

Trajectories of alcohol misuse among the UK Armed Forces over a 12-year period

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ABSTRACT

Aim To identify the main trajectories of alcohol misuse among UK military personnel from 12 years after the start of the Iraq war (2003) and the factors associated with each trajectory. **Design** Longitudinal cohort study with three phases of data collection (2004–06, 2007–09 and 2014–16). **Setting** United Kingdom. **Participants** Serving and ex-serving personnel of the UK Armed Forces ($n = 7111$) participating at Phase 1 and at least one follow-up phase of the King's Centre for Military Health Research (KCMHR) cohort study. **Measurements** Trajectories of alcohol misuse were derived from scores using the Alcohol Use Disorders Identification Test (AUDIT-10) over three data collection phases. Demographic and military characteristics were collected and, among the key covariates, post-traumatic stress disorder (PTSD) was measured using the PTSD checklist (PCL-C) and childhood interpersonal stress and violence was measured using items from the Adverse Childhood Experiences questionnaire. **Findings** Five trajectories of alcohol misuse were identified, including 'no misuse' ($n = 2249$, 31.6%) and 'hazardous' ($n = 3398$, 47.8%), 'harmful' ($n = 832$, 11.7%), 'severe-to-hazardous' ($n = 258$, 5.3%) and 'severe' ($n = 374$, 3.6%) drinking. Substantial changes were evident only among severe drinkers, where more than half reduced over the study period. The factors most strongly associated with belonging to harmful/severe drinking classes were young age, male gender and childhood adversities and antisocial behaviour. Severe drinkers at Phase 1 were more likely to report probable PTSD and shorter military careers and were less likely to serve as Officers. Persistent severe drinkers were less likely to serve in the RAF compared to the Army and were more likely to be reserves. Not misusing alcohol was also associated with reserve status and having left service. **Conclusions** In a cohort of approximately 7000 UK military personnel, trajectories of alcohol misuse appeared stable between 2004 and 2016. More than half of severe drinkers made substantial improvements over the period, but 68% of the cohort continued to drink dangerously or harmfully. Lack of change for the majority of the sample signals the need for strategies to address alcohol misuse and its cultural and psychosocial drivers.

Keywords Alcohol misuse, drinking, longitudinal, military, trajectories, UK armed forces, veterans.

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INTRODUCTION

Alcohol misuse remains a concern for the UK Armed Forces (UKAF), with 10% meeting criteria for harmful drinking compared to 3% of the general population [1,2]. Whilst rates of alcohol misuse remain high in the UKAF, prevalence is steadily decreasing [2–5], mirroring declining trends in wider society [1,6]. Rather than adhering to uniform decreases, drinking patterns inevitably vary within a

population. For example, increases were observed among UKAF personnel who reported combat exposures [7], persisting/new-onset symptoms of post-traumatic stress disorder (PTSD) and relationship breakdowns [5].

A number of international studies have assessed longitudinal alcohol outcomes in military samples [8–10]. Increasingly, such studies are applying advanced statistical methods, such as latent growth mixture modelling (LGMM), to study the heterogeneity of longitudinal change

within samples [11]. By dividing the sample into subgroups that follow distinctive trajectories, LGMM can enable an investigation into whether decreases in prevalence are apparent across all groups of the UKAF or if they are driven by specific subgroups. Using LGMM methods, Goodwin *et al.* (2017) demonstrated that only 3% of a UKAF sample reduced their alcohol consumption over an 8-year period [12]. Stable consumption was similarly observed in a study of US veterans, with only 2% decreasing over the 4-year period [13]. Whilst alcohol consumption has been analysed in the UK military in a comparatively older sample [12], no studies have longitudinally analysed trends of alcohol misuse. This is a salient outcome as it captures other elements of harm, such as alcohol-related problems and dependence [14].

The primary aim of this study was to identify the most common trajectories of alcohol misuse in a large UKAF cohort sample from 2004, soon after the start of the Iraq war (2003), to 2016. A second aim was to examine the drinking profiles of each class and a third aim was to analyse the demographic, military, health and social factors associated with belonging to the trajectory classes identified. In acknowledgement of the relationship between negative alcohol outcomes and deployment exposures [7,15–18], we examined associations between combat factors and trajectory class membership among those who deployed to Iraq or Afghanistan.

METHODS

Design

This study draws from three phases of data from the KCMHR cohort study, which was established to examine the mental and physical health of a random stratified UK tri-service sample serving at the time of the Iraq War [2–4]. Data were collected via self-report questionnaires focusing on socio-demographic characteristics, service details, deployment and post-deployment experiences, physical and mental health outcomes and relationship and life-style factors. Hard copy questionnaires were distributed by post and visits to military bases at each phase and, at Phase 3, electronic questionnaires were also employed. The sample used in this analysis consisted of participants with Alcohol Use Disorders Identification Test (AUDIT) scores at Phase 1 (baseline) and at least one other

phase (Phases 2 and/or 3). A total of 10 272 responded at Phase 1 (2004–06) with an overall response rate of 61% [3]. Of this sample, 7226 responded at Phase 2 (2007–09) and/or Phase 3 (2014–16). Response rates for the follow-up phases are described at Phases 2 [4] and 3 [2]. Participants were further excluded if they did not have full AUDIT scores at Phase 1 or lacked follow-up data. A total of 7111 were therefore included in the final analysis and the number responding at each phase is outlined in Table 1. The response rate for participants at Phase 1 who subsequently participated in Phases 2 and/or 3 was 70%.

