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Fourteen-year trajectories of posttraumatic stress disorder (PTSD) symptoms in UK military personnel, and associated risk factors

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ABSTRACT

The aim of this study was to examine trajectories of posttraumatic stress disorder (PTSD) symptoms over a 14-year period and the risk factors associated with each trajectory. 1885 UK military personnel provided information at four time points since 2002. The PTSD Check list-Civilian Version (PCL-C) was used at all time points. Growth mixture models (GMM) were estimated to examine whether individuals could be clustered into discrete groups with similar trajectories. Multinomial logistic regressions were carried out to investigate factors associated with class membership. The three-class GMM was the most parsimonious solution. This included 90.2% in the resilient class, 4.1% in the improving class and 5.7% in the deteriorating class. Both the deteriorating and improving classes were associated with childhood adversity (odds ratios (OR) 3.9 (95% CI 2.3, 6.7) and 3.3 (95% CI 2.1, 5.0) respectively) and antisocial behaviour (OR 2.8 (95% CI 1.9, 4.2) and 3.7 (95% CI 2.4, 5.8) respectively), alcohol misuse (OR 3.5 (95% CI 2.4, 5.1) and 3.3 (95% CI 2.1, 5.2) respectively) and longer time since leaving Service in comparison to the resilient group. Those in the youngest group and those in a combat role (OR 0.32, 95% CI 0.19, 0.54) were more likely to belong to the deteriorating class. 10% of the cohort had symptoms of PTSD; of those, up to half were symptomatic for most of the follow-up period. Those whose score improved did not reach the low scores of the resilient group. Younger age and combat role were associated with worse prognosis of PTSD.

1. Introduction

The many deployments carried out by UK Armed Forces (AF) in recent times have raised concerns about their mental health consequences, especially for posttraumatic stress disorder (PTSD). Most recent UK operations have been related to Iraq and Afghanistan. Numerous studies of different coalition partners have described the burden of mental health disorders, such as PTSD, but there have been far fewer longitudinal evaluations (Fear et al., 2010; Hoge et al., 2004; Hotopf et al., 2006; Rona et al., 2009a; Smith et al., 2008). Prospective studies based on two assessments have demonstrated that only half of those with PTSD at an initial assessment continued to have symptoms of PTSD at follow-up (Armenta et al., 2018; Rona et al., 2009a) and that some of those without PTSD at baseline have symptoms at follow-up (Goodwin et al., 2012). These studies show that many people with PTSD at the first evaluation improve over time, but others show an opposite evolution. However, the picture is unclear, as are the associations of improvement and deterioration.

One way of addressing this is to use latent growth mixture modelling (LGMM) techniques (Bonanno et al., 2012). Several studies that assessed military personnel on multiple occasions have reported variability in the evolution of PTSD (Andersen et al., 2014; Bonanno et al., 2012; Eekhout et al., 2016; Polusny et al., 2017), but most of these studies ran for a maximum of five years and did not study risk factors related to the trajectories, with the exception of the Millennium Cohort study. (Bonanno et al., 2012; Donoho et al., 2017; Porter et al., 2017). The number and shape of PTSD trajectories found in military samples differ. Symptom fluctuations in Danish personnel deployed to Afghanistan were described using six variants of resilient, increasing and decreasing trajectories across pre-, peri- and post-deployment time

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points (Andersen et al., 2014; Berntsen et al., 2012). Two studies showed three trajectories: a resilient trajectory, a deteriorating trajectory and a chronic trajectory (Eekhout et al., 2016; Polusny et al., 2017). US studies drawing on data from the Millennium Cohort, a prospective health study of US active duty and reserve forces, consistently identify four trajectories of resilient, increasing, decreasing and high symptoms (Bonanno et al., 2012; Donoho et al., 2017; Porter et al., 2017). Differences in symptom levels and rate of change are most evident in high symptom classes, which remain stable or show a deterioration and subsequent improvement among US personnel deployed to Bosnia (Dickstein et al., 2010). Growth mixture models have not been conducted to estimate PTSD trajectories in UK AF samples before. This study therefore adopts an exploratory approach, however it is expected that most of the sample will be assigned to a no/low class and that multiple classes will be needed to model longitudinal change.

The current study commenced in 2002, before the start of the war in Iraq (Rona et al., 2004). Personnel were then followed up on three further occasions up to 2016. The aims of this study were to investigate trajectories of PTSD symptoms between 2002 and 2016 and to assess the risk factors associated with the trajectories.

