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Forgotten fatalities: British military, mining and maritime accidents since 1900

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Background	Comparative long-term trends in fatal accident rates in the UK's most hazardous occupations have not been reported.
Aims	To compare trends in fatal accident rates in six of the most hazardous occupations (the three armed forces, merchant shipping, sea fishing and coal mining) and the general British workforce during peacetime years since 1900.
Methods	Examinations of annual mortality reports, returns, inquiry files and statistics. The main outcome measure was the fatal accident rate per 100 000 population employed.
Results	These six occupations accounted for ~40% of all fatal accidents in the British workforce. Fatal accident rates were highest in merchant shipping to 1914 (400–600 per 100 000) and in the Royal Air Force and sea fishing by the early 1920s (around 300 per 100 000). Since the 1950s sea fishing has remained the most hazardous occupation (50–200). Widespread reductions in fatal accident rates for each occupation have been greatest in recent years in the three armed forces and merchant shipping. Compared with the general workforce, relative risks of fatalities have increased in recent decades in all these occupations except shipping.
Conclusions	All six occupations still have high fatal accident rates. The greatly increased fatalities in sea fishing generally and in the Royal Air Force during its early years reflect, for different reasons, cultures of extreme risk-taking in these two sectors. Reductions in fatality rates in the armed forces over the last 20 years are due largely to decreases in land transport accidents.
Keywords	Accidents; army; injury; maritime; military; miners; naval; workplace hazards.

Introduction

Traditionally, fatalities in the British armed forces and maritime industries have not usually been registered with local registrars of deaths nor included in central mortality returns. Instead, they have been administered and registered separately with, respectively, the Ministry of Defence and the Registry of Shipping and Seamen.

In 1885, a Royal Commission to the House of Lords reported that 26 188 seafarers (1 in 73 of the workforce each year) had died through accidents in British merchant shipping between 1875 and 1883 [1]. This rose to 1 in 39 for sailing ships, which accounted for most British shipping vessels until the mid-1880s [2], and was 13 times higher than in British coal mining [1]. In the 1960s, hazards in trawler fishing received greater

attention following several major disasters in Arctic waters [3–5], and by the time of the 1981 census, sea fishing and merchant shipping were the two most hazardous occupations in Britain [6]. Comparisons of long-term trends in fatal accidents in the Royal Navy, Royal Air Force, Army, merchant shipping, sea fishing and coal mining have not been reported previously.

The main aim of this investigation is to compare and assess trends in fatal accident rates in these six occupations and in the general British workforce since 1900.

Methods

The study covered the period from 1900 to 2019 but excluded the World War I and II years from 1915 to 1918

Key learning points

What is already known about this subject:

- Traditionally, fatalities in the British armed forces and maritime industries fall outside conventional death registration systems and have not usually been registered with local registrars of deaths nor included in central mortality returns.
- The high mortality in merchant seafarers and in sea fishing has been identified but not previously compared with the armed forces.
- Heavy loss of lives from catastrophic ship losses and mining disasters has received much more attention than comparably large numbers of individual accident fatalities.

What this study adds:

- The high-risk sectors studied all show a reduction in fatal accident risk in the long term. This is in part due to changes in work activities and improved injury prevention, as well as a recent decrease in land transport accidents in the armed forces.
- The six occupations studied account for ~40% of all fatal work-related accidents in the British workforce since 1900 in peacetime years. All six occupations still have high fatal accident rates and, compared with the general workforce, relative risks of a fatal accident have increased in all except shipping.
- The Royal Air Force in its early years and sea fishing more generally have the highest and most persistent fatality rates. In both cases, but for different reasons, extreme risk-taking appears to be part of the culture in these sectors.