Measures

Alcohol outcomes

Alcohol misuse was assessed using the 10-item AUDIT-10 from the World Health Organization (WHO) [14]. Each item was scored from 0 to 4 and summed to generate a continuous score ranging from 0 to 40. We examined other drinking characteristics in a descriptive analysis. Excessive weekly consumption was defined as average alcoholic units per week calculated from responses to how often alcohol was consumed and how many units were consumed on a typical drinking day. The cut-off (> 14) for excessive weekly consumption was informed by current UK guidelines [19]. Symptoms of dependence (cut-off ≥ 4 ; range = 0–12) [17] were calculated by totalling three items within the domain, including how often participants were unable to stop drinking once starting in the previous year. Alcohol-related problems (cut-off ≥ 4 ; range = 0–12) [17] were calculated by summing items within the domain, including how often participants felt guilt or remorse after drinking. We calculated the number of abstainers per class, which was defined as those who answered ‘never’ to ‘how often do you have a drink containing alcohol?’ and if they had not been drinkers within the past year.

Covariates of trajectory classes

Socio-demographic characteristics were measured at baseline (Phase 1) and included age (18–24/25–34/35+ years), gender (male/female) and relationship status (married/single/separated, divorced or widowed) and living with

Table 1 Number and percentage of responses at each phase.

	<i>n</i>	%
Phases 1, 2 and 3	4059	57.08
Phases 1 and 2	2319	32.61
Phases 1 and 3	733	10.31

children under the age of 18 years (yes/no). Military characteristics were also measured at baseline (Phase 1) and included branch of service (Naval Services, including Royal Navy and Royal Marines/Army/Royal Air Force (RAF)), engagement type (regular or reserve) and rank [enlisted/Non-Commissioned Officer (NCO)/Commissioned Officer (CO)].

Deployment status was defined as never having deployed, deploying to a pre-2003 deployment only (including operations in Bosnia, Kosovo, Macedonia, Northern Ireland, the Falklands or Sierra Leone), deploying to a post-2003 Iraq (TELIC) and Afghanistan (HERRICK) operation, or having deployed to both pre- and post-2003 operations. Length of service was defined using self-reported data and missing data were supplemented using dates supplied by Defence Statistics (Ministry of Defence). Continuous years were categorized into short- (< 12 years) and long-term (\geq 12 years) service based upon the Army Terms of Service Regulations [20], where a 'short service engagement' was defined as 6 months to 12 years. A serving status variable was devised as 'still serving' or 'discharged by Phase 1/2/3', indicated by the phase participants first reported their ex-serving status. Missing data were supplemented using data from Defence Statistics.

Baseline Post-Traumatic Stress Disorder (PTSD) symptoms were measured using the 17-item National Centre for PTSD checklist (PCL-C) [21]. A cut-off of 50 indicated probable PTSD. Baseline sleeping difficulties were determined using an item from the Hopkins symptom checklist [22] and endorsements of 'moderate' and 'severe' problems indicated difficulties. A subanalysis explored three combat factors among those deployed to Iraq and/or Afghanistan: perceived threat of injury/death on an Iraq or Afghanistan deployment (yes/no) was determined using a single item asking if participants believed themselves to be in serious danger of being injured/killed at any phase. Proximity to the wounding/killing of others was defined using items from the Combat Experiences Scale (CES) [23] clustered by a previous analysis [24] and included seeing personnel seriously wounded or killed, witnessing a friend being shot, giving aid to the wounded and handling dead bodies. Combat role was defined as deploying in a direct combat role or a support/support service role at any phase.

Family childhood adversity was measured using the Adverse Childhood Experiences (ACE) questionnaire [25] and drawn from four positive items (e.g. 'I came from a close family') and four negative items (e.g. 'I used to be hit/hurt by a parent/caregiver regularly'). A count was categorized into 0, 1 and 2+ adversities [12]. Childhood antisocial behaviour was generated from positive endorsements of the ACE item: 'I used to get into physical fights at school' and at least one of the following items: 'I often

used to play truant at school', 'I was suspended or expelled from school' or 'I did things that should have got me (or did get me) into trouble with the police' [26].

Statistical analysis

Latent growth mixture modelling

Trajectories were estimated using latent growth mixture models (LGMM) [11] in Mplus version 7.4 with continuous AUDIT-10 scores as the outcome. This approach groups individuals with similar trajectories *post-hoc* rather than characterizing groups using *a priori* criteria. Three phases of data were used in this model. At each phase, respondents were more likely to be older, female, regulars, Officers and Royal Air Force (RAF) personnel compared to non-respondents. Non-response in the cohort study has not been associated with poorer mental health outcomes, but those with alcohol misuse at Phase 2 were less likely to respond at Phase 3 [2]. Response bias is mitigated by the use of full maximum likelihood estimation (FIML), which provides unbiased estimates under the assumption that data are missing at random (MAR) conditional on the variables related to the missingness mechanism being included in the analysis. It is not possible to confirm whether the MAR assumption holds but, to increase the likelihood that this assumption is satisfied, we tested conditional models incorporating associates of attrition (including age, rank and branch of Service). The resulting trajectory shapes were not substantially different to the unconditional models, showing that bias was not a significant concern in this analysis.

