Journal of Affective Disorders 354 (2024) 702–711

Contents lists available at ScienceDirect

Journal of Affective Disorders

journal homepage: www.elsevier.com/locate/jad

Research paper

Long-term trajectories of depressive symptoms in deployed military personnel: A 10-year prospective study☆

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ARTICLE INFO

Keywords:
Trajectories
Long-term depression
PTSD
Military personnel

ABSTRACT

Background: Military missions, especially those involving combat exposure, are associated with an increased risk of depression. Understanding the long-term course of depressive symptoms post-deployment is important to improve decision-making regarding deployment and mental health policies in the military. This study investigates trajectories of depressive symptoms in the Dutch army, exploring the influence of factors such as demographics, early-life trauma, posttraumatic stress disorder (PTSD) symptoms, and deployment stressors.
Methods: A cohort of 1032 military men and women deployed to Afghanistan (2005–2008) was studied from pre- to 10 years post-deployment. Depressive and PTSD symptoms were assessed using the Symptom CheckList-90 and the Self-Rating Inventory for PTSD. Demographics, early trauma, and deployment experiences were collected at baseline and after deployment, respectively. Latent Class Growth Analysis was used to explore heterogeneity in trajectories of depressive symptoms over time.
Results: Four trajectories were found: resilient (65%), intermediate-stable (20%), symptomatic-chronic (9%), and late-onset-increasing (6%). The resilient group experienced fewer deployment stressors, while the symptomatic-chronic group reported more early life traumas. Trajectories with elevated depressive symptoms consistently demonstrated higher PTSD symptoms.
Limitations: Potential nonresponse bias and missing information due to the longitudinal design and extensive follow-up times.
Conclusions: This study identified multiple trajectories of depressive symptoms in military personnel up to 10 years post-deployment, associated with early trauma, deployment stressors, adverse life events and PTSD symptoms. The prevalence of the resilient trajectory suggests a substantial level of resilience among deployed military personnel. These findings provide valuable insights and a foundation for further research.

1. Introduction

Between 2005 and 2008 the Dutch armed forces participated in the International Security Assistance Force (ISAF) of NATO with either the Provincial Reconstructions Teams or with the Task Force Uruzgan. Throughout the mission, the Dutch army played a role in facilitating the reconstruction, stability, and safety in Afghanistan. The most common stressors encountered by the personnel included exposure to enemy fire, witnessing suffering or injury, and injury or dead of colleagues (Reijnen et al., 2015). It is known that military missions such as ISAF, can have an impact on mental health, including depressive symptoms (Belding et al., 2022; Bonde et al., 2016; Milliken et al., 2007; Wells et al., 2010). Increases in depressive symptoms can present themselves not just in the short-term, but also long-term. Previous research from our group found long-term significant increases of depressive symptoms (Reijnen et al., 2015), even up to 10 years post-deployment (Van Der Wal et al., 2022). Therefore, it is important to gain insight in the long-term course of depressive symptoms in deployed military personnel to improve future

☆ A preprint is available on MedRxiv: doi:https://doi.org/10.1101/2023.08.14.23294068 (Plas et al., 2023).

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https://doi.org/10.1016/j.jad.2024.03.139
Received 21 December 2023; Received in revised form 7 March 2024; Accepted 24 March 2024
Available online 25 March 2024

deployment decisions or mental health care policies in the military. Additionally, these data give us the opportunity to learn more about the long-term course of depressive symptoms after a life stressor in general.

While the occurrence of depression in the military has been studied extensively, little attention has been paid to the long-term development (trajectories) of depression after deployment. Studies investigating trajectories of depressive symptoms mainly focused on civilian rather than military samples (Gao et al., 2021; Kaup et al., 2016; Lin et al., 2022; Zhang et al., 2022). Musliner et al. (2016) conducted a systematic review on the heterogeneity in long-term patterns of depressive symptoms and found that most of these studies identified three or four different symptom trajectories and sampled the general population. Only a small portion of the studies investigated depression trajectories in a military sample. Karstoft et al. (2020) studied the trajectories of depressive symptoms from pre- to post- deployment over a period of 6.5 years in Danish soldiers. They found three trajectories: 1) low and stable (86.5%), 2) medium and fluctuating (4.0%) and 3) low but increasing (9.4%). Two other military sample studies by Sampson et al. (2022, 2015) found four trajectories of depressive symptoms in the United States army over 4 years: 1) low and stable (resistant) (55.8–61.5%), 2) increasing (12.8–13.2%), 3) decreasing (16.1–18.7%) and 4) high and stable (chronic) (9.2–12.7%). As mentioned above, soldiers can experience depressive symptoms up to 10 years after deployment, but previous studies only covered periods that were significantly shorter. This study aims to broaden the knowledge of the long-term course of depressive symptoms in military personnel by including a 10-year follow-up measurement.

A valuable tool for investigating heterogeneity in symptom patterns is Growth Curve Modelling (GCM), a statistical method that analyses inter-individual variability in intra-individual patterns over time (Curran et al., 2010). One specific type of GCM is Latent Class Growth Analysis (LCGA), which considers unobserved heterogeneity (different groups) over time within a larger population (Jung and Wickrama, 2008; Nguena Nguefack et al., 2020; Ram and Grimm, 2009). In other words, LCGA can examine the growth and shape of the course of depressive symptoms over time and assess how individuals in the population group together based on their symptom patterns.

