeply in the fourth decade of life whilst the curves ran almost parallel after age 40 years (Figure 1). Confining the analysis to those aged over 40 years showed that there was no increase in risk in older veterans (Table 1). Among men, 7,173 (14.1%) veterans and 21,739 (14.3%) non-veterans had a record of RTA, whilst for women, the figures were 764 (14.6%) veterans and 3,398 (16.4%) non-veterans; the difference in risk in women did not achieve statistical significance (Table 1). Veteran women had a similar risk of RTA to veteran men, in contrast to non-veterans where the risk was higher in women than men.

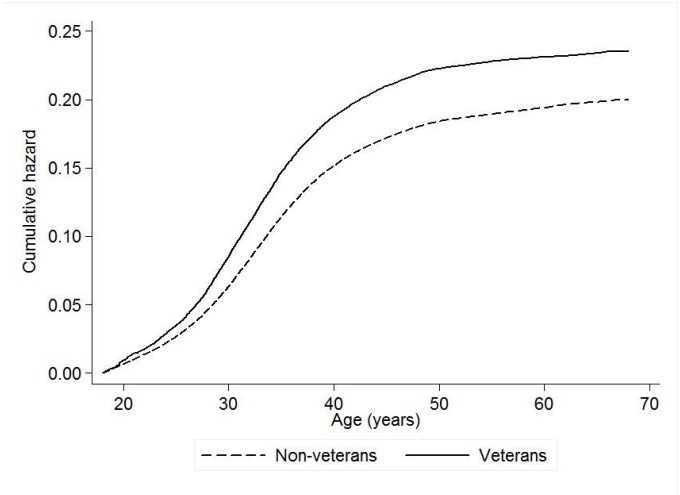


Figure 1. Nelson-Aalen plot of risk of road traffic accident by veteran status, landmark age 18 years

3.2 Birth cohort and length of service

Subgroup analysis by birth cohort, examining both men and women together, showed the risk to be significantly increased in veterans born between 1945 and 1969 (Figure 2), with a peak in the 1960-1964 birth cohort, but there was no significant difference for those born from 1970 onwards. There was an overall decline in risk from the 1960s birth cohorts onwards.

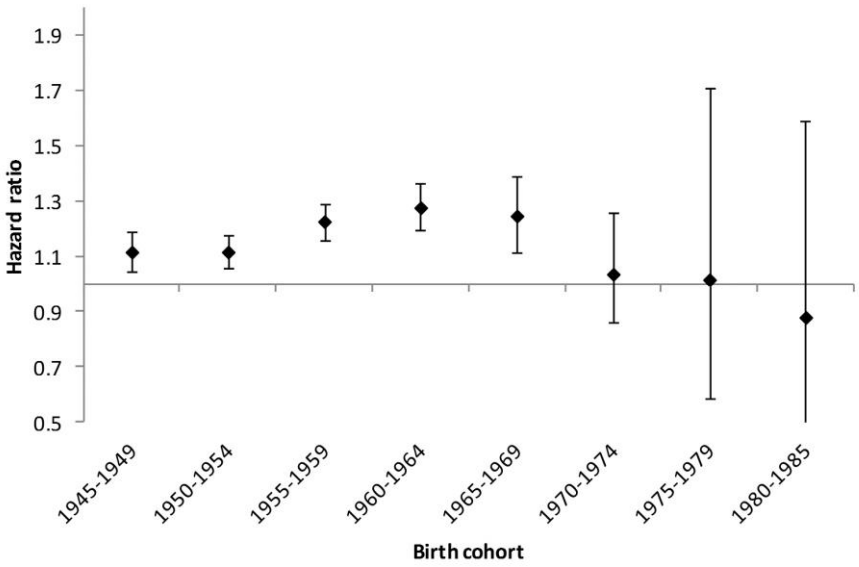


Figure 2. Hazard ratios for road traffic accident by birth cohort, veterans referent to non-veterans

Analysis by length of service showed the increased risk to be confined to veterans who had served for 12 years or less. The highest risk was in early service leavers (ESL), whether or not they had completed initial training. There was a smaller increase in risk in those who had competed training and served for up to 12 years, whilst for those with more than 12 years service, the risk was similar for veterans and non-veterans (Table 1).