Basic LGMMs were conducted with growth factor variances (i.e. random intercepts and slopes) constrained to zero, increasing within-class similarity and between-class differences. These were assessed against models where growth factors were allowed to vary. Due to the positive skew of alcohol misuse scores and evidence of a potential floor effect, alcohol misuse models assumed a censored normal distribution. The final models were unconditional, meaning that models included only repeated measures of the outcome with no additional covariates. Models with 1–6 classes were tested sequentially and model fit indicators were used to assess their relative fit to the data. These included Akaike's information criteria (AIC), Bayesian information criteria (BIC) and sample-size adjusted Bayesian information criteria (SABIC), where lower values indicated the most parsimonious solution. The Lo–Mendell–Rubin likelihood ratio test (LMR-LRT) indicated whether an additional class provided a better fit relative to a model with one less class [27]. The precision of class assignment was assessed using entropy values (where optimum values are closer to 1) and average posterior probabilities (where \geq 0.70 indicates adequate class

separation) [28]. In addition to formal statistical criteria, the interpretability and value of additional trajectories helped to inform the selection of a best class solution [28]. The trajectory classes were labelled in reference to the WHO's thresholds for 'hazardous' drinking (AUDIT ≥ 8) and 'harmful' drinking (AUDIT ≥ 16) and the term 'severe' was used to represent levels of drinking among classes scoring more than 20.

Descriptive drinking profiles and covariate analyses

Once the best-fitting model for alcohol misuse was identified, descriptive analyses were conducted in Stata version 15.0 to investigate the percentage of each class meeting cut-offs for other drinking outcomes derived from the AUDIT-10. We assessed the factors associated with class membership in univariate and adjusted multinomial logistic regression models using Stata version 15.0. Factors which remained associated were entered into multinomial logistic regression mixture models conducted in Mplus version 7.4 using a three-step approach [29]. This involved calculating and applying a measurement error from the average posterior probabilities of the best class solution, accounting for the uncertainty of classification. Factors were considered associated if *P*-values were below a conservative threshold of 0.005 in order to account for multiple comparisons [30].

Steps were repeated in a subanalysis of personnel deployed to Iraq or Afghanistan to examine combat factors. In preliminary analyses conducted in Stata version 15.0, only perceived threat of injury/death on deployment was associated with class membership and included in the final regression models. The latent class variable of the 'most likely' alcohol misuse class was used as the outcome of these models and the 'hazardous drinking' class was the reference group. The current analysis was not pre-registered on a publicly available platform, and therefore all results should be considered exploratory.

RESULTS

Sample characteristics

Most of the sample were male (89.1%, $n = 6332$) and younger than 35 years at Phase 1 (median = 34.6, interquartile range = 28.6–40.5) (Table 2). The majority were Army personnel (63.2%, $n = 4496$), NCOs (61.5%, $n = 4371$) and regulars (83.3%, $n = 5926$), and just over half were still serving at Phase 3 (51.3%, $n = 3647$). Most had experienced at least one experience of family childhood adversity (54.9%, $n = 3797$) and 88.5% ($n = 6280$) had deployed to a pre-2003 or post-2003 deployment; 3.6% ($n = 252$) reported symptoms of probable PTSD and 25.8% ($n = 1831$) reported sleeping difficulties at Phase 1. Of those deployed to Iraq or Afghanistan ($n = 5126$), 84.9% ($n = 4300$) had experienced perceived threat of injury or death on deployment.

Trajectory analyses

A one-class LGMM of the full sample showed an average decrease from an AUDIT score of 9 at Phase 1 to 8 at Phase 3. A five-class LCGA model (Fig. 1) was selected as the best class solution when balancing model fit statistics, a statistically significant LMRT result and the emergence of a class with a decreasing trajectory (Supporting information, Table S1).

The five alcohol misuse classes showed patterns of 'no misuse' (31.6%, $n = 2249$), 'hazardous' (47.8%, $n = 3398$), 'harmful' (11.7%, $n = 832$), 'severe' (3.6%, $n = 374$) and 'severe-to-hazardous' (5.3%, $n = 258$) drinking. 'No misuse' exhibited no indications of alcohol misuse during the study period. 'Hazardous' drinkers formed the largest class and levels of misuse were approximate to the lower threshold of alcohol misuse (AUDIT ≥ 8). Mean scores of the 'harmful' drinking class met the harmful threshold (AUDIT ≥ 16) and a non-significant slope suggested a stable trajectory. 'Severe-to-hazardous' drinkers

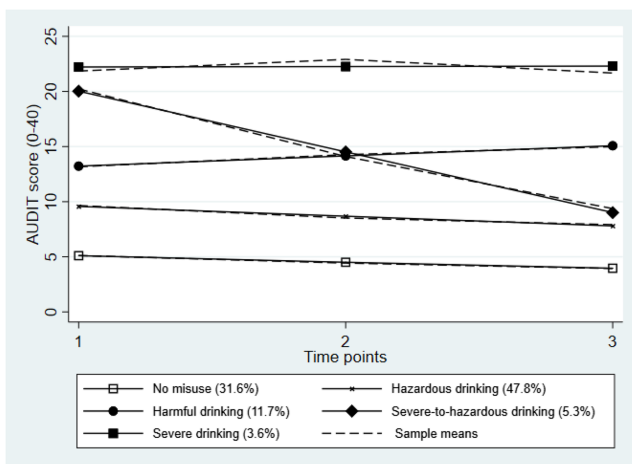


Figure 1 Estimated and sample mean trajectories of alcohol misuse in the whole sample ($n = 7111$)

Table 2 Characteristics and associations between covariates and alcohol misuse trajectory classes (reference category: hazardous drinking).