Multiple factors might be associated with the development of depressive symptoms. For example, deployment, and particularly deployment with combat exposure, is a risk factor for new-onset depression (Wells et al., 2010). Additionally, being female, poor education, prior trauma, and rank were found to be associated with depression or depression trajectories (Karstoft et al., 2020; Musliner et al., 2016; Tang et al., 2014). Knowledge about the factors associated with depression can help identify soldiers at risk for depression post-deployment. Also, depression often co-occurs with posttraumatic stress disorder (PTSD), a psychiatric disorder that can occur following exposure to traumatic experiences, which is common in the military context (American Psychiatric Association, 2022; Rhead et al., 2022; van der Wal et al., 2021; Vermetten and Ambaum, 2019). The comorbidity of PTSD and depression is more prevalent among military samples compared to civilian samples (Rytwinski et al., 2013). Here, we aim to expand the understanding of the factors linked to depression, as well as the co-occurrence of depressive and PTSD symptoms.

The aim of the present study is to investigate the course of depressive symptoms over a period of 10 years post-deployment in military personnel and assess the role of specific factors. To achieve this goal, GCM will be performed on data from the Prospective Research in Stress-Related Military Operations (PRISMO) cohort (Van Der Wal et al., 2019). The PRISMO study was initiated in 2005 by the Dutch Ministry of Defence with the aim of studying the biological and psychological factors related to mental health both longitudinally and prospectively. 1032 soldiers participated in the PRISMO study in which data was collected at multiple time points over a period of 10 years from pre- to post-deployment. The PRISMO cohort has yielded several scientific insights including the impact of sleep (Van Liempt et al., 2013) and biological factors (van Zuiden et al., 2012b, 2012a; Van Zuiden et al., 2012) on fatigue, PTSD, and depression. However, there remains an unexplored area within the PRISMO cohort concerning long-term depression and its associated risk factors. Based on previous literature (Musliner et al., 2016), we hypothesize that three or four trajectories of depression can be identified in deployed military personnel. Given that deployment is associated with depression (Wells et al., 2010) and considering the common co-occurrence of PTSD and depression (Rytwinski et al., 2013), we additionally hypothesize that individuals following more resilient trajectories will be less likely to experience deployment stressors and exhibit reduced levels of PTSD symptoms.

2. Methods

2.1. Design and participants

Full details of the PRISMO cohort and measurement protocol can be found in the PRISMO protocol paper (Van Der Wal et al., 2019). In brief, a total of 1032 military men and women participated in this prospective observational cohort study. All participants were deployed to Afghanistan between March 2005 and September 2008 on behalf of the ISAF mission. Data was collected over a period of 10 years (Fig. 1). Approximately 1 month before deployment, the baseline (T0) measurement was carried out at the army base. Two follow-up measurements were completed 1 month (T1) and 6 months (T2) after deployment at the army base. The 1-year (T3), 2-year (T4), and 5-year (T5) follow-up measurements were completed at home. Subsequently, the 10-year (T6) follow-up was completed at the research facility of the Military Mental Healthcare. Participants completed multiple questionnaires with paper-and-pencil (T0-T4, T6) or online (T5). Participants provided written informed consent prior to the study and all procedures were approved by the Institutional Review Board of the University Medical Centre Utrecht (Utrecht, The Netherlands).

2.2. Measures

2.2.1. Depression

For T0-T4 and T6, depressive symptoms were assessed with the depression subscale of the Dutch Symptom CheckList-90 (SCL-90) (Arrindell and Ettema, 2005). As the SCL-90 was not collected at T5 (the 5-year follow-up measurement), this time point will be omitted from analysis. The SCL-90 is a self-report questionnaire for the assessment of psychopathological symptoms in adults, which demonstrated good reliability, validity, and internal consistency (Arrindell and Ettema, 2005). The depression subscale of the SCL-90 contains 16 items with responses measured on a 5-point Likert Scale ranging from 1 (never) to 5 (extremely). Hence, the lowest possible sum score was 16 and the highest was 80. For the trajectory analysis, the total sum score of the SCL-90 depression subscale was used. Based on universal standards for the general population a moderate SCL-90 depression score ranges between 20 and 23 (Arrindell and Ettema, 2005). The depression subscale of the SCL-90 has been validated in various samples (Aben et al., 2002; Schmitz et al., 1999; Strik et al., 2001).

2.2.2. Covariates

At baseline, data on sex, age, rank, educational level, year of deployment, previous deployments (yes or no), and traumatic experiences in early life were gathered. Rank was categorized into private, corporal, non-commissioned officer (sergeant), and staff officer. Educational level was divided into three levels: low (some years of high school, but not finished), medium (finished high school), and high (any years of college or university education). Year of deployment was categorized into two groups: 2005–2006 and 2007–2008. Potential early life trauma was assessed with the Early Trauma Inventory Self-Report – Short Form (ETISR-SF), which is a 27-item questionnaire assessing traumatic experiences that have occurred before the age of 18 (Bremner

