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Retrospectively assessed trajectories of PTSD symptoms and their subsequent comorbidities

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ABSTRACT

Background: Dynamic trajectories of psychopathology, such as post-traumatic stress disorder (PTSD) provide a key to understanding human adjustment processes after trauma exposure. Recent studies have suggested more heterogeneous mental health outcomes than the initially identified four adjustment trajectories. To explore this heterogeneity, we investigated the after-trauma adjustment patterns of psychopathology based on retrospective lifetime data. This was first carried out on the PTSD symptoms (PTSS, including no symptoms, few symptoms, partial and full PTSD), and secondly together with their post-trauma comorbidities.

Methods: Data of trauma and the post-trauma mental disorders were collected for a large and randomly selected community sample, resulting in a N = 960 trauma-exposed subsample. Pattern recognition as carried out by latent class analysis (LCA) was implemented on this subsample. LCA was first exploited to identify the potential trajectory patterns of PTSS and next to explore the patterns of mental adjustments when additional post-trauma comorbid disorders, such as anxiety, mood and substance use disorders, were assessed.

Results: Four PTSS trajectory patterns were found, namely resilient, chronic, recovered, and delayed onset, consistent with findings from longitudinal PTSD studies. When post-trauma comorbidities were evaluated, other than the trajectory pattern of delayed onset which retained a low comorbidity profile, the other three split respectively and paired up with either low, moderate or high comorbidity profile.

Conclusions: Mental health outcomes after trauma exposure were considerably more complex than the four previously established adjustment trajectories. Here, we uncovered additional and more heterogeneous adjustment patterns comprised of PTSS trajectories and post-trauma comorbidity profiles.

1. Introduction

During their lifetime, most individuals are likely to encounter one or more potentially traumatic events (PTE, also referred to as trauma in this article) that are extremely stressful or life threatening, including disasters, combat/war, loss of loved ones or sexual abuse (Ogle et al., 2013; Karam et al., 2014). The link between exposure to PTE and PTSD has long been established (Breslau et al., 1991; Perkonigg et al., 2000). Studies on trajectories of PTSD have added important information to our understanding of the human adaptation processes after trauma exposure. Four robust adaptation trajectories were described by Bonanno (2004) and others: a) resilient, i.e. stable healthy functioning; b) recovered, i.e. prolonged psychopathology with eventual remission; c) chronic, i.e. long lasting and persistent psychopathology; and d) delayed onset of disorders after trauma exposure (Galatzer-Levy et al., 2018). These trajectories were found to be consistent both in forms and proportions across populations, contexts and outcomes, that is similar patterns of trajectories were found whether the post-trauma psychopathology were measured by PTSD or depression (Galatzer-Levy et al., 2018).

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Trajectory studies have shown the majority of trauma-affected individuals to be resilient. However, the notion of resilience as an absence of psychopathology, e.g., no PTSD or depression, has recently been questioned. For example, Bonnano et al. reframed resilience as minimal-impact resilience, which was defined as either a lack of any psychopathology or as transitional and minimal psychopathological symptoms (e.g. PTSD) during or after the trauma exposure (Bonanno et al., 2011; Bonanno and Diminich, 2013). In contrast, Masten et al. suggested that people are resilient as long as they can recover from PTSD (Masten and Narayan, 2011; Southwick et al., 2014). Meanwhile, those who evince only few PTSD symptoms (PTSS) may nonetheless suffer substantial disability of clinical relevance (Marshall et al., 2001; Müller et al., 2014; Chen et al., 2020). Therefore, it is necessary to assess the heterogeneity of pathology vs resilience after trauma exposure. To analyse this heterogeneity, we first proposed to explore the trajectory patterns of the whole spectrum of PTSS, from no or few symptoms to partial or full PTSD diagnosis.

Although PTSD is the most studied outcome to trauma exposure, comorbidity is also frequent among individuals with PTSD and rather the norm than an exception. Those with PTSD are twice as likely to develop other psychiatric disorders (Breslau, 2009), especially depressive disorders, anxiety disorders, or substance use disorders (Brady et al., 2000; Krysinska and Lester, 2010; Fani et al., 2020). Individuals with PTSD and comorbid disorders were shown to have greater PTSD severity and greater impairment of functioning (Quarantini et al., 2009). A recent study has further shown that in trauma-exposed veterans who were diagnosed with both PTSD and depression, trajectories of the two disorders moved in tandem (Armenta et al., 2019). Therefore, comorbidity can be taken as an indicator of the severity of PTSD (Johansen et al., 2013). Several comorbidity patterns among individuals with full/partial PTSD have also been reported (Müller et al., 2014). However, even though it is normal to use comorbid disorders of PTSD, such as depression, as an alternative to indicate the adjustment processes after trauma exposure, the post-trauma comorbidity patterns have not yet been examined for the PTSD trajectories, especially not when the whole spectrum of PTSS were assessed. Therefore, in the second step of heterogeneity analysis, we investigated the post-trauma comorbidity profiles of the PTSS trajectory patterns.