Covariates	Full sample N = 7111 (100%)		No misuse n = 2249 (31.6%)		Hazardous drinking n = 3398 (47.8%)		Harmful drinking n = 832 (11.7%)		Severe-to-hazardous drinking n = 374 (5.3%)		Severe drinking n = 258 (3.6%)	
	N (%)	n (%)	aOR ^a (95% CI)	n (%)	n (%)	aOR ^a (95% CI)	n (%)	aOR ^a (95% CI)	n (%)	aOR ^a (95% CI)	n (%)	aOR ^a (95% CI)
Age groups (years)												
18–24	862 (12.12)	167 (7.43)	1.00	375 (11.04)	135 (16.23)	1.00	110 (29.41)	1.00	75 (29.07)	1.00		
25–34	2838 (39.91)	726 (32.38)	1.74 ^a (1.13–2.68)	1420 (41.79)	411 (49.40)	0.35 ^c (0.20–0.62)	177 (47.33)	0.19 ^c (0.09–0.37)	104 (40.31)	0.11 ^c (0.04–0.31)		
35 +	3411 (47.91)	1356 (60.29)	4.07 ^c (2.53–6.56)	1603 (47.17)	286 (34.38)	0.13 ^c (0.08–0.23)	87 (23.26)	0.08 ^c (0.04–0.17)	79 (30.62)	0.06 ^c (0.02–0.16)		
Gender												
Male	6332 (89.05)	1859 (82.66)	1.00	3103 (91.32)	775 (93.15)	1.00	348 (93.05)	1.00	247 (95.74)	1.00		
Female	779 (10.95)	390 (17.34)	6.70 ^c (4.49–10.00)	295 (8.68)	57 (6.85)	0.33 ^c (0.21–0.53)	26 (6.95)	0.25 ^c (0.13–0.48)	11 (4.26)	0.07 ^c (0.03–0.17)		
Relationship status												
Married	5576 (78.41)	1905 (84.74)	1.00	2657 (78.22)	622 (74.76)	1.00	221 (59.25)	1.00	171 (66.28)	1.00		
Single	1063 (14.95)	207 (9.21)	0.38 ^c (0.28–0.52)	508 (14.95)	156 (18.75)	1.76 ^a (1.03–3.02)	123 (32.98)	3.67 ^c (2.09–6.44)	69 (26.74)	3.32 ^c (1.55–7.12)		
Separated/ divorced/ widowed	469 (6.60)	136 (6.05)	0.62 ^a (0.41–0.92)	232 (6.83)	54 (6.49)	1.00 (0.59–1.70)	29 (7.77)	1.22 (0.57–2.57)	18 (6.98)	0.75 (0.25–2.24)		
Living with children												
Yes	3056 (42.98)	1118 (49.71)	1.65 ^c (1.33–2.04)	1453 (42.76)	321 (38.58)	0.70 ^a (0.53–0.92)	86 (22.99)	0.34 ^c (0.23–0.52)	78 (30.23)	0.34 ^c (0.18–0.63)		
No	4055 (57.02)	1131 (50.29)	1.00	1945 (57.24)	511 (61.42)	1.00	288 (77.01)	1.00	180 (69.77)	1.00		
Branch of service												
Naval Services	1169 (16.44)	347 (60.43)	0.75 ^a (0.57–0.99)	568 (16.72)	135 (16.23)	1.03 (0.73–1.46)	70 (18.72)	1.35 (0.85–2.15)	49 (18.99)	1.23 (0.62–2.45)		
Army	4496 (63.23)	1359 (15.43)	1.00	2133 (62.77)	565 (67.91)	1.00	251 (67.11)	1.00	188 (72.87)	1.00		
RAF	1446 (20.33)	543 (24.14)	1.34 ^b (1.07–1.67)	697 (20.51)	132 (15.87)	0.59 ^c (0.42–0.81)	53 (14.17)	0.59 ^a (0.37–0.96)	21 (8.14)	0.15 ^c (0.07–0.30)		
Status												
Reserve	1185 (16.66)	507 (22.54)	1.54 ^c (1.18–2.04)	501 (14.74)	110 (13.22)	1.11 (0.77–1.59)	27 (7.22)	0.68 (0.38–1.19)	40 (15.50)	2.08 ^a (1.03–4.17)		
Regular	5926 (83.34)	1742 (77.46)	1.00	2897 (85.26)	722 (86.78)	1.00	347 (92.78)	1.00 (0.84–2.61)	218 (84.50)	1.00		
Rank												
Enlisted	1110 (15.61)	280 (12.45)	1.00	474 (13.95)	153 (18.39)	1.00	113 (30.21)	1.00	90 (34.88)	1.00		
NCO	4371 (61.47)	1327 (59.00)	0.80 (0.58–1.11)	2148 (63.21)	523 (62.86)	0.60 ^a (0.38–0.96)	223 (59.63)	0.42 ^b (0.23–0.78)	150 (58.14)	0.21 ^c (0.09–0.50)		
Officer	1630 (22.92)	642 (28.55)	1.05 (0.74–1.50)	776 (22.84)	156 (18.75)	0.60 ^a (0.36–0.98)	38 (10.16)	0.29 ^c (0.15–0.59)	18 (6.98)	0.08 ^c (0.03–0.20)		
Deployment												
Pre-2003 only	1163 (16.40)	417 (18.58)	0.82 (0.59–1.12)	551 (16.26)	113 (13.61)	0.92 (0.57–1.48)	47 (12.57)	1.11 (0.54–2.52)	35 (13.67)	1.24 (0.47–3.32)		
Post-2003 Iraq and Afghanistan only	1722 (24.28)	559 (24.91)	0.89 (0.66–1.22)	816 (24.08)	191 (23.01)	0.67 (0.43–1.04)	89 (23.80)	0.60 (0.34–1.08)	67 (26.17)	0.65 (0.25–1.70)		
Both pre- and post-2003 deployments	3395 (47.86)	928 (41.35)	0.64 ^c (0.48–0.86)	1678 (49.51)	448 (53.98)	1.23 (0.73–2.08)	208 (55.61)	1.60 (0.88–2.93)	133 (51.95)	2.04 (0.87–4.81)		
Non-deployed	813 (11.46)	340 (15.15)	1.00	344 (10.15)	78 (9.40)	1.00	30 (8.02)	1.00	21 (8.20)	1.00		
Serving status												
Still serving	3647 (51.32)	1029 (45.79)	1.00	1833 (53.96)	460 (55.35)	1.00	212 (56.68)	1.00	113 (43.80)	1.00		