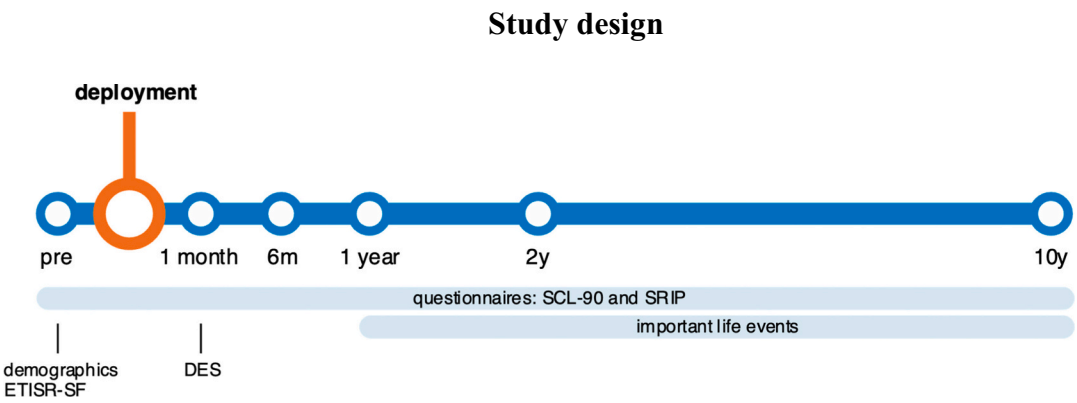

Fig. 1. Design of the used part of the Prospective Research in Stress-Related Military Operations (PRISMO). The PRISMO study collected data on 7 time points, but the SCL-90 was not collected at T5 and therefore this time point is omitted. Abbreviations: m, month; y, year; DES, Deployment Experience Scale; ETISR-SF, Early Trauma Inventory Self Report – Short Form; SCL-90, Dutch Symptom CheckList-90; SRIP, Self-Rating Inventory for Post-Traumatic Stress Disorder.

et al., 2007).

At T2, participants reported their function and experiences during the mission. Function described the participants role during the mission as activities inside the base (e.g., logistics), activities outside the base (e.g., patrols), or both. In addition, participants completed the Deployment Experience Scale (DES). The DES is a checklist to assess exposure to 19 combat-related and traumatic stressors during deployment such as witnessing dead, physical injury, and personal danger (Reijnen et al., 2015).

At all-time points, PTSD symptoms were measured with the Dutch Self-Rating Inventory for PTSD (SRIP), containing 22 questions scored on a 4-point Likert scale ranging from 1 (not at all) to 4 (very much). These items correspond to the DSM-IV criteria for PTSD (Hovens et al., 2000). The SRIP showed good reliability, validity, and internal consistency (Hovens et al., 2002, 1994). For the indication of substantial PTSD symptoms, a cut-off of 39 was used (Van Zelst et al., 2003).

2.3. Statistical analysis

2.3.1. Descriptive statistics

Participants with depression data at one or more time point(s) were included in the trajectory analysis. As a control for selection bias, the groups with and without any depression measurement were compared and assessed with chi-square tests. Differences in depression scores over time were assessed with Friedman's ANOVA. Descriptive statistics are presented as numbers and percentages.

2.3.2. Trajectory analysis

The data showed a skewed distribution with inflation at the minimum of the scale. Because preliminary analysis indicated convergence problems of the LCGA model due to this skew, a Box-Cox transformation was performed (Supplementary Fig. S2). This transformation makes it possible to examine the patterns of heterogeneity between participants in more detail. As LCGA requires complete data, missing data on the depression and PTSD items was imputed using the missForest single imputation algorithm, which uses a random forest model of all other variables to interpolate missing values. In simulation studies, single imputation using missForest shows comparable performance to best practice algorithms (Stekhoven and Bühlmann, 2012). Additionally, it can be applied to all types of data and does not require assumptions about the distribution of the data (Stekhoven and Bühlmann, 2012). As LCGA assumes that the data is not multivariate normal, non-parametric imputation is appropriate (Van Lissa et al., 2023). Measurement invariance analyses for depressive symptoms are described in Supplementary Table S3. For the trajectory analysis and assessment of covariates (demographics, early trauma, deployment experience, PTSD symptoms and life events) we followed the three-step approach which accounts for classification errors of the model (Vermunt, 2010). In this approach an auxiliary model is estimated based on the latent classification and the cases are weighted by group-specific BCH weights (Bolck et al., 2004). Afterwards an omnibus likelihood ratio test was obtained to test for significant differences across trajectories. For all omnibus likelihood ratio tests the *p*-values were corrected for multiple comparisons using the false discovery rate. If the omnibus test was still significant after correction, post hoc test results were obtained and likewise subjected to correction for multiple comparisons using the false discovery rate.

All analyses were performed using the programming language R (version 4.2.2, package for trajectory analysis: tidySEM; (Lissa, 2023)) (with significance level set at $p < .05$ (two-tailed)). All R code is made publicly available on GitHub at https://github.com/XandraPlas/prismo_trajectoryAnalysis

To detect heterogeneity in the course of depressive symptoms after deployment, LCGA was conducted, which assumes the existence of multiple prototypical developmental trajectories (Jung and Wickrama, 2008; Nguena Nguefack et al., 2020; Ram and Grimm, 2009). Previous studies (Musliner et al., 2016) identified three to six subgroups of depression trajectories. For this reason, models with one- to seven classes were estimated. To model the potential effect of deployment on depression, a dummy variable was included that was zero before deployment (T0) and one after deployment (T1-T4, T6). To model potential change in the course of depressive symptoms after deployment, both linear and quadratic terms were included and the unequal time intervals between measures were specified in the model. Differences between the identified trajectories in intercept, slope and step parameters were assessed with Wald tests.

The best performing model was selected based on a combination of the Bayesian information criterion and interpretability (Nagin and Odgers, 2010; Nguena Nguefack et al., 2020; Ram and Grimm, 2009). Common fit indices are Information Criteria (IC) including the Bayesian Information Criteria (BIC), sample-size-adjusted BIC (saBIC), and the Akaike Information Criteria (AIC). The general principle is to select the model with the lowest value on these ICs (Nylund et al., 2007; van der Nest et al., 2020; Van Lissa et al., 2023). With contradicting ICs, the inflection point in a scree plot can be used to decide which additional classes have a minor contribution to the decrease in ICs (Nylund-Gibson and Choi, 2018). To assess the model classification performance, entropy, posterior classification probability (probability of belonging to the class one is assigned to), and class size were evaluated. Clearly separable solutions were considered to be desirable because we intended to interpret the class solution. Class separability is related to entropy, with high entropy indicating separate and clearly distinguishable classes (Van Lissa et al., 2023; Weller et al., 2020). We thus eliminated solutions with entropy $< .90$ from consideration. Second, if individuals' posterior

Table 1
Demographics and baseline characteristics of the deployed participants in the PRISMO cohort, n (%).