2. Methods

2.1. The sample

Data were collected from a representative sample of the UK regular military in 2002 and the initial part of 2003 prior to the Iraq conflict. The sample of service personnel was drawn from units of the Royal Navy, Army, and Royal Air Force (RAF) according to the strengths in July 2001 and latterly included ex-serving personnel who were in the original sample. Units were randomly selected, and 45 individuals were randomly selected from each unit. Participants in the baseline sample (time 1) were followed up between 2004 and 2006 (time 2), between 2007 and 2009 (time 3), and between 2014 and 2016 (time 4) (Fig. 1). 1888 participants responded at times 1 and 2 (Rona et al., 2009a). At time 1, the total sample was randomised to a short questionnaire and a full questionnaire to assess the impact of length of questionnaire on response rate. In the short questionnaire, some items from the measures of mental disorders were omitted from the questionnaire and alcohol consumption was not assessed. Older, female and higher ranking personnel were more likely to complete the questionnaires, as has been shown in every study of Armed Forces personnel (Hotopf et al., 2006; Rona et al., 2010). We investigated preferential participation bias related to mental disorders comparing the baseline (time 1) characteristics of responders and non-responders to our study at time 2. Altogether 1885 of baseline individuals were available in our study and 988 were lost. Our analysis demonstrated that there was no significant difference between responders and non-responders for PTSD using 14 or 17 items ($p = 0.10$ and $p = 0.58$ respectively), for the General Health Questionnaire - 4 items (GHQ-4) or GHQ-12 ($p = 0.88$ and $p = 0.80$ respectively) and alcohol misuse ($p = 0.08$). We repeated the analysis comparing baseline characteristics of responders and non-responders at other time assessments, but the results did not change because the larger number of non-responders occurred between times 1 and 2.

The study received approval from the Ministry of Defence Research Ethics Committee (MODREC) and for subsequent surveys from King's College Hospital local research ethics committee.

2.2. Measures

2.2.1. Independent variables

At time 1, participants provided information about their sex, age, rank, and Service. Data on education were categorised as reaching Ordinary Levels (O Levels)/General Certificate of Secondary Education (GCSE) or below, and Advance Levels (A Levels) or above. At time 2, information was collected on marital status and participants' role in their parent unit was stratified into “combat role” or “support role” (role in parent unit is highly associated with role during deployment and applies to everybody). Ex-serving or currently serving personnel were assessed by time since separation from service, as provided by the Defence Statistics, and divided into six categories. Latest deployment was reported by each member of the cohort: no deployment recorded; last deployed up to 3 years before time 1; last deployed between times 1 and 2; last deployed between times 2 and 3, and last deployed between times 3 and 4. Time since last deployment was calculated from date of last deployment to time of questionnaire completion.

Two measures of childhood adversity were collected at time 2. (Iversen et al., 2007)' (Felitti et al., 1998) The first assessed family relationship adversity and included 8 items (e.g. “I used to be hit/hurt by a parent or caregiver regularly”), which were summed and analysed as 0, 1 and 2 + adversities. The second measure assessed childhood antisocial behaviour and was scored positively if participants answered “true” to “I used to get into physical fights at school” plus one of the following; “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” (Macmanus et al., 2012).

The GHQ-12 was used to record symptoms of psychological distress related to anxiety and depression (Goldberg et al., 1997). Each of the symptoms was rated on a four-point scale. For this study the bi-modal scoring method of 0-0-1-1 was used. A cut-off of 4 or more was used to identify probable psychological distress (range zero to 12). At time 1, only those receiving a full questionnaire completed the GHQ-12; those receiving the short questionnaire completed the GHQ-4. We used the recommended cut-off of two for the GHQ-4 (Jacobsen et al., 1995). The GHQ-12 and, when appropriate, the GHQ-4 were used in the results section. Alcohol misuse was measured using the Alcohol Use Disorders Identification Test (AUDIT), a 10-item questionnaire which assesses alcohol consumption, alcohol dependence and the consequences of alcohol abuse in the last 12 months. The AUDIT gives a total score that ranges between 0 and 40 with scores of 16 or more defined as a “high level of alcohol problems” (Babor et al., 2001). We used a score of 16 rather than a score of eight (hazardous drinking) because the prevalence of hazardous drinking was very high in the UK military (67% for men and 49% for women) (Fear et al., 2007). Functional impairment was assessed using an item from the Short-Form 36: “to what extent has the physical health or any emotional problems interfered with normal social activities with family, friends, neighbours or groups” and stratified into groups who were impaired “quite a bit” or “extremely” and not impaired “not at all”, “slightly” or “moderate” (Ware et al., 1993). We have shown that this single item is as meaningful as using several items to assess functional impairment in previous studies (Rona et al., 2009b, 2010).

2.2.2. Outcome variable

Symptoms of PTSD were assessed by the National Center for PTSD Checklist–Civilian Version (PCL-C) (Weathers et al., 1993); a 17-item questionnaire assessing five re-experiencing, seven avoidance and five hyperarousal symptoms, with scores ranging between 17–85 (Blanchard et al., 1996). At time 1, participants completed either a full or a short PCL-C questionnaire with 949 (50%) completing the full questionnaire and 939 (50%) completing the abridged questionnaire. To shorten the questionnaire, the principal investigators removed three items (trouble remembering important parts of a stressful experience, feeling as if your future will somehow cut short and having difficulty concentrating). Single-value imputation, using the median of the rest of the items of a dimension, was estimated for each of the dimensions where items were omitted by design (avoidance and hyperarousal) to account for the three missing PCL-C items in those completing the short questionnaire.