(Continues)

Table 2. (Continued)

Covariates	Full sample N = 7111 (100%)		No misuse n = 2249 (31.6%)		Hazardous drinking n = 3398 (47.8%)		Harmful drinking n = 832 (11.7%) (5.3%)		Severe-to-hazardous drinking n = 374 (5.3%)		Severe drinking n = 258 (3.6%)	
	N (%)	n (%)	aOR [†] (95% CI)	n (%)	aOR [†] (95% CI)	n (%)	aOR [†] (95% CI)	n (%)	aOR [†] (95% CI)	n (%)	aOR [†] (95% CI)	n (%)
Discharged By Phase 1	735 (10.34)	261 (11.63)	1.84 ^c (1.32–2.56)	315 (9.27)	80 (9.63)	1.36 (0.75–2.46)	40 (10.70)	0.74 (0.33–1.66)	39 (15.12)	1.39 (0.49–3.93)		
Discharged By Phase 2	1437 (20.22)	498 (22.16)	1.62 ^c (1.25–2.10)	642 (18.90)	153 (18.41)	1.08 (0.73–1.58)	71 (18.98)	0.55 ^a (0.30–0.98)	73 (28.29)	1.17 (0.60–2.27)		
Discharged By Phase 3	1288 (18.12)	459 (20.43)	1.47 ^c (1.16–1.86)	607 (17.87)	138 (16.61)	0.94 (0.69–1.29)	51 (13.64)	0.64 (0.40–1.05)	33 (12.79)	0.85 (0.42–1.74)		
Length of Service Long-term (≥ 12 years)	6100 (86.12)	1959 (87.42)	1.00	2960 (87.52)	714 (85.82)	1.00	289 (77.69)	1.00	178 (69.53)	1.00		
Short-term (< 12 years)	983 (13.88)	282 (12.58)	0.74 (0.53–1.01)	422 (12.48)	118 (14.28)	0.98 (0.61–1.56)	83 (22.31)	2.44 ^c (1.32–4.55)	78 (30.47)	3.70 ^c (1.54–9.09)		
Family childhood adversity												
0	3125 (45.15)	1120 (51.28)	1.00	1504 (45.38)	316 (38.82)	1.00	123 (34.17)	1.00	62 (24.80)	1.00		
1	1362 (19.68)	413 (18.91)	0.78 ^a (0.61–0.99)	687 (20.73)	151 (18.55)	1.13 (0.80–1.60)	63 (17.50)	1.19 (0.74–1.93)	48 (19.20)	2.29 ^a (1.14–4.58)		
2+	2435 (35.18)	651 (29.81)	0.66 ^c (0.53–0.82)	1123 (33.89)	347 (42.63)	2.21 ^c (1.51–3.24)	174 (48.33)	2.59 ^c (1.68–4.00)	140 (56.00)	6.62 ^c (3.62–12.11)		
Childhood antisocial behaviour												
Yes	5942 (84.28)	193 (8.67)	0.43 ^c (0.32–0.58)	499 (14.80)	177 (21.38)	2.82 ^c (1.68–4.72)	143 (38.54)	9.02 ^c (5.15–15.77)	96 (37.65)	9.47 ^c (4.41–20.30)		
No	1108 (15.72)	2032 (91.33)	1.00	2872 (85.20)	651 (78.62)	1.00	228 (61.46)	1.00	159 (62.35)	1.00		
Probable PTSD												
Yes	252 (3.58)	55 (2.48)	1.30 (0.73–2.33)	72 (2.14)	27 (3.29)	2.53 ^a (1.23–5.20)	50 (13.44)	21.63 ^c (8.94–52.28)	48 (18.75)	98.60 ^c (31.88–304.91)		
No	6785 (96.42)	2167 (97.52)	1.00	3294 (97.86)	794 (96.71)	1.00	322 (86.56)	1.00	208 (81.25)	1.00		
Sleeping difficulties												
Yes	1831 (25.79)	491 (21.87)	0.73 ^b (0.58–0.91)	788 (23.22)	262 (31.53)	2.29 ^c (1.55–3.40)	161 (43.05)	3.24 ^c (2.04–5.13)	129 (50.19)	5.13 ^c (2.65–9.92)		
No	5270 (74.21)	1754 (78.13)	1.00	2606 (76.78)	569 (68.47)	1.00	213 (56.95)	1.00	128 (49.81)	1.00		
Covariates												
	Deployed sample n = 5126 (100%)	No misuse n = 1490 (29.1%)		Hazardous drinking n = 2498 (48.7%)	Harmful drinking n = 640 (12.5%)		Severe-to-hazardous drinking n = 297 (5.8%)		Severe drinking n = 201 (3.9%)			
	n (%)	n (%)	aOR [†] (95% CI)	n (%)	n (%)	aOR [†] (95% CI)	n (%)	aOR [†] (95% CI)	n (%)	aOR [†] (95% CI)	n (%)	aOR [†] (95% CI)
Perceived threat of injury/death												
Exposed	4300 (84.85)	1214 (82.4)	1.01 (0.77–1.34)	2074 (84.14)	570 (89.48)	1.40 (0.91–2.20)	262 (89.42)	1.35 (0.76–2.42)	180 (90.45)	1.72 (0.70–4.23)		
Unexposed	768 (15.15)	260 (17.6)	1.00	391 (15.86)	67 (10.52)	1.00	31 (10.58)	1.00	19 (9.55)	1.00		