	Participants with outcome values at one or more time point(s) (n = 978)[a]		Participants without any outcome values (n = 29)[a]		*p*-Value
Sex					
Male	893	(91%)	28	(97%)	0.32
Female	85	(9%)	1	(3%)	
Age in years[b]	28.5	(SD: 8.94)	23.2	(SD: 2.51)	<0.01
Rank[c]					
Private	388	(40%)	6	(50%)	0.41
Corporal	199	(21%)	4	(33%)	
Non-commissioned	346	(36%)	2	(17%)	
Staff officer	35	(4%)	0	(0%)	
Educational level[d]					
Low	33	(4%)	0	(0%)	0.73
Medium	764	(85%)	11	(92%)	
High	105	(12%)	1	(8%)	
Function[e]					
Outside the military base	476	(60%)	7	(64%)	0.56
Inside the military base	244	(31%)	4	(36%)	
Both outside and inside the military base	73	(9%)	0	(0%)	
Year of deployment					
2005–2006	251	(26%)	10	(34%)	0.29
2007–2008	727	(74%)	19	(66%)	
Previous deployments[f]					
No	469	(53%)	9	(75%)	0.12
Yes	421	(47%)	3	(25%)	

Differences in demographics between participants with and without outcome values were tested with a chi-square or Mann-Whitney *U* test. Significance at $p < .05$. Abbreviations: SD, standard deviation.

[a] Numbers might not add up to total sample-size because of missing values within the descriptive variables. For variables with missing data the sample sizes are indicated.

[b] n = 1000.

[c] n = 980.

[d] n = 914.

[e] n = 804.

[f] n = 902.

classification probability is high for one class and low for the other classes, the classes are distinct, i.e., the model can adequately group individuals with similar trajectories (Andruff et al., 2009). We accepted solutions with a minimum average posterior classification probability > .90 (Weller et al., 2020). Finally, previous research recommended class sizes of at least 50 individuals or 5% of the total sample (Muthén and Muthén, 2000; Weller et al., 2020). We therefore considered classes with at least 50 participants.

2.3.3. Exploration of (adverse) life events

To get more insights in the trajectories and associated life events we assessed differences in the number of experienced adverse life events between the different classes. We used the same three-step approach with the omnibus likelihood test used for the covariates and the results were also corrected for multiple comparisons. All participants reported their adverse life events (e.g., divorce, relationship problems, financial problems) over the past year (T3 and T4) or the past 6 months (T5 and T6). We decided to remove events that were not necessarily negative (e.g., marriage, birth, move, retirement). In addition, we examined whether there were differences in trajectories among individuals who remained on active duty.

3. Results

3.1. Descriptive statistics

A total of 1032 military men and women participated in the PRISMO cohort. Of this total, 978 were included in this study. Participants were excluded if they were eventually not deployed (n = 25) or did not have a depression measurement at any of the time points ($n = 29$). The comparison between the group with and without any measurements is shown in Table 1 with all baseline characteristics of the participants. For most of the baseline characteristics, except age, no significant differences were found between participants missing all depression measurements and participants with at least one depression measurement. Supplementary Table S4 shows the total number of participants per time point and the percentage of participants with low (< 20), average (20 – 23), or high (> 23) levels of depressive symptoms based on the norm of Arrindell and Ettema (2005). The sample average depression score did not significantly change over the 10 years after deployment ($\chi^2(5) = 9.56, p = .09$).

3.2. Trajectory analysis

3.2.1. Model selection

A complete table of model characteristics and fit statistics of the linear and quadratic models are shown in Supplementary Table S5. A selection of characteristics and fit statistics is presented in Table 2 for the linear models. All quadratic models, except the one-class quadratic model, encountered convergence problems and failed to find a final solution. This suggests that the quadratic models are too complex for our dataset (Van Lissa et al., 2023). While it is feasible to explore alternative non-linear patterns, the persisting issue lies in the apparent complexity associated with models incorporating many parameters.

For the linear models, a reduction in BIC, saBIC and AIC was observed with increasing class number (Supplementary Fig. S6). The reduction in ICs flattened after three classes. In addition, the Lo-Mendell-Rubin (LMR) likelihood ratio test was significant with every additional class and entropy was above.90 for all models. Posterior group probability was acceptable (above.90) up to the four-class model. Therefore, the models with five or more classes were not accepted. For all models with one to four classes, the class size was larger than 5% and

Table 2
Model characteristics and fit indices.

Model	LL	Parameters	AIC	BIC	saBIC	Entropy	Minimum posterior classification probability	Minimum group size (% of total sample)	LMR	LMR *p*-Value
Linear step										
1	526	9	−1035	−991	−1049	**1.00**	**1.00**	**100%**		
2	1903	13	−3779	−3716	−3802	**0.94**	**0.97**	**24%**	2626	**<0.01**
3	2251	17	−4468	−4385	−4498	**0.93**	**0.93**	**9%**	665	**<0.01**
4	2351	21	−4660	−4558	−4699	**0.94**	**0.90**	**6%**	191	**<0.01**
5	2431	25	−4811	−4689	−4858	**0.90**	0.83	**6%**	152	**<0.01**
6	2466	29	−4874	−4732	−4928	**0.90**	0.83	2%	68	**<0.01**
7	2484	33	−4903	−4742	−4965	**0.91**	0.80	1%	35	**<0.01**

Bold is in accordance with our criteria or indicates significance ($p < .05$).
Abbreviations: LL, Log-likelihood; AIC, Akaike Information Criteria; BIC, Bayesian Information Criteria; saBIC, sample-size-adjusted Bayesian Information Criteria; LMR, Lo-Mendell-Rubin likelihood test.