What impact this may have on practice or policy:

- Fatal accident data from the occupations studied, if regularly collected, analysed and publicized in association with information on other occupations, could improve priority setting for preventative measures.
- Standardization of data collection across sectors would enable comparisons to be refined and priority settings improved.
- Comparable international studies, also including non-fatal injuries, would improve the basis for prevention.

and 1940 to 1945, when fatal accidents were often difficult to distinguish from war casualties. The information sources used for collecting data on fatal work-related accidents and the populations employed annually in each occupation and the general workforce are detailed in the [Appendix](#) (available as [Supplementary data](#) at *Occupational Medicine Online*).

These include annual mortality reports, mortality returns, death inquiry files and statistics from the Ministry of Defence, Medical Director of the General Admiralty, Board of Trade, National Coal Board, the Health and Safety Executive and others listed in the [Appendix](#) (available as [Supplementary data](#) at *Occupational Medicine Online*). Most of these were sourced and examined at specialist archives, libraries, museums and government agency collections across England and Wales. These include the Ministry of Defence Burnett Library at Whittington barracks, Lichfield; the Institute of Naval Medicine Historic Library, Gosport; the Air Historical Branch Museum, London; the Wellcome Trust library, London; the Registry of Shipping and Seamen, Cardiff; and the Marine Accident Investigation Branch, Southampton.

The fatal accidents included in this study were all those that occurred when in regular service for the armed forces; at sea or when signed on UK-registered merchant ships and fishing vessels; within the area of

coal mines; or at work for the general population. For the armed forces, the study excluded fatalities among those who had been discharged from active service or who were in the reserve forces. For the maritime occupations, it excluded those who were on shore leave, discharged ashore through sickness or who were employed in non-UK merchant and fishing vessels. The study excluded deaths through war casualties and other non-accidental fatalities from disease, suicide and homicide.

The geographical coverage of fatal accidents varies slightly for the armed forces and maritime industries (UK coverage) compared with the general workforce, based on Health and Safety Executive data (Great Britain coverage which excludes Northern Ireland). For coal mining, coverage has changed over time between the UK and Great Britain. For the general British workforce, annual fatal accident data were available for all 110 peacetime years of the study period. For the six study occupations, annual fatality coverage was as follows; for the Royal Air Force (82 years), Royal Navy (85), army (97), coal mining (108), merchant shipping (109) and sea fishing (98). Details of these years are provided in the [Appendix](#) (available as [Supplementary data](#) at *Occupational Medicine Online*). Years with missing data were excluded from the analysis.

The main study outcome measure was the annual fatal accident rate (excluding war casualties) per 100 000 population employed each year. Methods of analysis include, first, relative risks to compare fatal accident rates in the study occupations with those in the general British workforce (which excludes the armed forces and the maritime occupations). Second, trends in annual fatal accident rates over the 120-year study duration, which were smoothed using 5-year moving averages. The study also investigated trends in fatal accident rates according to the type of accident. This was limited by a lack of detailed information provided in many annual returns, frequent amendments over time to the classification of accidents reported and the inherently different causal patterns and classifications used across occupations. We have, nonetheless, reported on trends in fatality rates for 'land transport accidents' compared with 'other accidents' in the armed forces from 2001 to 2019. Logistic regression models were used to compare percentage annual changes in fatal accident rates with 95% confidence intervals, using weighting according to the annual numbers of deaths from fatal accidents versus the rest of the populations employed annually in each armed force. Statistical significance was measured at the 5% level.

Ethical approval for the study data was not required as it was based on annual mortality reports, mortality returns, death inquiry files and statistics. Approval was obtained instead from the Ministry of Defence, coroners, the Registry of Shipping and Seamen and the Marine Accident Investigation Branch.

Results

There were almost 50 000 work-related fatalities from accidents in coal mining during peacetime years since 1900, >30 000 in merchant shipping, over 20 000 in the armed forces (with some years missing) and >5000 in the fishing industry (Table 1). This compares with 180 467 fatal accidents in the general British workforce (excluding the armed forces and the maritime occupations). A small minority of the fatalities in the armed forces and the maritime industries involved non-UK nationals, while the general workforce covers Great Britain rather than the UK and excludes the civil aviation industry, which is not covered by Health and Safety Executive reporting. Nonetheless, the six occupations in this study (with fatalities for some years not available) account for ~40% of all fatal accidents among the British workforce during the study period.