^aFactors adjusted for all others in the model; aOR = adjusted odds ratio; CI = confidence interval; NCO = non-commissioned officer. Missing data ranged from n = 3 (for the variable relationship status) to n = 189 (for family childhood adversity). For all variables, the proportion of missing data was less than 10%. ^bIndicates results where P < 0.05; ^cIndicates results where P < 0.01; ^dIndicates results where P < 0.005.

Table 3 Number (n, %) of abstainers and number (n, %) and means (standard deviation) of excessive weekly consumption, symptoms of dependence and alcohol-related problems within each alcohol misuse class (Phases 1–3); SD = standard deviation.

Alcohol outcomes	Time-point	No misuse n = 2249 (31.6%)			Hazardous drinking n = 3398 (47.8%)			Harmful drinking n = 832 (11.7%)			Severe-to-hazardous drinking n = 374 (5.3%)			Severe drinking n = 258 (3.6%)		
		n (%)	Means (SD)	n (%) of class	Means (SD)	n (%) of class	Means (SD)	n (%) of class	Means (SD)	n (%) of class	Means (SD)	n (%) of class	Means (SD)	n (%) of class	Means (SD)	
Abstainers (> 1 year)	Phase 1	169 (2.38)	-	159 (7.07)	-	10 (0.29)	-	0 (0.00)	-	0 (0.00)	-	0 (0.00)	-	0 (0.00)		
	Phase 2	142 (2.00)	-	128 (5.69)	-	10 (0.29)	-	0 (0.00)	-	3 (0.80)	-	3 (0.80)	-	1 (0.39)		
	Phase 3	187 (2.63)	-	152 (6.76)	-	25 (0.74)	-	0 (0.00)	-	10 (2.67)	-	10 (2.67)	-	0 (0.00)		
Excessive weekly consumption (> 14 alcoholic units)	Phase 1	2792 (40.65)	16.52 (17.66)	96 (4.27)	4.38 (5.10)	1542 (45.38)	17.34 (14.49)	575 (69.11)	25.84 (18.32)	344 (91.98)	43.22 (22.38)	235 (91.09)	42.70 (22.47)			
	Phase 2	2014 (31.90)	13.17 (14.98)	38 (1.82)	3.37 (3.73)	968 (31.25)	13.09 (11.43)	562 (72.80)	26.33 (17.69)	236 (70.24)	24.71 (17.55)	210 (89.74)	41.70 (22.47)			
	Phase 3	1286 (28.18)	11.79 (14.57)	32 (2.08)	3.11 (4.18)	684 (29.74)	12.10 (11.68)	393 (73.18)	27.95 (18.41)	57 (27.80)	12.02 (13.03)	120 (82.19)	38.40 (24.46)			
Symptoms of dependence (cut-off ≥ 4)	Phase 1	349 (4.93)	0.67 (1.34)	3 (0.13)	0.82 (0.37)	46 (1.35)	0.47 (0.89)	31 (3.73)	1.05 (1.22)	147 (39.30)	3.26 (1.98)	124 (48.06)	3.56 (2.27)			
	Phase 2	252 (3.98)	0.59 (1.25)	1 (0.05)	0.05 (0.25)	16 (0.53)	0.34 (0.71)	74 (9.85)	1.54 (1.53)	28 (8.56)	1.42 (1.34)	133 (57.33)	4.19 (2.31)			
	Phase 3	137 (2.95)	0.45 (1.08)	2 (0.13)	0.38 (0.25)	5 (0.22)	0.26 (0.60)	54 (10.09)	1.49 (1.49)	2 (0.98)	0.57 (0.89)	75 (51.72)	3.77 (2.20)			
Alcohol-related problems (cut-off ≥ 4)	Phase 1	1441 (20.44)	2.35 (1.90)	19 (0.85)	1.18 (0.53)	491 (14.45)	2.11 (1.27)	380 (45.67)	3.34 (1.49)	357 (95.45)	6.36 (1.94)	239 (92.64)	6.75 (2.31)			
	Phase 2	1050 (16.59)	2.15 (1.78)	16 (0.79)	1.12 (0.39)	258 (8.57)	1.81 (1.04)	450 (59.92)	4.03 (1.76)	172 (52.60)	3.69 (1.82)	225 (96.98)	7.22 (2.32)			
	Phase 3	629 (13.56)	2.00 (1.65)	11 (0.72)	1.10 (0.36)	213 (9.28)	1.73 (1.01)	366 (68.41)	4.27 (1.75)	36 (17.48)	2.33 (1.17)	143 (97.95)	6.85 (2.29)			

demonstrated a mean intercept of 20 at baseline (levels linked with dependence [14]) and a decrease by 12 points during the study period, with drinking remaining at hazardous levels (AUDIT ≥ 8). ‘Severe’ drinkers demonstrated a mean intercept of 22, which was largely stable over time. At Phase 3, 68.4% ($n = 4862$) of the sample were drinking at or above hazardous levels. Of these, 15.3% ($n = 1090$) were drinking at or above harmful levels. Observed means are included in the Supporting information, Table S2.