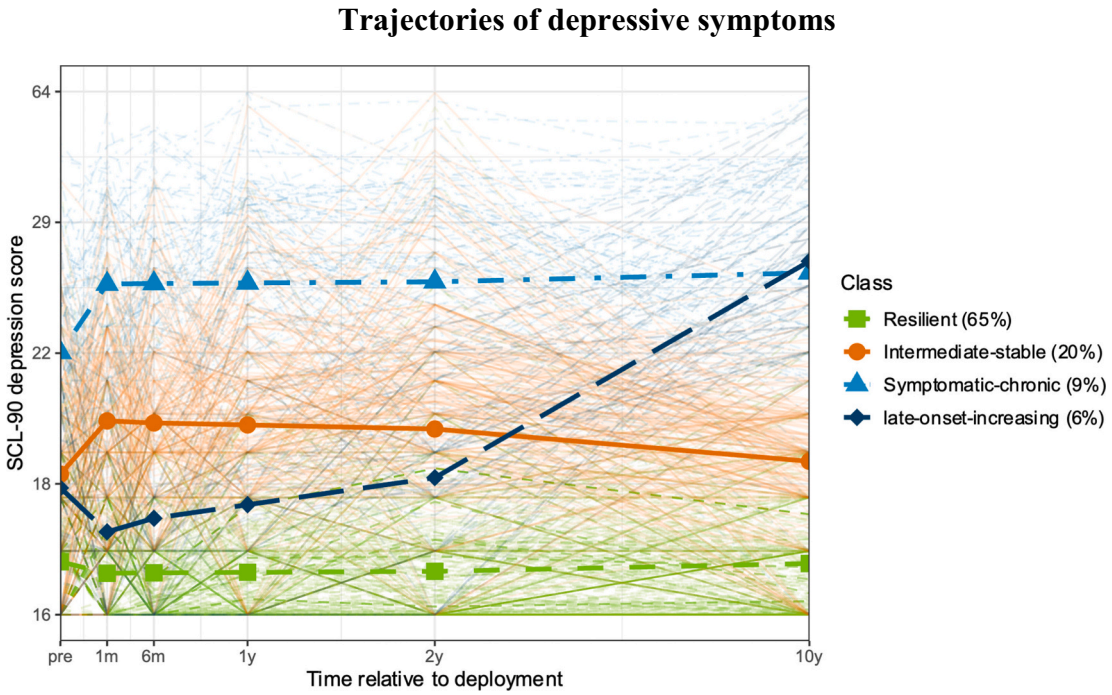

Fig. 2. Predicted depression trajectories and individual depression scores at the different time points. Different colors indicate the four different classes. SCL-90 (Short CheckList – 90) score is rescaled from Box-Cox transformation. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

consisted of at least 50 individuals.

Altogether, most quadratic models did not converge, and both the three- and four-class model performed well and had acceptable classification performance. But the four-class model was able to capture the small group of soldiers exhibiting a late-onset increase in depressive symptoms. Therefore, we selected the linear four-class model as the final model.

3.2.2. Depression trajectories

The four classes identified were a resilient class with 639 participants (65%), an intermediate-stable class with 199 participants (20%), a symptomatic-chronic class with 86 participants (9%), and a late-onset-increasing class with 54 participants (6%) (Fig. 2). The resilient group showed low levels of depressive symptoms before deployment with a small significant decrease after deployment, followed by stability ($p < .01$, Supplementary Table S7). The intermediate-stable and symptomatic-chronic group showed a significant increase in depressive symptoms after deployment that slightly decreased over time for the intermediate-stable group and remained elevated and stable until the 10-year time point for the symptomatic-chronic group ($p < .01$, Supplementary Table S7). The late-onset-increasing group started between the low and intermediate group before deployment, showed a significant decrease in depressive symptoms from pre- to post-deployment followed by an increase from there until 10 years post-deployment ($p < .01$, Supplementary Table S7).

Results of the Wald tests (Supplementary Table S8) showed that the pre-deployment scores for depressive symptoms (intercepts) and the increase from pre- to 1-month post-deployment (step parameter) differed significantly between all classes ($p < .01$). Furthermore, the trajectories differed significantly in slope ($p < .01$). (See Supplementary Table S9 for pairwise comparisons with Bonferroni correction).

3.2.3. Covariates

Assessment of covariates using the three-step approach revealed that the trajectories did not differ in any of the demographical variables, including sex $(\Delta LL(5) = 6.3, p = .27, p_{corr} = .37)$, age $(\Delta LL(8) = 8.4, p = .40, p_{corr} = .50)$, rank