Table 1. Cox proportional hazards model of the association between veteran status, sex, age at RTA, length of service, and risk of RTA, landmark age 18 years

		Univariate			Multivariate[a]		
		HR	**95% CI**	**P value**	**HR**	**95% CI**	**P value**
Overall	All RTA	1.17	1.14-1.20	<0.001	1.17	1.13-1.20	<0.001
	Men	1.18	1.15-1.22	<0.001	1.18	1.15-1.22	<0.001
	Women	1.07	0.99-1.17	0.104	1.05	0.97-1.14	0.242
RTA death	All	0.90	0.68-1.18	0.441	0.88	0.67-1.17	0.387
Age at RTA	All ages	1.17	1.14-1.20	<0.001	1.17	1.13-1.20	<0.001
	≥ 40 years	1.04	0.98-1.10	0.231	1.03	0.98-1.10	0.254
Length of service[b]	ESL (did not complete training)	1.31	1.23-1.40	<0.001	1.30	1.22-1.38	<0.001
	Trained ESL	1.28	1.22-1.34	<0.001	1.27	1.21-1.33	<0.001
	4-12 years	1.13	1.09-1.17	<0.001	1.13	1.08-1.17	<0.001
	> 12 years	0.99	0.91-1.07	0.793	0.99	0.92-1.07	0.850

HR hazard ratio; CI confidence interval; ESL Early Service Leavers

[a]adjusted for Scottish Index of Multiple Deprivation

[b]Intervals correspond to common lengths of military service

The mean age at first record of RTA was 34.0 years, similar to the mean age for non-veterans, and was similar for all lengths of service, indicating that there was no relation to age at leaving service (and hence time elapsed since leaving), apart from those with the longest service who were older (Table 2).

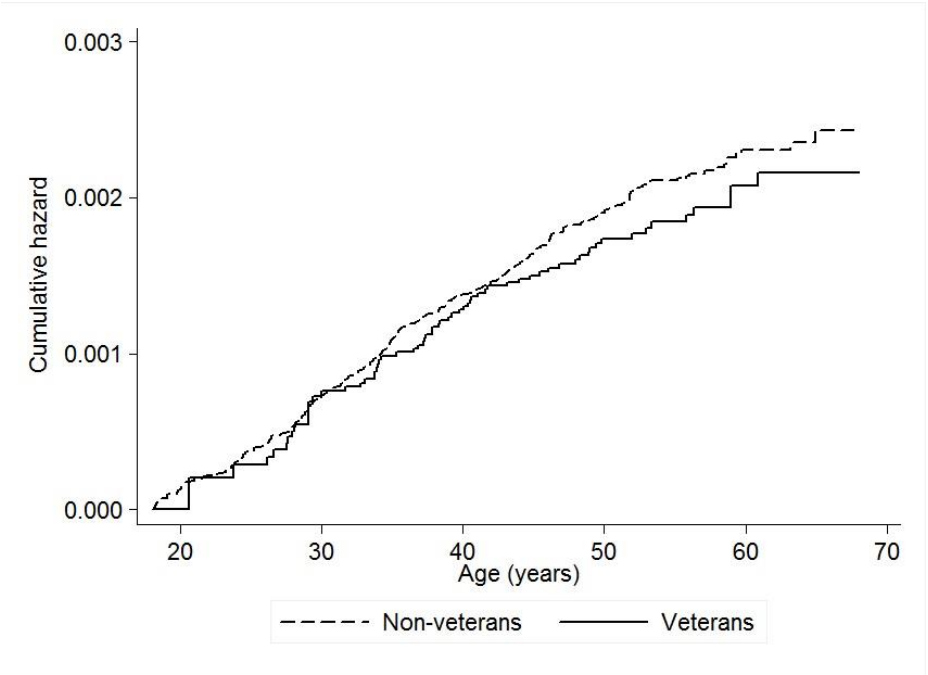
Table 2. Age at first road traffic accident – veterans and non-veterans

	Cases	Mean age at 1st RTA (years)	SD	Mean age at discharge from service (years)	SD
All veterans	7934	34.0	7.9	27.9	8.4
Initial training	990	34.2	7.1	21.9	6.4
Trained ESL	1500	33.9	7.1	20.7	4.9
4-12 years	3239	34.6	6.9	26.5	4.6
Over 12 years	1371	36.5	7.2	38.8	5.9
All non-veterans	23,907	34.1	7.5	N/A	N/A

RTA road traffic accident; ESL Early Service Leavers; SD standard deviation

3.3 *RTA death*

Sixty-six veterans (0.12%) and 288 (0.17%) non-veterans died as a result of RTA, constituting 1.87% of all veteran deaths and 2.63% of all non-veteran deaths. Veterans were at non-significantly reduced risk of death from RTA compared with non-veterans (Table 1 and Figure 3). There was no overall pattern when analysed by either birth cohort or length of service although the small number of veteran deaths may have provided insufficient statistical power.