Covariates of alcohol misuse classes

This analysis examined the covariates associated with belonging to trajectory classes (Table 2). Compared to the hazardous drinking class, the most strongly associated covariates of belonging to the no misuse class were being female, aged more than 35 years (compared to ages 18–24 years), having left the military at any phase, not being single at Phase 1 and not reporting childhood antisocial behaviour. This class was more likely to report serving as a reserve and living with children at Phase 1 and were less likely to report multiple family childhood adversities, deploying on either a pre-2003 or post-2003 deployment and sleeping difficulties.

Covariates most strongly associated with the classes drinking harmfully/severely at Phase 1 were being aged under 25 years at Phase 1, male gender, reporting multiple childhood adversities and antisocial behaviour and sleeping difficulties at Phase 1. Those with persistent harmful or severe drinking were less likely to serve in the RAF than the Army. Additionally, the classes who drank severely at any time-point (severe-to-hazardous and severe stable) were more likely to report PTSD at Phase 1, were less likely to serve as Officers compared to enlisted rank, were more likely to be single than married and less likely to live with children at Phase 1. The severe stable class was less likely to serve as NCOs than enlisted ranks. Severe-to-hazardous and severe stable drinking classes were more likely to report shorter military careers (less than 12 years).

We compared the severe and severe-to-hazardous drinking classes to assess the factors associated with persistent high scores (Supporting information, Table S3). Compared to severe-to-hazardous drinkers, the most strongly associated covariates suggested that the severe stable drinking class were more likely to report probable PTSD and were less likely to serve in the RAF (compared to the Army), as an officer (compared to enlisted) and to be female. Severe stable drinkers were also more likely to serve as a reserve and report multiple family childhood adversities.

In the subanalysis of those deployed to Iraq or Afghanistan, perceived threat of injury/death was the

only combat factor associated [harmful drinking: odds ratio (OR) = 1.40, 95% confidence interval (CI) = 1.05–1.87] and included in the final regression mixture models. When applying the measurement error this association attenuated (OR = 1.40, 95% CI = 0.91 to 2.17).

Drinking characteristics of the trajectory classes

Throughout the whole sample, excessive weekly consumption, probable dependence and alcohol-related problems decreased over time. When examining the classes, only a small percentage of the severe-to-hazardous drinking class became abstainers ($n = 10$ of 374 at Phase 3); reductions were instead related to excessive weekly consumption (from 92.0% at Phase 1 to 27.8% at Phase 3), symptoms of dependence (from 39.3% at Phase 1 to 0.9% at Phase 3) and alcohol-related problems (95.5% at Phase 1 to 17.5% at Phase 3). The percentage of harmful drinkers with excessive weekly consumption was stable over time, but more reported dependence (3.7% at Phase 1 to 10.1% at Phase 3) and alcohol-related problems over time (45.7% at Phase 1 to 68.4% at Phase 3). Among those continuing to drink at severe levels, the percentage exceeding weekly limits decreased marginally (91.1% at Phase 1 to 82.2% at Phase 3), but more reported alcohol-related problems over time (92.6% at Phase 1 to 97.0% at Phase 3). The number of severe drinkers reporting dependence symptoms between Phases 1 and 3 were largely stable and peaked at Phase 2 (48.1% at Phase 1, 57.3% at Phase 2 and 51.7% at Phase 3).

DISCUSSION

Alcohol misuse has not changed substantially for UK Armed Forces personnel participating in Phase 1 of the KCMHR cohort study. In total, 68% of the cohort continued to drink hazardously and, of these, 15% drank harmfully. Concerningly, dependence and alcohol-related problems appear to worsen over time among those continuing to drink above harmful levels. More than half of severe drinkers (approximately 9% of the sample) improved considerably during the 12-year period, but remained drinking hazardously. Membership to the harmful and severe drinking classes was associated with being male, younger, single, enlisted rank, reporting probable PTSD, childhood antisocial behaviour and family childhood adversities. Severe drinkers at Phase 1 were more likely to report probable PTSD and shorter military careers and were less likely to serve as Officers, and those who persisted were less likely to serve in the RAF compared to the Army. Reserves appeared to exhibit both the lowest and the most serious levels of drinking in the sample. The polarity of these findings demonstrates the advantages of LGMM approaches and subsequent multivariate analyses which

can highlight the associations specific to different levels of drinking.

Prevalence rates of alcohol misuse have decreased since the start of the cohort study [2]. By identifying distinct longitudinal trajectories, we found that most who served in the military during the first operations of Iraq (when drinking was arguably more embedded in military culture) do not exhibit the reductions implied by previous cross-sectional studies. Decreases in the overall prevalence of alcohol misuse in the UK Armed Forces may be explained by the substantial decreases of the minority severe-to-hazardous drinking class (5%). It is possible that younger personnel, excluded from the present analysis due to a lack of baseline data at Phase 1, may also contribute to decreases in prevalence found in cross-sectional research [2,4] as they might be among the growing number of younger people in the general population who are not drinking [1,6]. Overall, severe drinkers made the greatest improvements, where more than half reduced to lower (albeit hazardous) levels and dependence resolved almost entirely (40% at Phase 1 to less than 1% at Phase 3). This demonstrates the ability for those severely misusing alcohol to establish more moderate drinking patterns.

There were indications that following trajectories of either harmful or severe drinking were related to younger age at Phase 1 (when generational differences in drinking in the general population were not as pronounced), being male, single, not living with children, lower rank and serving in the Army. These associations have been reported elsewhere [17,31–33] and reinforce the links between heavy drinking, stage of life (i.e. having fewer responsibilities) and exposure to in-service drinking cultures where social drinking is common [34,35]. These findings make a compelling case for developing approaches that address the social and cultural contexts of in-service drinking.