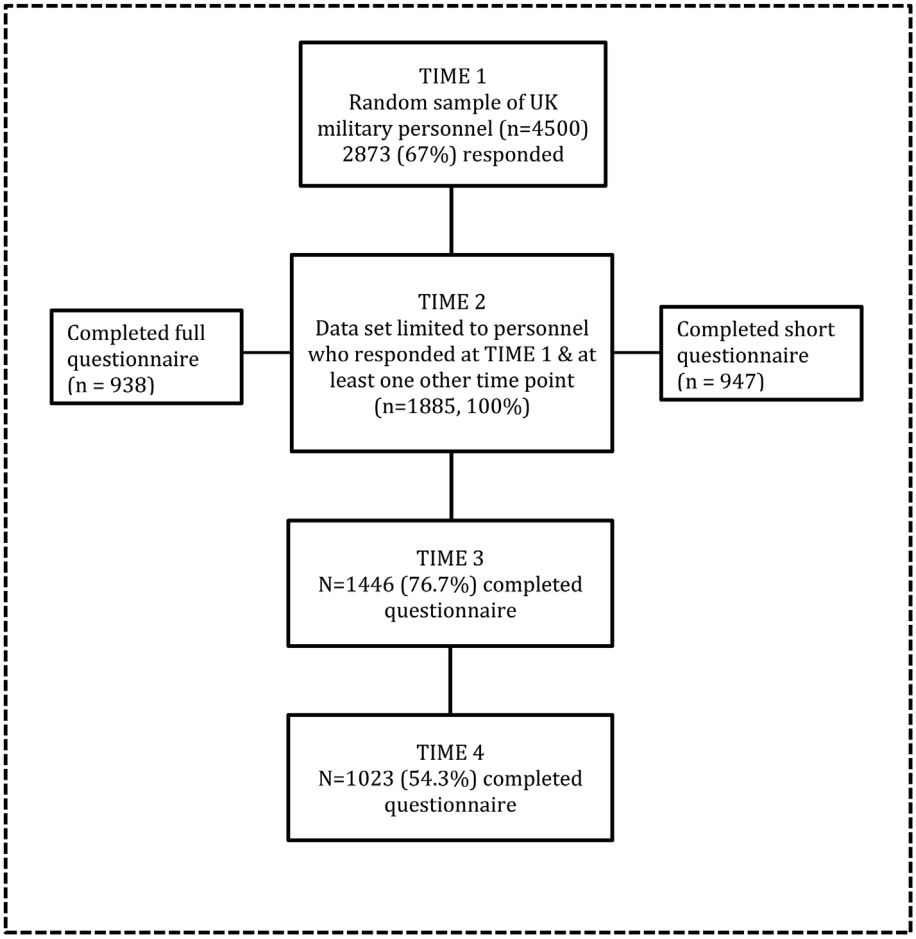

Fig. 1. Flow-diagram of participant recruitment and response.

2.2.3. Statistical analysis

Latent growth mixture modelling (GMM) was conducted in Mplus 7.4 to identify classes sharing similar trajectories of PTSD symptoms within the sample. This approach estimates a mixed-effects longitudinal model incorporating a random intercept and time slope (growth factors) that clusters individuals' growth factors into a discrete number of trajectories (Jung and Wickrama, 2008).

Due to the positive skew of PCL scores, with many scorings at the minimum possible value, all models assumed a censored-normal distribution for the outcome variable so not to violate the within-class normality assumption. Missing outcome data over time was handled by full information maximum likelihood estimation (FIML) which utilises all available data under the assumption that missing data are missing at random (MAR) (Rubin, 2009).

A series of unconditional models were fitted (see supplementary materials). The best class solution was chosen from the GMM models where the variances on the intercept were freed. Due to issues of non-convergence, the final models allowed the free estimation of the intercepts but not the linear and quadratic time slope parameters. As such, in the specification of the model, rather than as a hypothesis, the rate of change was permitted to vary across the classes, but not within each class.

Models with one through to six latent classes were considered to determine the optimal number of classes. Relative model fit was assessed using Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), sample size adjusted BIC (SABIC), entropy and the Lo–Mendell–Rubin Likelihood Ratio Test (LMR-LRT). The AIC, BIC and SABIC indices perform by balancing model complexity with goodness of fit. Entropy was used to evaluate the precision of individuals' classification with higher entropy reflecting more accurate assignment (maximum of 1). While entropy is not to be used explicitly for class enumeration (Ramaswamy et al., 1993), values were assessed to examine whether homogeneous clusters of individuals were obtained. This was supported by observing average posterior class probabilities which exceeded 0.70 in each class (Nagin, 2005). The LMR-LRT compares the improvement of fit provided by a model with *k* classes to one with *k-1* classes. In addition to formal statistical criteria, interpretability and theoretical justification were used to identify the most parsimonious solution.

Adjusted multinomial regression models were fitted in Mplus 8.0 where analyses account for the classification error of belonging to trajectory classes, in line with the recommended three-step approach (Asparouhov and Muthen, 2013). Associations are described in Table 4.