Between 1900 and 1914, fatal accident rates were highest in merchant shipping (400–600 per 100 000 population employed each year). By the early 1920s, fatality rates had become higher in sea fishing and in the newly formed Royal Air Force, founded in 1918 (both around 300 per 100 000). By the mid-1930s, fatalities were highest in sea fishing (>350) followed by the Royal Air Force and merchant shipping (150–300).

In the years immediately following World War II, a greatly reduced fatal accident rate in sea fishing (about 100) was lower than in merchant shipping and the Royal Air Force (125–200). However, from the 1950s onwards sea fishing has been the most hazardous occupation in

Table 1. Relative risks of a fatal accident at work in the British armed forces and other occupations, compared with the general British workforce since 1900

Time period	Relative risk (RR) of a fatal accident at work in each occupation compared with the general British workforce (number of fatal accidents)					
	Royal Air Force	Royal Navy	Army	Merchant shipping	Commercial sea fishing	Coal mining
	RR (No.)	RR (No.)	RR (No.)	RR (No.)	RR (No.)	RR (No.)
1900–14	^a	4.8 (1927)	3.8 (2764)	20.0 (15 705)	12.1 (1201)	5.6 (19 394)
1919–29	16.3 (807)	6.5 (887)	5.5 (1697)	13.6 (6301)	15.2 (1021)	5.7 (11 792)
1930–39	12.9 (822)	6.1 (459)	5.8 (980)	12.2 (2954)	29.5 (1059)	8.7 (8944)
1946–59	11.4 (2822)	11.7 (678)	9.5 ^b	16.0 (2994)	17.1 (652)	9.3 (6076)
1960–69	14.2 (736)	19.1 (320)	21.7 ^b	16.3 (1153)	31.6 (369)	9.5 (2006)
1970–79	19.5 (468)	22.0 (253)	21.5 (1320)	26.2 (823)	48.4 (338)	7.9 (638)
1980–89	23.6 (456)	21.6 (313)	27.7 (937)	30.1 (302)	50.7 (241)	8.9 (271)
1990–99	28.9 (244)	32.8 (152)	41.5 (558)	20.6 (58)	99.7 (233)	21.4 (48)
2000–09	33.1 (134)	41.8 (127)	52.4 (469)	18.7 (48)	121.7 (127)	18.4 (11)
2010–19	32.2 (61)	24.5 (40)	57.1 (257)	13.0 (21)	113.5 (65)	48.2 (7)
Total (1900–2019)	10.8 (6550)	11.5 (5156)	10.1 (10 512)	30.0 (30 089)	27.3 (5306)	13.3 (49 187)

Details of years with missing annual mortality returns for each occupation are provided in the [Appendix](#) (available as [Supplementary data](#) at *Occupational Medicine* Online).

^aThe Royal Air Force was not founded until 1918.

^bNumbers of deaths not available from mortality returns.

the UK (50–200). From the 1960s, fatal accident rates have been broadly comparable in the three armed forces and merchant shipping, but often higher than in coal mining. However, in the most recent years since about 2012, there has been some evidence of a divergence across the armed forces, with a continuing reduction in the fatality rate in the Royal Navy, but a slight increase in the army (Figure 1b). In the most recent decades, reductions in fatal accident rates have been greatest in the three armed forces and merchant shipping (Figure 1b).