In summary, we first aimed to identify the PTSS trajectory patterns to trauma exposure that correspond to PTSD trajectories in longitudinal studies. Information on PTSS severity and time course (i.e., delay of onset, duration, and persistence) was retrospectively collected for the most severe trauma of individuals' lifetime. Latent class analysis (LCA, a statistical tool for pattern recognition) was implemented to subgroup the trauma-exposed subjects and identify the PTSS trajectory patterns. Second, we investigated the adjustment patterns when both trajectories of PTSS and the post-trauma comorbid disorders were considered. Lastly, associated factors, such as sex, age at trauma exposure, socioeconomic status and trauma types were explored.

2. Methods

2.1. Sample & instruments

The trauma-exposed sample (N = 960, 35–38 years) used for the current study was derived from the randomly selected Swiss population cohort of CoLaus|PsyCoLaus (Firmann et al., 2008; Martin Preisig et al., 2009), which explored associations between mental disorders and cardiovascular diseases. The psychiatric evaluation was carried out by trained psychiatrists and psychologists using the French version (Preisig et al., 1999) of the semi-structured Diagnostic Interview for Genetic Studies (DIGS) (Nurnberger et al., 1994), which collected diagnostic information relating to DSM-IV Axis I criteria and the course and chronology features (Preisig et al., 1999). Supplementary 11 provided more details of this cohort and the related instruments.

2.2. Potentially traumatic events and post-traumatic stress disorder symptoms

Information regarding the nature of potentially traumatic events as well as subsequent PTSS was extracted from the PTSD section of the interview (Perrin et al., 2014). Five types of traumatic events were assessed: 1) accident or severe catastrophe, 2) active combat or war, 3) witnessing trauma to others, 4) violent crime (e.g. kidnapping, hard blows or murder), and 5) sexual trauma. Those who reported at least one of these PTE were further evaluated with the PTSD symptom section and included in the current analysis (N = 960). If more than one type of trauma exposure was documented, the interviewer determined which type had led to the development of PTSS. Age related to the traumatic event associated with PTSS was recorded. Information on the time course of the PTSS was also collected (Müller et al., 2018).

Four mutually exclusive categories were constructed for the PTSD symptom severity variable: trauma exposure with a) no symptoms, b) only a few symptoms, c) partial PTSD, or d) full PTSD. Full PTSD was defined according to DSM-IV standards. As described in detail in Table 1, those who manifested PTSD symptoms, yet fell short of partial PTSD, were classified as PTSD cases with few symptoms. Three time-course variables of PTSS were considered: delay of onset after trauma exposure, whether or not present at time of interview and how long they had lasted by time of interview. More information on these variables and their levels can be found in Table 1.

2.3. Post-trauma comorbid mental disorders and the sociodemographic variables

The assessment of comorbid disorders was restricted to those that had occurred in the aftermath of trauma. Accordingly, only the comorbid disorders for which ages of onset were the same as or older than the age of trauma exposure, were considered. Most of the common mental disorders (CMDs) were covered and pooled into three groups: 1) Anxiety disorders: including overanxious disorder, social phobia, generalized anxiety disorder, agoraphobia, panic disorder, simple phobia, separation anxiety, obsessive compulsive disorder; 2) Mood disorders: major depressive disorder (recurrent), bipolar disorders, dysthymia and schizoaffective disorders; 3) Substance use disorders (SUD) (both abuse and dependence): Alcohol use disorders and drug use

Table 1
PTSD symptom severity and timing variables derived from the DIGS.

Variable Names	Levels of Variables	Details
ON	<=1 week >1 week & <=6 months >6 months	How long the onset of PTSS was delayed after trauma exposure.
persistent	No Yes	Whether or not PTSS were still persistent at the time of interview.
duration	<=1 year >1 year & <=10 years >10 years	How long PTSS had lasted by the time of interview.
Severity of PTSS	No symptoms	Trauma exposure without PTSD symptoms.
	Few symptoms	Trauma exposure with one or more PTSD symptoms yet falling short of partial PTSD.
	Partial PTSD	With ≥1 symptom in each of the DSM-IV PTSD criteria B, C and D as well as ≥ 1-month duration.
	Full PTSD	Defined as in the DSM-IV: ≥ 1 of 5 criteria B symptoms (experiencing the trauma), ≥3 of 7 criteria C symptoms (avoidance and numbing), ≥2 of 5 criteria D symptoms (hyperarousal symptoms), ≥ 1-month duration (E) and clinical significance (F).

disorders. These CMDs were diagnosed according to the DSM-IV criteria operationalized in the DIGS.

The Hollingshead index (HI) (Hollingshead, 1975) was used to measure subjects' social status based on four domains: marital status, employment status, educational levels, and occupational prestige. In addition, demographic information, i.e., age and sex, was also collected.