3. Results

Those completing the questionnaire at times 1 and 2 were contacted at times 3 and 4. 76.7% and 54.3% of them completed the questionnaire at times 3 and 4 respectively (Fig. 1). The age group 30–34 years was the largest (28%) at time 1. Most participants were male (92%), and served in the Army (48%). 84% of the sample was married or in a long-term relationship, 13% reported childhood antisocial behavior and 36% endorsed at least two family adversity items. 86% had a support role in the parent unit (see Table 1).

3.1. Trajectory analysis

A series of unconditional models without covariates were fitted

Table 1
Social demographic, military and other characteristics of the sample at time 1 or time 2.

Characteristic	N (%)
Sex (time 1)	
Male	1742 (92.4%)
Female	143 (7.6%)
Age group (time 1)	
< 25	270 (14.3%)
25-29	346 (18.4%)
30-34	527 (28.0%)
35-39	406 (21.5%)
40+	336 (17.8%)
Education (time 2)	
O level/GCSE or lower	699 (37.2%)
A level or higher	1182 (62.8%)
Marital status (time 2)	
In a relationship	1590 (84.4%)
Not in a relationship	294 (15.6%)
Rank (time 1)	
Officer	429 (22.8%)
Other rank	1456 (77.2%)
Service (time 1)	
Naval Service	446 (23.7%)
Army	909 (48.2%)
Royal Air Force	530 (28.1%)
Role within parent unit (time 2)	
Combat	268 (14.4%)
Support	1595 (85.6%)
Deployment status	
No deployment in the 3 years before time 1	438 (23.2%)
Last deployed in the 3 years before time 1	479 (25.4%)
Last deployed between time 1 and time 2	314 (16.7%)
Last deployed between time 2 and time 3	462 (24.5%)
Last deployed before time 4	192 (10.2%)
Time since leaving service (at 21/07/2015)	
Still serving	575 (30.5%)
Up to 3 years	274 (14.5%)
3–6 years	291 (15.4%)
6–9 years	355 (18.8%)
9–12 years	343 (18.2%)
12–15 years	47 (2.5%)
Alcohol misuse (time 2)	
No	1681 (89.6%)
Yes	196 (10.4%)
Childhood adversity score (time 2)	
0	849 (45.9%)
1	342 (18.5%)
2 or more	657 (35.6%)
Childhood antisocial behaviour (time 2)	
No	1642 (87.5%)
Yes	235 (12.5%)

Table 3
Observed mean PCL-17 score, frequency of case positive status for GHQ-12 and for functional impairment at each phase by trajectory class.

Trajectory class (N)	Time 1 N = 1885	Time 2 N = 1885	Time 3 N = 1446	Time 4 N = 1023
Mean (SD) PCL score				
1 Resilient (1703)	21.4 (5.5)	21.3 (6.2)	21.2 (5.5)	22.2 (7.0)
2 Deteriorating (108)	31.8 (11.0)	43.2 (14.6)	51.1 (10.1)	47.6 (17.0)
3 Improving (77)	53.0 (10.4)	32.5 (13.7)	28.1 (10.0)	33.3 (13.7)
GHQ case positive N (%)				
1 Resilient (1703)	133 (15.7)+	257 (15.2)	206 (15.9)	139 (15.3)
2 Deteriorating (108)	20 (38.5)+	64 (59.3)	64 (76.2)	43 (70.5)
3 Improving (77)	32 (82.1)+	36 (46.8)	17 (29.3)	19 (50)
Impaired social functioning N (%)				
1 Resilient (1703)	54 (6.4)+	118 (7.0)	80 (6.6)	70 (7.7)
2 Deteriorating (108)	14 (26.9)+	42 (39.3)	34 (42.5)	31 (50.0)
3 Improving (77)	22 (56.4)+	21 (28.0)	7 (13.2)	9 (23.7)

+ At time 1 only those who received the full questionnaire (N = 938) completed the GHQ-12 and the functional impairment items. Of those who completed the GHQ-4 in the shortened questionnaire (N = 947), 130 (15.2%) were in the Resilient trajectory class, 20 (35.7%) were in the Deteriorating class and 31 (81.6) in the Improving class.

beginning with a latent class growth analysis (LCGA), where the variance of the growth factors was fixed to zero. This assumes that variability in the initial level and rate of change in PTSD was completely determined by the class and did not vary across individuals within a specific class. Models were then re-fitted with a quadratic term for time to assess whether non-linear latent growth curves provided a better fit to the data. Non-linear curves demonstrated superior fit when comparing linear and non-linear curves to the observed means. Finally, GMMs were conducted where the variances on the intercept were freed. The three-class GMM allowing for a quadratic time trend provided the optimal fit to the data (Fig. 2 and Table 2). Across the model types, a notable reduction of BIC and SABIC was observed between the one, two to the three classes, but this plateaued when introducing a fourth class. The selection of the three-class model was supported by a significant LMR-LRT value (p = 0.0073) and a non-significant value for the four-class model (p = 0.0893). Classification was deemed accurate with high entropy values and average posterior probabilities exceeding 0.70.