Figure 2 shows trends in fatal accident rates for ‘land transport accidents’ and all ‘other accidents’ for each of the armed forces over the recent 19-year period from 2001 to 2019. For land transport accidents, there were large significant annual reductions in fatality rates for each of the armed forces (army = 8% reduction per annum; 95% confidence interval = 6–10%; Royal Navy = 10%; 6–13%; Royal Air Force = 9%; 5–12%). For other types of accident, there were smaller or non-significant annual reductions (army = 0%; –2–3%; Royal Navy = 6%; 1–10%; Royal Air Force = 1%; 3–5%).

In coal mining, during peacetime years between 1900 and 1938, roof or ground falls and firedamp or coal dust explosions accounted for 55% of 10 891 fatalities from accidents in South Wales alone. This had fallen to 46% of 1275 fatalities by 1948–69 and 24% of 102 fatalities during 1970–78.

The fatal accident rate in the general British workforce fell over time from 26 per 100 000 employed in 1900 to 16 by the 1920s, 8.4 in the late 1940s, 3.0 during the 1970s and 0.5 since 2010. Compared with the general British workforce, the relative risk of a fatal accident at work has increased since the 1970s or 1980s in each of the armed forces, commercial sea fishing and coal mining (Table 1). During the most recent time period from 2010 to 2019, the corresponding relative risks were: commercial sea fishing (114), army (57), coal mining (48), Royal Air Force (32), Royal Navy (25) and merchant shipping (13).

Discussion

The study reports on several of the most hazardous occupations with fatalities that fall outside conventional death registration processes. It is also the first study that has documented long-term trends in fatal accident rates comparatively across occupations that have traditionally been considered as among the most hazardous in the UK, and how they compare with the general workforce. It shows that widespread reductions in fatal accident rates over time for each occupation have been greatest in recent years in the three armed forces and merchant shipping. Compared with the general workforce, however, the relative risks of a fatal accident have increased during recent decades in the armed forces, coal mining and sea fishing, but not in merchant shipping.

The study covers >100 000 people who died from accidents at work in the six occupations investigated. This represents ~40% of all fatal work-related accidents in the British workforce during the study period. The study is based on annual mortality returns, reports, death inquiry files and statistics, accessed at or from specialized archives, libraries, museums and government agencies across the country.

Limitations are that the annual mortality reports or returns could not be located for every year and in some years they were not released. The inclusion criteria for fatal accidents differ slightly across some occupations; thus, for the armed forces all fatal accidents while in service are covered, for seafarers and fishermen it is those that occur at sea or during each time-limited contract of employment and for coal miners it is those that take place within the area of the mine.

The armed forces differ from other sectors as recorded accident fatalities include road transport deaths, not only on bases and during training, but also during off-duty periods. Such accidents are inherently excluded from the data for the maritime industries, while for miners and for the general working population they are only recorded when at work and not on public roads outside work or when commuting. Thus, comparisons of absolute rates between the armed forces and other occupations need to be made with some care, although trend data are comparable.

Although there was some variation across occupations in geographical coverage of fatalities between the UK and Great Britain, as the population of Northern Ireland is <3% of the UK, this would have little effect on fatality comparisons. UK coverage also changed after the Irish Free State was established in 1922, although a 7% population reduction should also not affect the fatality trends and comparisons substantially.

For the armed forces, in a few mortality reports, fatal accidents were not distinguished from non-accidental deaths, which variously included homicide, suicide and/or war casualties. The latter three would usually account for a small minority of fatal injuries, except in World War years which have been excluded from this study. Further details of this coverage are included in the notes to Figure 1. In the Royal Navy and the maritime industries many fatal accidents involve unwitnessed drowning, which are not always possible to determine conclusively as accidental, although they are often recorded as accidental deaths at coroner’s inquests. Also, the causes of disappearances from ships at sea are not always possible to determine from marine or overseas consular investigations—and coroner’s inquests are seldom held without post-mortem evidence—but are conventionally included with suicides.