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242 **Figure 3.** Nelson-Aalen plot of risk of death from road traffic accident by veteran status,
243 landmark age 18 years

244 *3.4 Incident type - RTA deaths*

245 Analysis of incident type was only possible for fatal cases, where an ICD code was recorded,
246 and only for ICD-10 as the ICD-9 codes of the earlier records provided insufficient detail for
247 analysis. A higher percentage of veteran fatalities was recorded as car drivers colliding with
248 either another vehicle or a fixed object (for example a wall or a tree) at 45%, compared with
249 33% of non-veteran fatalities; nonetheless the difference was not statistically significant, OR
250 1.70, 95% CI 0.79-3.65. A further 30% of veteran fatalities were among the motorcyclists,
251 similar to the 31% of non-veterans. Six per cent of veterans were HGV or van drivers,
252 compared with 9% of non-veterans, and a further 6% of veteran fatalities were pedal
253 cyclists, compared with 1% of non-veterans. Fatalities due to a pedestrian being hit by a
254 vehicle were much less common in veterans at 3%, compared with 25% in non-veterans OR
255 0.16, 95% CI 0.02-1.21.

4. DISCUSSION

4.1 Risk in veterans

We have shown that over the study period as a whole, the risk of RTA in veterans was increased compared with non-veterans, with the highest increase (30%) in those with the shortest service (ESL). However the excess risk has decreased over time and was no longer apparent among veterans born after 1970. Unlike the period following operational deployment (Kang et al., 2002; Lincoln et al., 2006), we have found no evidence that the period following discharge from the Services is especially risky for injury or death due to RTA. Instead, the overall pattern of RTA in veterans mirrors that in non-veterans, with the highest risk occurring in the fourth decade, irrespective of the length of service and hence the age at which discharge from service took place.

4.2 Risk in serving personnel

Serving members of the Armed Forces have been known for some time to be at increased risk of death and injury from RTA, which are known in UK Armed Forces as land transport accidents (LTA) in order to encompass off-road incidents as well as events occurring on the public road. In this discussion we have therefore used the term LTA when referring to published Ministry of Defence (MOD) reports. The publication in 2013 of the first Official Statistics notice on LTA deaths in serving members of the UK Armed Forces highlighted the scale of deaths from this cause. Despite a downward trend since 2004-2006, 124 personnel lost their lives due to LTA in the five years 2008-2012, the second highest cause of death in the Armed Forces after hostile action. Until 2007, LTA had been the largest single cause of death, accounting for an average of 37% of all Army deaths in the period 1998-

2007. In 2008-2012, off duty male non-commissioned ranks were at highest risk. Motorcycle accidents accounted for 27% of LTA deaths, whilst 15% of fatal accidents overall were to pedestrians, increasing to 27% in 2012 (Defence Statistics (Health), 2013).

4.3 Risk factors

Earlier research has shown that the risk of involvement in an RTA is increased on return from operational deployment, the excess risk declining over time (Kang et al., 2002; Kang & Bullman, 2001), and that risky driving is common among serving personnel (Fear et al., 2008; Sheriff et al., 2015). We have added to the body of evidence by demonstrating that in an unselected cohort encompassing a wide range of deployments, exposure to combat, lengths of service, and time since leaving service, veterans overall remain at increased risk of RTA, compared with people with no record of military service, throughout the fourth decade of life.

Although the confidence intervals are wide, there is some evidence that veterans born since 1970 are not at increased risk. These individuals would have been aged 36 and under, and therefore at peak age for RTA, at the time of implementation of the MOD's enhanced road safety programme in 2006, providing guarded optimism that the programme has been effective.