In the three-class model (Fig. 2), most individuals belonged to a 'resilient' class (90.2%) following a low and stable trajectory (mean

Table 2
Model fit indices for 1 to 6 class models based on latent class growth analysis (LCGA), LCGA with a quadratic term, and growth mixture models (GMM) with a quadratic term.

		1 class	2 class	3 class	4 class	5 class	6 class
LCGA (all growth factors constrained)	AIC	37210.7	35641.0	35195.0	35032.7	34889.9	34803.5
	BIC	37244.0	35690.9	35261.5	35115.8	34989.6	34919.9
	SABIC	37224.9	35662.3	35223.4	35068.1	34932.4	34853.1
	Entropy	–	0.91	0.86	0.94	0.8–1	0.74
	LMR-LRT, *p* value	–	0.0000	0.0044	0.4715	0.22	0.1549
LCGA quadratic (all growth factors constrained)	AIC	37199.6	35625.7	35178.3	34990.9	34809.6	34674.1
	BIC	37238.4	35686.7	35261.4	35096.2	34937.0	34823.8
	SABIC	37216.1	35651.8	35213.8	35035.9	34864.0	34738.0
	Entropy	–	0.91	0.86	0.87	0.81	0.79
	LMR-LRT, *p* value	–	0.0000	0.0193	0.3521	0.1710	0.0896
GMM (intercept freed, slope and quadratic term constrained)	AIC	35376.2	34975.5	34661.4	34488.0	34391.3	34315.3
	BIC	35420.5	35042.0	34750.0	34598.9	34524.3	34470.5
	SABIC	35395.1	35003.9	34699.2	34598.9	34448.0	34381.5
	Entropy	–	0.94	0.94	0.93	0 .94	0.92
	LMR-LRT, *p* value	–	0.0041	0.0073	0.0893	0.0317	0.3430

AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; SABIC = Sample size adjusted BIC; LMR-LRT = Lo–Mendell–Rubin Likelihood Ratio Test.

Table 4
Associations between sociodemographic and military characteristics, childhood factors, deployment history and health with PTSD trajectories (N = 1885).

Male	1575 (92.6)	98 (90.7)	1.00	69 (89.6)	1.00
Female	125 (7.4)	10 (9.3)	0.88 (0.53–1.48)	8 (10.4)	1.24 (0.71–2.15)
Age group					
< 25	229 (13.5)	30 (27.8)	1.00	11 (14.3)	1.00
25-29	310 (18.2)	15 (13.9)	0.38 (0.23–0.64)	21 (27.3)	1.56 (0.90–2.71)
30-34	484 (28.5)	27 (25.0)	0.43 (0.28–0.66)	16 (20.8)	0.73 (0.40–1.35)
35-39	367 (21.6)	24 (22.2)	0.51 (0.32–0.80)	15 (19.5)	0.94 (0.51–1.75)
40+	310 (18.2)	12 (11.1)	0.34 (0.20–0.59)	14 (18.2)	1.38 (0.75–2.56)
Education					
O level/GCSE or lower	619 (36.5)	50 (46.3)	1.00	30 (39.0)	1.00
A level or higher	1077 (63.5)	58 (53.7)	0.75 (0.46–1.23)	47 (61.0)	1.08 (0.76–1.55)
Marital status					
In a relationship	1443 (84.9)	86 (79.6)	1.00	61 (79.2)	1.00
Not in a relationship	256 (15.1)	22 (20.4)	1.19 (0.73–1.92)	16 (20.8)	1.29 (0.81–2.04)
Rank					
Officer	408 (24.0)	14 (13.0)	1.00	7 (9.1)	1.00
Other rank	1292 (76.0)	94 (87.0)	1.60 (1.16–2.21)	70 (90.9)	3.09 (2.06–4.62)
Service					
Naval Services	412 (24.2)	19 (17.6)	0.51 (0.28–0.96)	15 (19.5)	0.71 (0.43–1.19)
Army	793 (46.7)	71 (65.7)	1.00	45 (48.4)	1.00
Royal Air Force	495 (29.1)	18 (16.7)	0.30 (0.14–0.65)	17 (22.1)	0.59 (0.36–0.96)
Role within parent unit					
Combat	229 (13.7)	29 (26.9)	1.00	10 (13.0)	1.00
Support	1449 (86.4)	79 (73.2)	0.32 (0.19–0.54)	67 (87.0)	0.90 (0.52–1.57)
Deployment status**					
No deployment in the 3 years before time 1	401 (23.6)	19 (17.6)	1.00	18 (23.4)	1.00
Last deployed in the 3 years before time 1	409 (24.1)	39 (36.1)	1.99 (1.11–3.60)	31 (40.3)	1.64 (0.92–2.92)
Last deployed before time 2	293 (17.2)	10 (9.3)	0.57 (0.24–1.39)	11 (14.3)	0.76 (0.34–1.70)
Last deployed between time 2 and time 3	416 (24.5)	32 (29.6)	2.19 (1.16–4.11)	14 (18.2)	0.77 (0.32–1.84)
Last deployed before time 4	181 (10.7)	8 (7.4)	1.45 (0.57–3.71)	3 (3.9)	0.38 (0.04–2.85)
Time since leaving service					
Still serving	527 (31.0)	29 (26.9)	1.00	19 (24.7)	1.00
Up to 3 years	252 (14.8)	12 (11.1)	0.94 (0.41–2.13)	10 (13.0)	1.10 (0.47–2.60)
3–6 years	273 (16.1)	13 (12.0)	1.01 (0.46–2.22)	5 (6.5)	0.30 (0.10–0.87)
6–9 years	324 (19.1)	13 (12.0)	0.82 (0.37–1.82)	18 (23.4)	1.72 (0.78–3.80)
9–12 years	288 (16.9)	36 (33.3)	3.81 (2.06–7.05)	19 (24.7)	2.10 (0.99–5.15)
12–15 years	36 (2.1)	5 (4.6)	3.88 (1.35–11.17)	6 (7.8)	5.46 (1.99–15.03)
Alcohol misuse (time 2)					
No	1547 (91.3)	77 (72.0)	1.00	57 (75.0)	1.00
Yes	147 (8.7)	30 (28.0)	3.48 (2.36–5.13)	19 (25.0)	3.32 (2.12–5.20)
Childhood adversity score					
0	798 (47.8)	33 (31.4)	1.00	18 (24.3)	1.00
1	317 (19.0)	15 (14.3)	1.00 (0.47–2.12)	10 (13.5)	1.17 (0.62–2.49)
2 or more	554 (33.2)	57 (54.3)	3.94 (2.30–6.73)	46 (62.2)	3.27 (2.10–5.08)
Childhood antisocial behaviour					
No	1511 (89.3)	79 (73.2)	1.00	52 (67.5)	1.00
Yes	181 (10.7)	29 (26.9)	2.78 (1.86–4.15)	25 (32.5)	3.72 (2.40–5.76)