The study shows a history of very high fatal accident rates in each of the six occupations studied. Rates for all six have fallen progressively over most of the 20th

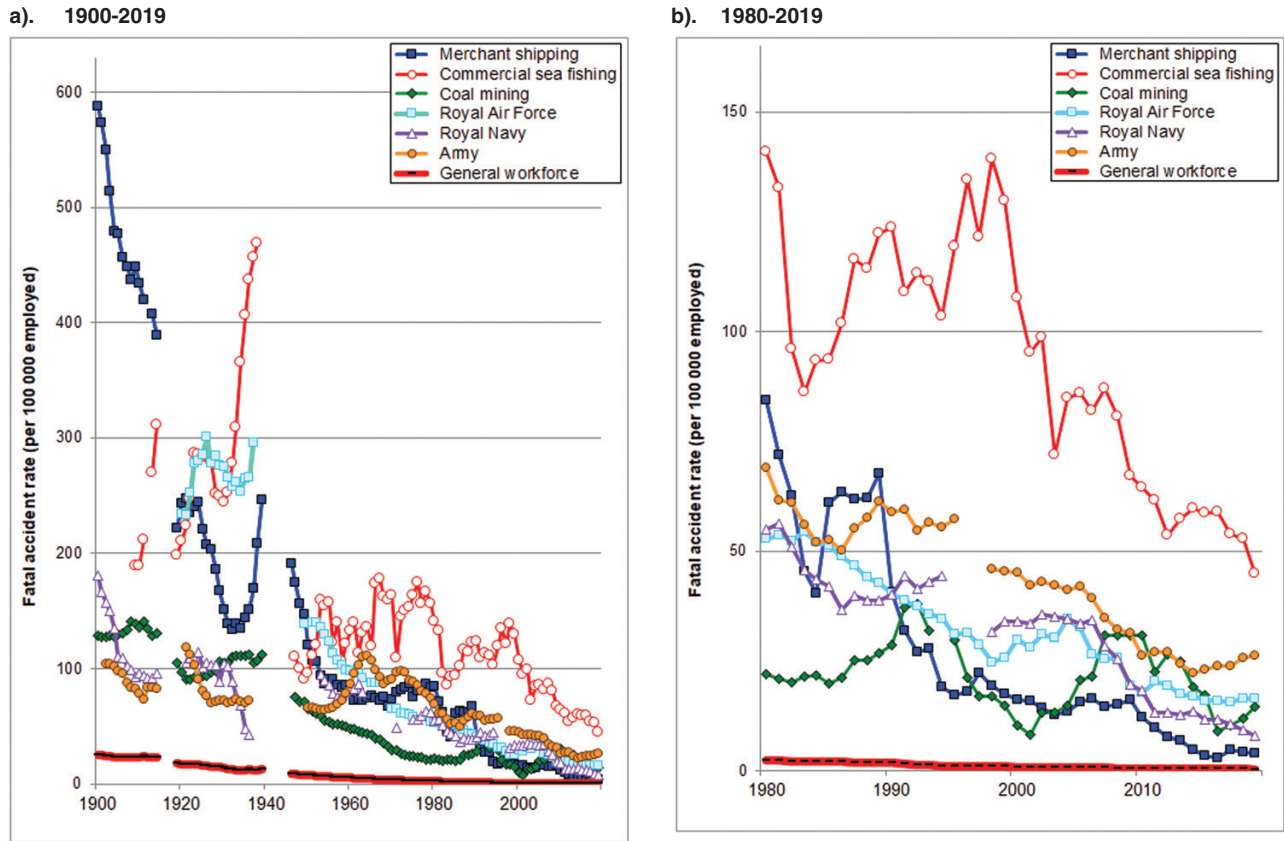


Figure 1. Trends in fatal accident rates in the British armed forces, other occupations and the general British workforce: (a) 1900–2019, (b) 1980–2019.

Notes: Fatal accident rates are smoothed using 5-year moving averages.