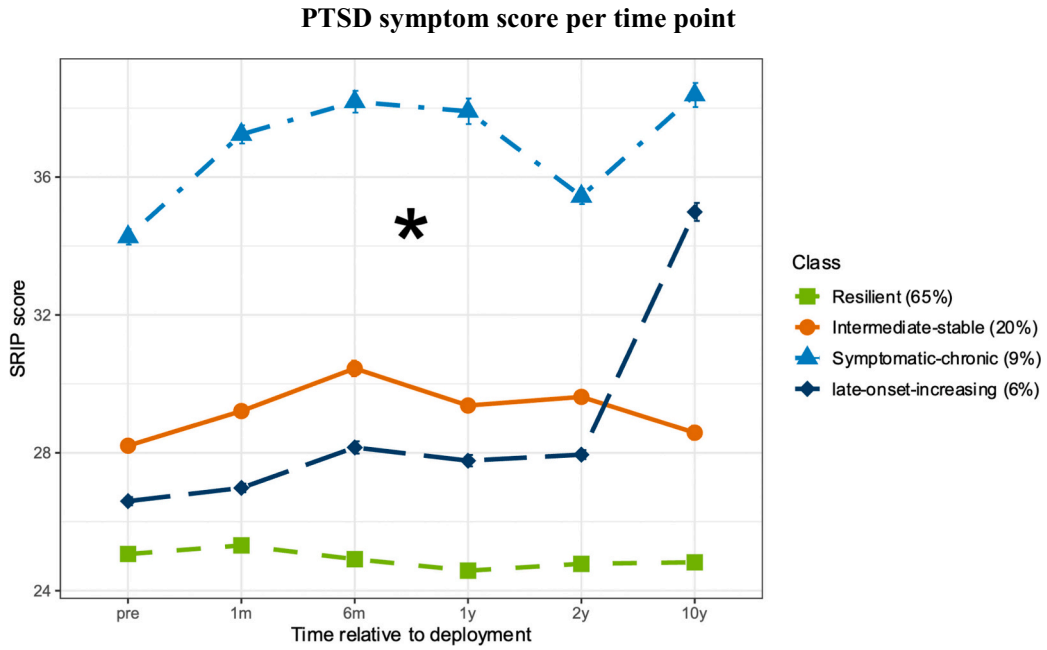

Fig. 3. PTSD scores per time point (mean and standard deviation ($n = 978$)). Colors indicate different classes. *All trajectories differed significantly at each time point ($p_{corr} < .05$), except for the intermediate-stable and late-onset-increasing group at the 1-year time point ($p_{corr} = .08$). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

$(\Delta LL(11) = 13.5, p = .26, p_{corr} = .37)$, educational level
$(\Delta LL(9) = 7.1, p = .63, p_{corr} = .66)$, function
$(\Delta LL(8) = 8.1, p = .43, p_{corr} = .51)$, year of deployment
$(\Delta LL(5) = 3.6, p = .61, p_{corr} = 66)$, or previous deployments
$(\Delta LL(6) = 3.0, p = .81, p_{corr} = .81)$. For early life traumas, the symptomatic-chronic group experienced more early life traumas compared to the other trajectories $(p < .01, p_{corr} < .01)$ and both the resilient and late-onset-increasing group experienced significantly less early life traumas compared to the intermediate-stable group $(\Delta LL(2) = 21.6, p < .01, p_{corr} < .01; \Delta LL(2) = 8.1, p < .05, p_{corr} < .05)$ (Supplementary Fig. S10).

Significant disparities in the number of deployment stressors were observed, with the resilient group exhibiting lower counts of deployment stressors compared to the intermediate-stable group $(\Delta LL(2) = 23.0, p < .01, p_{corr} < .01)$, symptomic-chronic group $(\Delta LL(2) = 325.7, p < .01, p_{corr} < .01)$, and late-onset-increasing group $(\Delta LL(2) = 9.5, p < .01, p_{corr} < .05)$ (Supplementary Fig. S11). A detailed breakdown of percentages per stressor is provided in Supplementary Table S12.

3.2.4. Depression and PTSD

Significant differences in PTSD symptom scores were observed across all four trajectory groups at nearly every time point (Fig. 3, Supplementary Table S13). The resilient group consistently exhibited significantly lower levels of PTSD symptoms compared to the intermediate-stable, symptomatic-chronic, and late-onset-increasing group ($p < .01$, $p_{corr} < .01$). Additionally, the symptomatic-chronic group scored higher on PTSD symptoms compared to the intermediate-stable and late-onset-increasing group across all time points ($p < .01, p_{corr} < .05$). Until the 2-year time point, the late-onset-increasing group consistently reported lower levels of PTSD symptoms compared to the intermediate-stable group, with statistical significance observed at all time points ($p < .01$, $p_{corr} < .01$), except for the 1-year time point $(\Delta LL(2) = 5.5, p = .06, p_{corr} = .08)$. At the 10-year time point, the late-onset-increasing group demonstrated significantly higher levels of PTSD symptoms compared to the intermediate-stable group $(\Delta LL(2) = 53.1, p < .01, p_{corr} < .01)$.

3.2.5. Depression and (adverse) life events

From deployment to the 1-year time point, participants in the resilient group reported fewer life events compared to the intermediate-stable $(\Delta LL(8) = 20.6, p < .01, p_{corr} < .01)$ and symptomatic-chronic group $(\Delta LL(8) = 20.8, p < .01, p_{corr} < .01)$ (Supplementary Fig. S14). Starting from one year after deployment and continuing to the 10-year time point, the resilient group consistently exhibited fewer life events compared to all the other trajectories $(p < .01, p_{corr} < .01)$(Supplementary Fig. S14). From two years after deployment to ten years post-deployment, the late-onset-increasing group reported more life events compared to the intermediate-stable group $(\Delta LL(9) = 10.2, p < .01, p_{corr} < .01)$. A detailed breakdown of percentages per life event is provided in Supplementary Tables S15–S17.

We found no significant difference in the trajectories among individuals who remained on active duty $(\Delta LL(6) = 9.8, p = .13, p_{corr} = .20)$. This suggests that active-duty status did not significantly influence the trajectory of depressive symptoms over time.

4. Discussion

The current study investigated trajectories of depressive symptoms up to 10 years after deployment in military personnel. Therefore, a LCGA was performed based on a group of 978 veterans who were deployed as part of ISAF. In line with the hypothesis, four distinct trajectories were identified: 1) resilient, 2) intermediate-stable, 3) symptomatic-chronic, and 4) late-onset-increasing. The trajectories differed on deployment stressors, early trauma, PTSD symptoms, and adverse life events.