We additionally found that reserves were more likely to be at extreme ends of the drinking spectrum. It is possible that, among lower-level drinkers, distance from the insular and potentially heavier drinking environments of regular service [17] might encourage healthier patterns of drinking. This might also explain why not misusing alcohol was associated with being discharged from the military in the current analysis. Conversely, the persistence of severe drinking among some reserves may be because they are not restricted by the structures and full-time operational demands of regular service. In the present analysis, severe drinkers at Phase 1 were also more likely to have shorter military careers, which is consistent with findings from a US Air Force study [31]. A novel finding of the present analysis, however, was that history of serious alcohol misuse appeared to negatively impact career trajectories irrespective of eventual improvements.

Unlike previous studies [4,16,18,33,36], combat exposure was not a contributor to harmful or severe drinking, although those who did not misuse alcohol during the time period were less likely to have deployed. Associations between severe drinking and family childhood adversity, childhood antisocial behaviour, enlisted rank and probable PTSD supported the compounding effects of pre-enlistment psychological and socio-economic vulnerabilities and mental health problems. To interpret these findings, alcohol use might be most usefully framed as a practice resulting from motivations on an individual level—as expressed by self-medication theories linking alcohol use to the alleviation of psychological problems [37]—and broader social contexts within which specific drinking practices emerge, as proposed by social practice theory [38].

Overall, our findings reinforce the presence of a subgroup within the Armed Forces usually concentrated in the lower ranks, who experience early adversity, co-occurring severe alcohol misuse and mental health issues and who tend to leave service after shorter periods [12,39,40]. This group represents a serious concern considering that they present to alcohol services with higher levels of drinking, more complex needs and at later stages compared to their civilian counterparts [41]. Successful approaches of alcohol-reduction should therefore focus upon engendering both cultural change and, for at-risk groups in particular, addressing the individual psychological drivers of alcohol misuse.

Strengths and limitations

This study followed the course of alcohol misuse over a 12-year period using three phases of data. The sample included in this analysis was large, the attrition rate over time was satisfactorily low and the time-period allows for the inference of the long-term correlates of alcohol misuse. The use of the three-step approach to examine covariates of trajectory classes accounted for the degree of uncertainty surrounding classification. It is worth noting that those who lacked baseline data were excluded from the present study, and therefore the trajectories identified only reflect the trends of those with available longitudinal data. In addition, data collection periods for each time-point of this cohort study spanned 2 years, leading to some variation in the length of follow-up periods. The present analysis tested growth mixture models in order to estimate the within-class variance of growth factors, but these models encountered estimation problems due to issues with convergence. Future research adopting these methods may need to consider a greater number of time-points to avoid similar problems. Some covariates, such as length of service, were simplified into binary variables to ensure statistical power, but this might have prevented a more detailed analysis of groups such as early service leavers. Another

limitation of this study and many others in alcohol research is a reliance upon self-report data. Participants may under-report their alcohol use as a result of social desirability bias [42]; however, the persistence of most trajectories indicates that reporting bias does not seem to be a serious problem in our study.

Implications

We found that approximately 70% of the sample continued to drink hazardously or harmfully over a 12-year period. Lack of change among these groups is concerning considering that harmful drinkers are prone to underestimating their levels of drinking [43]. This may be more pronounced among UKAF personnel given that functional impairment is not reported until drinking is at severe levels [44]. Furthermore, military personnel may not recognize the risks of episodic heavy drinking or binge-drinking considering that hazardous drinkers may not necessarily exceed weekly consumption guidelines. Our findings support the necessity to acknowledge indicators of alcohol-related harm in screening, intervention programmes and official guidelines that focus upon consumption (e.g. quantity of alcohol and frequency of use).

Reductions among severe drinkers highlight the possibility of moderating drinking regardless of its level and other modes of recovery than sobriety. Approaches geared towards harm reduction or moderation may offer some individuals more realistic, appealing alternatives that could more effectively support long-term success [45,46].

Severe drinkers in this study were characterized by their single status, lower rank, pre-enlistment vulnerabilities, mental health problems and possibly shorter military careers. The link between this level of drinking and problems in early life, mental health and sleeping difficulties emphasise the need for approaches to address multiple and complex health and social problems. Interventions seeking to ameliorate alcohol problems should consider not only how to engage this cohort, but how to address alcohol misuse in the context of psychological and social problems.

CONCLUSIONS

This study found that trajectories of alcohol misuse were stable for most UKAF personnel between 2004 and 2016. More than half of severe drinkers made substantial improvements, but a total of 68% continued to drink hazardously or at levels of harm, with dependence and alcohol-related problems worsening in those drinking harmfully. Our findings support the need for strategies to improve alcohol problem recognition and interventions

that can engage those experiencing concomitant mental health problems and social disadvantages.

Declaration of interests

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Author contributions

Laura Palmer: Conceptualization; formal analysis; investigation; methodology; project administration. **Sam Norton:** Formal analysis; methodology; supervision. **Margaret Jones:** Data curation; methodology; supervision. **Roberto Rona:** investigation; methodology; supervision. **Laura Goodwin:** Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; supervision. **Nicola Fear:** Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; supervision.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1 Model fit indices for unconditional alcohol misuse models in the UKAF sample.

Table S2 Observed means and standard deviations of AUDIT-10 scores for alcohol misuse classes (phase 1–3).

Table S3 Regression mixture model of phase 1 covariates of membership to the severe drinking class compared to the severe-to-hazardous drinking class (reference category).