1. World war years (1915–18 and 1940–45) have been excluded from the study.

2. The Royal Air Force was founded in 1918.

3. Other years with missing data are because annual death returns were not available or because fatal accidents could not be distinguished from war casualties or deaths ‘in action’ in the annual returns, during years that involved conflicts involving the respective armed forces.

4. Fatal accident rates are smoothed using 5-year moving averages.

5. Royal Air Force: 1920–37 includes injuries through homicide

Royal Navy: 1953–71, 1976, 1978 includes injuries through suicide, homicide and deaths ‘in action’

Army: 1950–78 includes injuries through suicide and homicide, and refers to males

6. The maximum and minimum numbers employed in each armed force or industry (for years with fatal accident rates that were available) are as follows:

Merchant shipping:	largest population employed = 278 593 in 1920; smallest = 20 120 in 1992
Commercial sea fishing:	105 349 (1908); 11 692 (2017)
Royal Air Force:	493 965 (1946); 25 932 (1920)
Royal Navy:	158 300 (1914); 32 480 (2018)
Army:	286 801 (1902); 79 030 (2019)
Coal mining:	1 269 547 (1920); 732 (2017)

century and through to 2019. The extremely high mortality in merchant shipping during the earliest years was caused largely by excess mortality in sailing ships, compared with less hazardous steamships, as reported in the earlier 1885 Royal Commission into Loss of Life at Sea [1]. Because of their low fuel costs and difficulties navigating the Suez and Panama canals with sails, large sailing ships and barques were normally used instead of steamships on the longest, most hazardous voyages around Cape Horn and the Cape of Good Hope [7]. Smaller sailing vessels, mostly trading around the UK and northern Europe, were vulnerable to wrecking

or foundering in sudden storms and gales. Following World War I, most sailing ships had been decommissioned, leading to a greatly reduced fatal accident rate, which has continued with the subsequent replacement of steamships with motor vessels and successive improvements in ship design, safety and ship communications. The reduced fatalities in recent decades also reflect that most UK cargo-carrying ships were re-registered during the 1980s with flags of convenience such as Panama, Liberia and Cyprus, so that UK merchant shipping has become comprised largely of less hazardous passenger ships, ferries, tugs and dredgers [8].

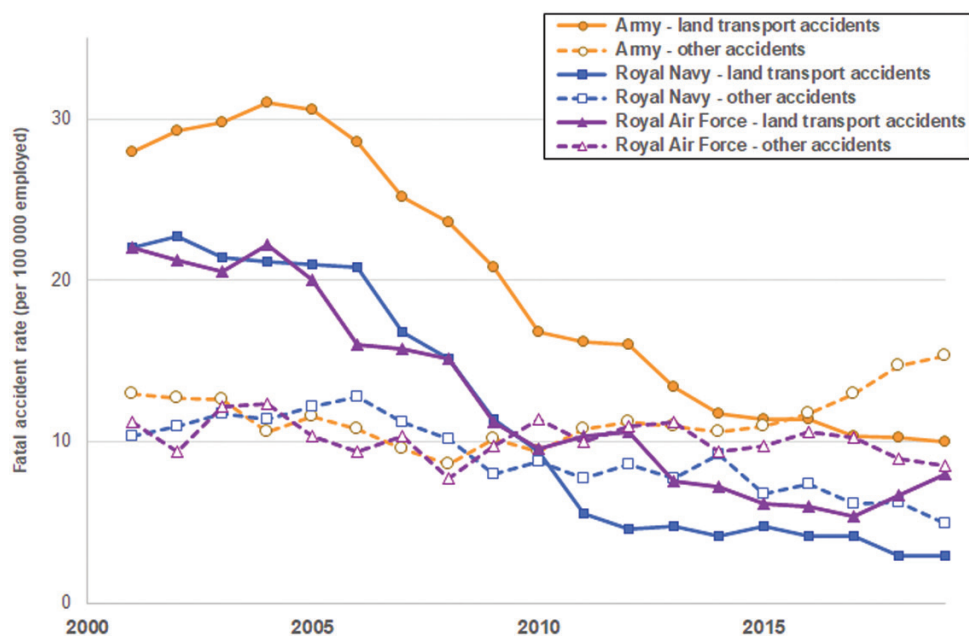


Figure 2. Trends in fatal accident rates in the British armed forces since 2001 according to the type of accident. Note: Fatal accident rates are smoothed using 5-year moving averages.