Most of the study sample fell within the resilient trajectory (65%), displaying no or low levels of depressive symptoms. This finding is consistent with previous studies conducted in military samples, where a resilient group (55.9%–86.5%) was observed comprising most of the participants (Karstoft et al., 2020; Sampson et al., 2022, 2015). Furthermore, this large resilient group was also identified in recent studies investigating depression trajectories in students, older adults, and adolescents(Gao et al., 2021; Lin et al., 2022; Zhang et al., 2022).

The intermediate-stable trajectory (20%) exhibited an increase in depressive symptoms after deployment and slightly elevated levels of depressive symptoms compared to the resilient trajectory. This intermediate-stable trajectory with low levels of depression was also found in previous studies in the civilian population (Hybels et al., 2016; Salmela-Aro et al., 2008). Both the resilient and intermediate-stable trajectories remained below average symptom levels (average levels: 20 − 23 (Arrindell and Ettema, 2005). These findings support the idea that resilience is more common than expected (Bonanno, 2004) and might imply resiliency in deployed military personnel, which is a protective factor for depression (Brailovskaia et al., 2018; Watters et al., 2023). In addition, assuming that deployed military personnel are an extraordinary selection of young and healthy individuals, high resilience in the face of adversity is expected.

Unlike the resilient and intermediate-stable trajectories, a symptomatic-chronic group (9%) was present which showed medium levels of symptoms before deployment, and this increased to high levels (> 23 (Arrindell and Ettema, 2005)) after deployment. This finding is in line with the studies of Sampson et al. (2022, 2015), who found a chronic (dysfunction) group within a military cohort, consisting of respectively 12.6% and 9.2% of the individuals. Although trajectories with high depressive symptoms over time are rare, studies both in the military and civilian samples report long-term chronic, high levels of depressive symptoms in small proportions (<10%) of the study population (Musliner et al., 2016; Sampson et al., 2022, 2015). Recognizing the presence of a chronic trajectory underscores the importance of regular screening within the military to promptly address ongoing symptoms. Additionally, this highlights the importance of educating deployed military personnel who develop depressive symptoms, emphasizing that these symptoms may not necessarily decrease over time.

Finally, the model was able to capture a late-onset-increasing group (6%). This increasing group has also been identified in previous military studies (Karstoft et al., 2020; Sampson et al., 2023, 2015). Our trajectory resembled the low-increasing group discovered by Karstoft et al. (2020), although there was a notable distinction in the timing of the increase. In their study, the trajectory drastically increased directly at homecoming, whereas ours increased more gradually. On the other hand, Sampson and colleagues found a mild increasing group, which differed from our late-onset-increasing group that experienced a large increase of symptoms. Looking at our results, this disparity can be explained by the shorter study period of Sampson and colleagues. It was only towards the 10-year point that our late-onset-increasing group exhibited above-average levels of depressive symptoms. Despite the relatively low absolute levels of depressive symptoms observed in the late-onset-increasing trajectory, there is cause for concern regarding this group. Prior research has demonstrated that larger increases in symptoms over a deployment period are associated with higher post-military stress and a reduced civilian job satisfaction (Campbell-Sills et al., 2023). This suggests that monitoring and addressing increases in depressive symptoms may be crucial for their long-term well-being.

Significant differences between all trajectories were found for both the intercept, step (from pre- to 1-month post), and slope, indicating that individuals at risk might be identified before deployment and react differently to deployment. It may be speculated that the differences in the trajectories of depressive symptoms are influenced by multiple factors, including pre-existing individual differences and the experience of significant life events. Our results showed that individuals in trajectories with higher levels of depressive symptoms, were more likely to experience adverse life events. It is important to note, however, that these results cannot be interpreted causally because life events were measured during the course of the study. It is thus equally plausible that these adverse life events influenced trajectories of depressive symptoms, or that trajectories of depressive symptoms influenced the likelihood of experiencing, or perceived salience, of life events. Notably, the late-onset-increasing group demonstrated an increase in both adverse life events and depressive symptoms from two to ten years post-deployment. Furthermore, the significant differences in intercepts between classes suggest that individuals may have varying levels of vulnerability or predispositions to depression even before deployment. These vulnerabilities could be attributed to genetic factors, early-life experiences, personality traits, or other underlying biological and psychological factors (Choi et al., 2019; Saavedra and Salazar, 2021; Sampson et al., 2023). If individuals with higher vulnerability or pre-existing depressive symptoms enter the military, the exposure to stressful and traumatic events during deployment (e.g., separation from loved ones, combat, or witnessing injuries and harmful situations) could exacerbate depressive symptoms, leading to a more severe trajectory of depressive symptoms post-deployment. Further research is needed to understand the interplay between pre-existing vulnerabilities, exposure to deployment stressors, and the course of depressive symptoms, particularly in military contexts where exposure to traumatic events can be prevalent.

Analysis of covariates revealed no differences between trajectories for demographic variables. While others have found female veterans to be more likely to develop depression (Haskell et al., 2010), we did not find any differences in sex between the trajectories. This could be explained by lack of power, as our sample included only a small number of women. The trajectories did differ in the number of traumatic events in early life, with the symptomatic-chronic group reporting the highest number. This aligns with the study by Sampson et al. (2022) and a previous PRISMO study, which found that early trauma is negatively associated with aspects of personality (e.g., cooperativeness and self-directedness), which in turn leads to a higher risk of adult psychopathology (Rademaker et al., 2008). Due to the relatively high prevalence of adverse childhood experiences in military personnel, surpassing that of the general population (Afifi et al., 2016; Blosnich et al., 2014), these findings emphasize the need for monitoring individuals with early trauma. As the results indicate, those with such experiences may exhibit higher levels of depressive symptoms before deployment and maintain a stable and chronic trajectory of these symptoms over a period of 10 years post-deployment.