*Adjusted for sex, age and rank at baseline.
**Adjusted additionally for time since leaving service.

intercept = 19.5, SE = 0.2). A second 'deteriorating' class, with a membership of 5.7% demonstrated a marked increase of symptoms with the mean intercept of 30.6 (SE = 1.6) reaching the usual clinical cut-off for PTSD (a score of 50). A third class, comprising 4.1%, started with a mean PCL intercept of 51.2 (SE = 2.6) and showed substantial improvement from times 2 to 4.

The four-class solution was considered carefully during the model selection, but the three-class model was considered the most parsimonious and statistically supported solution (Table 2 and Fig. 1 in supplementary material).

3.2. Validation of the trajectories

We carried out a pragmatic assessment of the suitability of the three trajectories by looking at the PCL scores, GHQ-12 caseness and functional impairment prevalence at times 1 to 4. The mean PCL scores observed at each time point were consistent with the three trajectories. The resilient to PTSD symptoms trajectory had a consistent PCL score in the low twenties; the deteriorating trajectory had a PCL score near 32 at time 1 which changed to a mean between 43 and 48 from times 2 to 4, and the improving trajectory decreased from a score of 53 at time 1 to a score around 33 between times 2 and 4 (Table 3). The pattern of GHQ-12 and functional impairment in terms of prevalence rates were synchronic with the PCL scores at each time (Table 3). GHQ-12 at time 1 was available for half the sample, but prevalence for GHQ-4 available for all participants showed similar results.

3.3. Associations of the trajectories in relation to covariates

We carried out multinomial logistic regression analysis to assess the associations for each covariate with the trajectory classes using the resilient group as a reference group and adjusting for age, sex and rank as assessed at time 1 (Table 4). In comparison to the resilient group, the deteriorating group was more likely to be in the youngest group (20–25 years at time 1) and in the non-officer group, to have left the services 9 years or more ago, to have a childhood adversity score of 2 or over and to report childhood antisocial behavior, to misuse alcohol and were less likely to belong to the RAF or Navy and to have a support role. When adjusted for time since leaving the services, the deteriorating group were more likely to have last deployed at time 1 (corresponding to Kosovo, Bosnia, Sierra Leona and Northern Ireland) or between times 2 and 3 (corresponding to Iraq and/or Afghanistan between 2005 until