Examining recent fatalities, veterans were more likely than non-veterans to have been car drivers or pedal cyclists, but less likely to have been pedestrians, although none of the differences achieved statistical significance owing to small numbers. The percentages for veterans are similar to those recently reported for serving personnel, where 39% of fatalities involved motor vehicles and 33% motorcycles, other than for pedestrians where

the figure was 21% for serving personnel (Defence Statistics (Health), 2016). The increase in risk in veteran car drivers accords with earlier research showing increased prevalence of risky driving behaviour in serving personnel, and suggests that this pattern persists into post-service life. However our finding that the risk of RTA injury is highest in those with the shortest service, who did not complete initial training and therefore could not have deployed, accords with the reported association between risk-taking (especially risky driving) and childhood adversity (Fear et al., 2008; MacManus et al., 2012), which itself is known to be associated with premature separation from service (Buckman et al., 2013), and does not suggest that a short period of non-deployed military service plays a causal role. The absence of an increase in risk of fatality in motorcyclists suggests that UK safety legislation, especially in respect of helmet-wearing, is protective (Ankarath et al., 2002), as a US report of an increased risk in Gulf War veteran motorcyclists highlighted that they were less likely to wear helmets (Kang et al., 1997), in a country where helmet-wearing is optional in the majority of states.

4.4 Strengths and limitations

The strengths and limitations of the present study are similar to those described elsewhere (Bergman et al., 2014). A major strength that it was based on a large cohort covering the whole of Scotland with 30 years follow-up. It has added to the sparse evidence on accident risk in this occupational group by demonstrating that there is an overall increase in risk in younger veterans which is unrelated to the previously documented deployment-related risk. Importantly, it has also demonstrated a probable beneficial impact of a workplace-based road safety strategy. The record of RTA is based on hospital admission and death records, and is therefore likely to be reliable in respect of severe events occurring within Scotland.

The use of record linkage to analyse individual level data directly derived from health service data allowed a robust cohort study design to be employed. The results were able to be matched or adjusted for potential confounders including sex and deprivation. It was possible to do subgroup analysis by sex, birth cohort and length of service.

Limitations of the study include possible loss to follow-up of subjects due to migration away from Scotland, and the lack of any follow-up data prior to 1 January 1981. For those who are military veterans, we have not been able to link to in-service health or service records and thus any RTA occurring during service will not have been captured. The data do not reflect the overall incidence of RTA since minor injury not requiring hospitalisation, and non-injury collision, will not have been captured. We have made the assumption that there are no systematic differences in the likelihood of admission between veterans and non-veterans other than the incidence and severity of injury, and that the relative magnitude of deaths and hospitalisations equates to the relative magnitude of all episodes of RTA. Because the dataset was derived from demographic, vital record and hospital admissions data, no information was available on current or former alcohol consumption or other potential individual risk factors. As our dataset was derived from NHS records and we were unable to link to Ministry of Defence records, we had no data on the Service to which a veteran belonged (Naval Service, Army or Royal Air Force) and were therefore unable to analyse whether there were differences between the three Services. Veterans with Reserve service only could not be identified from NHS records and were therefore included among the non-veterans. This could have weakened the strength of association with military service. The paucity of literature on overall RTA risk in veterans, other than in relation to operational deployment, represented a knowledge gap, which we have sought to address.

4.5 Conclusion and recommendations for further research

The increased risk of RTA observed in serving military personnel persists in veterans through the fourth decade of life, irrespective of time elapsed since leaving service. The risk is highest in those with the shortest service, including those who did not complete training and therefore could not have deployed, and may therefore be related to risk factors other than military service, including previous childhood adversity. There is some evidence to support the effectiveness of recent MOD road safety programmes in reducing the long-term risk of RTA injury. Future research should be aimed at more in-depth identification of risk factors, especially amongst early service leavers, and monitoring ongoing trends.

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AUTHOR CONTRIBUTION STATEMENT

BPB conceived the idea and designed the study, with advice from JPP and DFM. BPB carried out the data analysis, which was overseen by DFM, and interpreted the findings. BPB wrote the first draft of the report, which was critically reviewed and edited by all authors. BPB revised the article following peer review, with advice from JPP and DFM. All authors approved the revised article.

PREVIOUS PUBLICATION

This article has not been published previously and is not under consideration for publication elsewhere.

COMPETING INTERESTS STATEMENT

Conflicts of interest: none.

BPB is a British Army veteran and former military medical officer.

FIGURE CAPTIONS

Figure 1. Nelson-Aalen plot of risk of road traffic accident by veteran status, landmark age 18 years

Figure 2. Hazard ratios for road traffic accident by birth cohort, veterans referent to non-veterans

Figure 3. Nelson-Aalen plot of risk of death from road traffic accident by veteran status, landmark age 18 years

TABLE CAPTIONS

Table 1. Cox proportional hazards model of the association between veteran status, sex, age at RTA, length of service, and risk of RTA, landmark age 18 years

Table 2. Age at first road traffic accident – veterans and non-veterans

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