Regarding deployment stressors and PTSD, differences were observed among distinct trajectories. Previous research has established a consistent correlation between depression and military deployment, particularly in deployments that involve combat exposure. Conversely, military deployment without such exposure has been linked to a reduced risk of depression (Bonde et al., 2016; Sareen et al., 2007; Wells et al., 2010). In our study, those who exhibited a resilient trajectory tended to report fewer negative experiences during deployment, such as personal danger, screaming of injured, and feeling out of control. Again, it is important to note that these results cannot be interpreted causally. Considering the differences of depressive symptoms between the trajectories prior to deployment, it is plausible to propose that these trajectories of depressive symptoms influenced the perception of stressors during deployment. In accordance with our results, Porter et al. (2018) found that depression was associated with witnessing abuse, feeling in danger, knowing someone is injured, or being injured oneself. Regarding PTSD, trajectories with higher depressive symptoms also exhibited higher levels of PTSD symptoms. Notably, the symptomatic-chronic and late-onset-increasing group approached the PTSD cut-off score of 39 (Van Zelst et al., 2003) at the 6-month, 1-year, and 10-year follow-up assessments. However, a trend emerged indicating that participants with higher depressive symptoms had higher PTSD symptom scores. PTSD and depression co-occur frequently (Rytwinski et al., 2013), and while there are overlapping symptoms, PTSD and depression are distinguishable disorders characterized by unique patterns of symptoms (Ben Barnes et al., 2018; Grant et al., 2008). It would be interesting for future research to explore the potential mediating role of PTSD symptoms in the relationship between deployment stressors and depressive symptom trajectories.

One of the limitations of the current study is the use of self-report questionnaires, which might not correspond with clinician assessment

of depression. However, for measures of depression, there remains a lack of consensus regarding the extent of disagreement between clinician-rated and self-reported measures of depression (Dunlop et al., 2014, 2010; Rush et al., 2006). Thereby, the use of a self-report questionnaire was consistent over all time points, ensuring that symptoms are consistently assessed in the same way. This was also confirmed with the analysis of measurement invariance. In addition, there was a lack of diversity in the sample population, with a majority of participants being of the same ethnicity and a minority of women. This limits the generalizability of the study's findings to other groups. Another limitation is that around 40% of participants did not complete all measurements. This is a common limitation in longitudinal studies, and we cannot discount the possibility that nonresponse may have an influence on the study results. Additionally, most criteria for model selection in LCGA have known limitations (Van Lissa et al., 2023; Weller et al., 2020), resulting in subjective judgements and inconsistencies among different individuals or groups. We have chosen strict criteria, ensuring that the performance of the model was appropriate. Another limitation is the extensive interval between the 2-year and 10-year measurement resulting in a lack of crucial information, including the timing and type of received treatment in the study period, which could limit interpretability. As a result, we cannot attribute any changes in trajectories to the treatments they may have received during the study period.

In addition, during the long follow-up periods, potential changes in depressive symptoms could not be detected. Unfortunately, our study did not include a non-deployed control group for comparing depressive symptoms between deployed and non-deployed personnel. This comparison is essential for determining if the observed increases in depressive symptoms are solely due to deployments or influenced by other factors. Future research should incorporate a control group to address this limitation to enhance the understanding of the impact of military deployments on mental health. At last, it is important to acknowledge the uncertainty regarding the direct link between depressive symptoms observed at the 10-year time point and deployments a decade ago. While subsequent deployments or other life events may influence these symptoms, this study provides valuable insights into the long-term post-deployment course of depressive symptoms in a military cohort. Another strength of this study is that it was one of the first to perform LCGA using free open-source software, most notably R and the tidySEM package. Furthermore, all code used in this analysis is available in a reproducible repository, thereby enabling all researchers to reuse the code to perform similar analyses. Finally, a notable strength of the study lies in the unique value offered by the dataset, which spans a time period of ten years.

In conclusion, four trajectories of depressive symptoms were identified in a military sample up to 10 years after deployment, the trajectories were associated with deployment stressors, early trauma, PTSD symptoms and adverse life events. These insights in the long-term course of depressive symptoms may guide decisions regarding deployment and mental health care policies within the army. For the increasing trajectory, monitoring is important, extending beyond the military service into the post-military transition phase. Additionally, the symptomatic-chronic group underscores the need to support ongoing mental health management. Our findings give insights in important factors associated with different trajectories of depressive symptoms and identify key factors worthy of monitoring. However, the question remains why depressive symptoms can develop differently in military personnel and veterans. More research is needed to investigate which factors are associated with and predict the different depression trajectories.

Funding statement

This work was supported by the Dutch Ministry of Defence. The funder had no role in the design and reporting of the study.

CRediT authorship contribution statement

Xandra Plas: Writing – original draft, Visualization, Software, Methodology, Formal analysis, Conceptualization. **Bastiaan Bruinsma:** Writing – review & editing, Methodology, Conceptualization. **Caspar J. van Lissa:** Visualization, Software, Methodology, Formal analysis. **Eric Vermetten:** Writing – review & editing. **Remko van Lutterveld:** Writing – review & editing, Methodology, Conceptualization. **Elbert Geuze:** Writing – review & editing, Supervision, Investigation, Funding acquisition, Conceptualization.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ChatGPT in order to improve readability and language. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Declaration of competing interest

All authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data availability

The data that support the findings of this study are available upon reasonable request from any qualified investigator. Restrictions apply to the availability of these data due to privacy or ethical considerations. For inquiries regarding data access, please contact the Brain Research and Innovation Centre at expertisecentrumMGGZ@mindef.nl.

Acknowledgments

The authors thank the Dutch commanders and troops and all members of the PRISMO team involved in data acquisition for their ongoing commitment to the study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jad.2024.03.139.

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