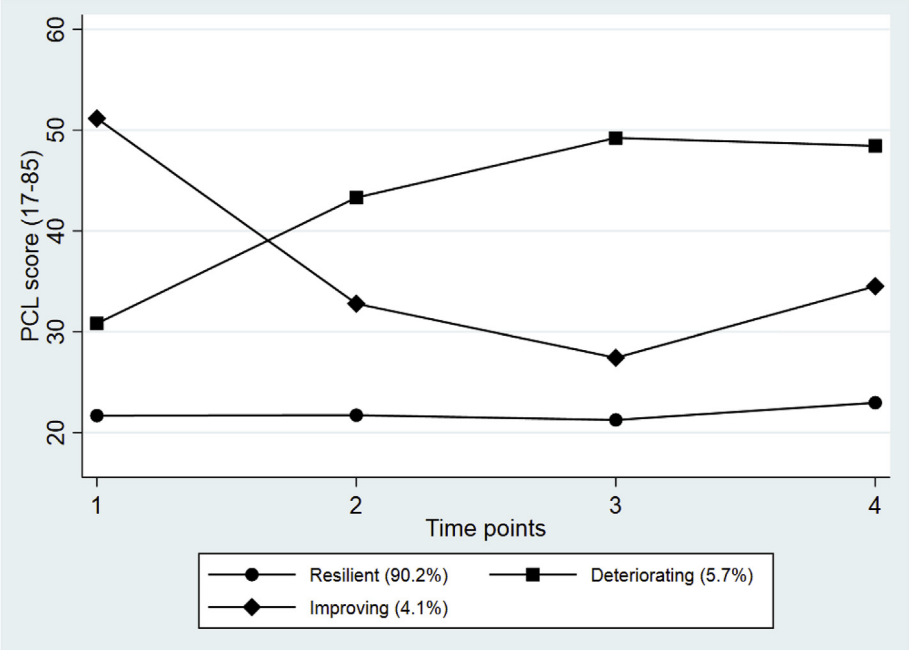

Fig. 2. The three trajectories based on a growth mixture model (GMM) of PCL data assessed four times over a period of approximately 14 years.

2009).

In comparison to the resilient group, those in the improving trajectory were more likely to be in the non-officer group, to have left the Service 12 years or more ago, were likely to have a childhood adversity score of 2 or more, to have reported childhood antisocial behavior and to misuse alcohol.

The mean length of time since the resilient group left Service was 6.5 (SD 3.5) years, while the mean length time for the deteriorating and the improving groups was longer (8 years (SD 3.6) and 8 years (SD 3.7) respectively), probably because resilient personnel tend to remain in the forces.

We carried out a multinomial analysis in STATA 14.0 to directly compare the improving and deteriorating classes. The only meaningful association was that those in a combat role were more likely to belong to the deteriorating group (29% against 10%). The other covariates did not differ, except for age which showed unspecific heterogeneity between the two groups.

4. Discussion

The main finding was the emergence of a three-class GMM quadratic model as the best fitting model. 90.2% of the sample remained resilient throughout the follow-up period. However, 9.8% of the sample had symptoms of PTSD; 4.1% had initially shown high PCL score but improved over time, whilst 5.7% had the opposite, initially having low scores but deteriorating over the course of follow-up. The deteriorating class had a high PCL score over approximately 10 years of follow-up and the improving category never fully reached the low scores of the resilient group in the three-class model. Adjusted multinomial logistic regression models showed some commonality between the improving and deteriorating trajectories, in comparison to the resilient trajectory, for childhood adversity and childhood antisocial behavior. Those in the youngest group at time 1 and those having a combat role were more likely to belong to the deteriorating trajectory and those belonging to the improving class were more likely to belong to other ranks.

4.1. The trajectories

Our study is consistent with other trajectory studies insofar as most of the sample (90.2%) was PTSD resilient for the full period of the study (Andersen et al., 2014; Bonanno et al., 2012; Dickstein et al., 2010; Eekhout et al., 2016; Polusny et al., 2017). This demonstrates that most service personnel cope with military occupational exposures and this resilience persists after leaving the Armed Forces. In part, this resilience might be explained by prior experience and training which have been shown to be associated with positive outcomes in populations at risk of traumatic exposure (Dougall et al., 2000).

A minority (9.8%) experienced PCL scores compatible with PTSD at some stage during follow-up. The severity of PTSD varies over time, reaching levels compatible with partial PTSD (Rona et al., 2009a; Stein et al., 1997). Some studies have shown patterns similar to our study reporting a three-class model (Eekhout et al., 2016; Polusny et al., 2017) and others have reported a four-class model similar to the trajectories of our four-class model (Dickstein et al., 2010; Porter et al., 2017). Bonanno and colleagues showed a chronic PTSD trajectory over a shorter duration of follow-up in the Millennium Cohort study than Porter and colleagues (Bonanno et al., 2012; Porter et al., 2017). The literature, with some exceptions (Andersen et al., 2014; Dickstein et al., 2010), shows that those with a PCL score compatible with PTSD at some point in the evolution of their condition may ameliorate, but rarely recover to become asymptomatic (Berntsen et al., 2012; Eekhout et al., 2016; Porter et al., 2017). In addition, the deteriorating trajectory in our study may be compatible with the chronic evolution of PTSD in Bonanno and colleagues' study as the PCL scores were high for approximately 10 years (Bonanno et al., 2012).