In the years following both World Wars, fatal accident rates in sea fishing were substantially reduced as local fishing stocks replenished through greatly decreased fishing during war time. Fatality rates then subsequently increased through to the 1930s and 1970s, respectively, as local fishing stocks declined and a greater volume of fishing moved to more hazardous Arctic conditions off Iceland, Norway, Bear Island, Newfoundland and Russia. Although Arctic fishing largely ceased during the late 1970s, following the Icelandic Cod Wars, and most distant-water trawlers were decommissioned, the fatal accident rate has remained much higher and has fallen less than in the other occupations. This has been linked to extreme occupational hazards [4,9], a long-standing culture of risk-taking and a lack of attention to safety recommendations in the fishing industry, with continuing hazardous working practices such as lone fishing, deficient safety equipment and unseaworthy vessels [10,11].

There has also been less evidence of a recent reduction in the fatal accident rate in coal mining, although few deep coal mines now remain [12]. The numbers employed in UK coal mining have fallen from a peak of 1.27 million in 1920 to fewer than 1000 in recent years, so that the recent annual fatality trend is less stable than for the other occupations. Fatality reductions in coal mining were linked to improvements over time in safety, particularly the prevention of roof or ground falls and firedamp or coal dust explosions [13].

After the Royal Air Force was founded in 1918, an extremely high fatal accident rate led to the Service becoming, briefly, the most hazardous British occupation in the late 1920s. This has been linked to a culture of

risk-taking and error of judgement among some pilots, as well as unreliability of early aircraft. For example, the first (military aviation) Inspector of Accidents reported from an investigation of 473 accidents between 1920 and 1924, that error of judgement was the main cause for 54%, and engine failure, structural or design defects for 30% [14]. Since the 1960s, the fatal accident rate in the Royal Air Force has become broadly comparable with the Royal Navy and army. The reduction in fatalities can be explained partly by improvements in aircraft design and safety measures, including the evolution of parachutes and later ejector seats [15–17], and a decrease over time in the proportion of Royal Air Force personnel who were flight crew rather than ground crew.

There have been widespread and continuing reductions over time in fatal accident rates in each of the six occupations studied. In the last 20 or 30 years, these have been greatest in the armed forces and merchant shipping. In the armed forces, this is largely due to a decrease in off-duty land transport accidents, but also reflects changes in work activities and improved injury prevention. The Health & Safety at Work Act of 1974 applies to the armed forces [18]. Although the Secretary of State for Defence can claim exemption on behalf of the armed forces from some requirements, in the interests of national security, in practice this is rarely exercised. A review of 112 fatal land transport accidents in the armed forces between 2009 and 2013 reported that most (85%) occurred when off-duty and most were motor vehicle (44%) or motorcycle accidents (32%) followed by pedestrian (16%) and occupation-specific accidents (8%) [19].

Heavy loss of life from catastrophic ship losses and mine disasters has received much more attention than comparably large numbers of individual accident fatalities [20–25]. This study reports on ‘forgotten’ fatal accidents during peacetime years in occupations that mostly fall outside conventional death registration systems and reporting. There have been widespread reductions in fatal accident rates over time for each occupation. However, compared with the general workforce, the relative risk of a fatal accident has increased over the last 30 or 40 years in all occupations except shipping. These increased risks are greatest in commercial sea fishing, which remains the most hazardous occupation in the UK.

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Competing interests

None declared.

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