4.2. Covariates associated with the trajectories

It is difficult to compare our multinomial analysis with other trajectory studies, as the follow-up periods for most studies were shorter than ours, the sample sizes were small for statistical inference, and the fitted trajectories and the covariates studied differed in detail between studies, except for demographic and some military variables such as Service, rank and occupational role. Pre-service vulnerability factors (childhood adversity and antisocial behavior) were associated with both the improving and deteriorating trajectories in our study. It has been demonstrated in cross-sectional studies that these vulnerability factors play a role in the aetiology of PTSD (Cabrera et al., 2007;

Iversen et al., 2007). Our study shows that these vulnerability factors may influence the emergence of symptoms of PTSD, but it does not influence its prognosis. In other studies, childhood environment, family life variables and trauma in childhood were marginally associated with trajectories of symptoms of PTSD (Berntsen et al., 2012; Polusny et al., 2017). These findings suggest that trauma exposure is more likely to affect individuals already vulnerable following early stressful/emotional life experiences.

Another common factor in the improving and deteriorating classes was their strong association with alcohol misuse. This was also reported in the Millennium Cohort study (Bonanno et al., 2012). This finding underscores the fact that alcohol misuse should be addressed in patients who seek help for PTSD symptoms.

An interesting finding in our study is that there was a tendency for those who left Service twelve years or more ago to be over-represented in the deteriorating and improving classes. The effect sizes of the associations were fairly large (ORs of 2.8 and 4.1). Our study demonstrates that those who have left Service might remain with symptoms of PTSD for a long period of time giving support to the findings from the Vietnam War in terms of evolution, if not proportions (Dohrenwend et al., 2006; Marmar et al., 2015). There are several explanations for our findings; those who experience symptoms compatible with PTSD may leave Service earlier than others (Milliken et al., 2007) or that early traumatic experiences in the military career have more impact. We explored the association between period of the last reported deployment and PTSD, adjusting for years since leaving Service. Our results were different for the deteriorating and the improving groups. Last deployment prior to the start of the Iraq and Afghanistan conflicts and between times 2 and 3 was associated with PTSD in the deteriorating class. This is a salient finding as during the period between 2005 and 2009 the UK military's involvement in Iraq and Afghanistan may have overstretched the capability of UK forces (Rona et al., 2007). It is possible that for this cohort, deployments to Kosovo, Bosnia and/or Northern Ireland had an impact on PTSD, a finding that has not previously been reported.

We found that having a combat role was associated with the deteriorating class only. This is consistent with the results of the Millennium Cohort study and a clinical study (Bray et al., 2016; Donoho et al., 2017). Our findings are not concordant with the findings of an Israeli study that experienced conflicts in other settings (Karstoft et al., 2013).

We found that a lower rank was more strongly associated with a recovering class than a deteriorating class. A possible explanation, besides fluctuation within a sample, is that commissioned officers, reluctant to admit symptoms while in Service, are readier to acknowledge these after leaving the Armed Forces.

4.3. Strengths and limitations

This is the first study to examine the trajectories of PTSD in a large representative sample of the UK Armed Forces over a period of 14 years. The study had high response rates. There were also potential limitations to the study. This was a largely male sample and these results should not be extrapolated to UK female personnel. Some of the subgroups were of small size and statistical inference was limited. Our data did not contain information about help-seeking behaviour for PTSD and about support from family and friends support; as such it is not possible to determine the effect of health care and social support on the PTSD trajectories. However, we know that the percentage of service personnel seeking help for PTSD symptoms was low during most of the period of this study (Hines et al., 2014; Rona et al., 2017). We recommend caution in the interpretation of the results related to childhood adversity and childhood antisocial behaviour, as the information on these variables was obtained when the participants were already in the UK AF and might be subject to reporting bias. As in all observational studies there might be possible confounders for which we did not collect data. However, the range of independent variables in our study was wide. This study did not include Special Forces.

4.4. Implications

This cohort study shows that 90% of Armed Forces personnel are persistently resilient to symptoms of PTSD. However, approximately 10% will experience PTSD symptoms at some point over 14 years and a large percentage of those may experience persistent high levels of symptoms for 10 years. The remainder will have fewer symptoms but will not be asymptomatic. Regardless of the pattern of symptoms, vulnerability factors such as childhood adversity and childhood antisocial behavior play an important role in the response to trauma exposures. Combat exposure is a factor that may worsen the prognosis of PTSD.

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Contributors

RJR, SW and MJ designed the original study; MJ, RJR, NTF and SW were responsible for the questionnaires and data collection; GT, LP, MJ, SN and RJR planned the analysis; LP, MJ and GT performed the analysis; LP and RJR wrote the final draft; SN provided statistical supervision; SW, NTF and RJR secured funding for the study, LP, RJR, SW, NTF, SN, MJ and GT, interpreted the data and revised the manuscript adding important quality content.

Declaration of interest

SW is affiliated to the National Institute for Health Research Health Protection Research Unit (NIHR HPRU) in Emergency Preparedness and Response at King's College London in partnership with Public Health England (PHE), in collaboration with the University of East Anglia and Newcastle University. He is also a trustee of the charity Combat Stress. NTF is trustee of a veteran's charity and member of a group advising NHS Digital on the release of patient data. The other authors have no conflict of interest to declare.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2018.11.023.

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