2.4. Analysis design and statistics

The analysis was performed in three steps. First, we aimed to identify the PTSS trajectory patterns after trauma and the pattern recognition was carried out by LCA on PTSS severity and time course variables. In the next step, to further explore the comorbidity profiles of the PTSS trajectory patterns, a second LCA was implemented on these PTSS trajectory variables as well as post-trauma comorbid disorders. In the final step, χ^2 test and Kruskal-Wallis H test were used for the analysis of associated sociodemographic and trauma type factors.

Latent class analysis was carried out in Latent GOLD® 5.1. The LCA model selection was first based on two information criteria: the Akaike information criterion (AIC) and the Bayesian information criterion (BIC) (Nylund et al., 2007). The lower the information criteria are the better the model fits. However, the class/subgroup numbers tend to be overestimated by AIC and underestimated by BIC (Dziak et al., 2019). Accordingly, instead of for the selection of a single model, AIC and BIC were shown to be better suited for model exclusion, specifically using AIC to indicate a maximal number of classes, and BIC, a minimal number of classes. (Collins and Lanza, 2010; Dziak et al., 2019; Kadane and Lazar, 2004). In the current LCA analysis, AIC and BIC were referenced to select a range of potential models for further decision. If more than one class number was suggested through this exclusion procedure, the Bootstrap likelihood ratio test (Bootstrap LRT) was implemented to facilitate further selection, since Bootstrap LRT has been shown to perform most robustly under various situations for model comparison (Nylund et al., 2007; Wu, 2009). Additionally, the distinction, size and theoretical adequacy of the classes were also taken into account for the final step. Other data processing and analysis steps were carried out in IBM® SPSS® Statistics 25.0.

3. Results

3.1. Trajectory patterns of PTSS

The trajectory pattern recognition was carried out by the first LCA on the PTSS severity and time course variables (descried in detail in Table 2). Models with different numbers of classes/subgroups and patterns were explored and compared. Using information criteria AIC, BIC and the Bootstrap likelihood ratio test, the model with four subgroups was identified as the best fitting one (see model fits in Suppl. 9 and the model selection process in the Method section). These four subgroups were characterised by qualitatively distinguishable severity of PTSS, delay of onset, duration or persistence of symptoms (Fig. 1). Accordingly, four PTSS trajectory patterns were established.

Among these PTSS trajectory pattern subgroups, the subgroup c1 comprised predominantly individuals with no symptoms (51.8%), few symptoms (30.9%), and partial PTSD (11.3%) (Suppl. 4). Even though a minor portion of c1 subjects potentially reached the level of full PTSD, they recovered quickly, mostly within 6 months (Suppl. 3). The adjustment pattern of subgroup c1 concurred with the minimal-impact resilient trajectory, defined as no or transitional and minimal dysfunction after exposure to potentially traumatic events. Therefore, it is the resilient PTSS trajectory pattern.

In contrast, the other subgroups comprised large portions of few symptoms and partial PTSD besides the full PTSD. Especially in c2 and c3, where PTSS persisted (more than 10 years and still present) or had disappeared within 1–10 years, the percentages of few symptoms, partial and full PTSD were similar (34.3%, 28.3%, 36.9% and 31.2%, 29.9%, 38.9% respectively, Suppl. 4). Therefore, they were referred as the chronic and recovered PTSS trajectory pattern subgroup, respectively.

The last subgroup c4, comprised mostly few symptoms (72.2%, Suppl. 4) with minor portions of partial and full PTSD (9.3%, 18.5% respectively). For all the cases, onset of PTSS were delayed for at least a week after trauma (Suppl. 1). Therefore, it is referred as the delayed-onset PTSS trajectory pattern subgroup.

3.2. PTSS trajectory patterns and their post-trauma comorbidity profiles

To further explore the heterogeneity of mental adjustments after trauma exposure, pattern recognition as carried out by the second LCA was enriched by the post-trauma comorbid disorders besides the PTSS trajectory patterns, namely aggregated anxiety disorders, mood disorders, and substance use disorders (Table 2). Similar modelling procedure was carried out as that with the first LCA and the model with six subgroups was identified as best fitting (see model fits in Suppl. 10 and the model selection in Methods section). As shown in Fig. 2, these six subgroups differentiated qualitatively from each other not only by characteristics of PTSS trajectory patterns, but also with their profiles of post-trauma comorbidity. Therefore, they represented the adjustment patterns of the PTSS trajectory and their post-trauma comorbidity. Table 3 summarized the membership shifting between the subgroups of PTSS

Table 2
Prevalence of PTSD symptoms and comorbid mental disorders among the trauma-exposed sample.

			Men		Women		Total	
			N	%	N	%	N	%
PTSD symptoms	ON	<=1 week	375	89.3%	427	80.6%	802	84.4%
		>1 week & <=6 months	31	7.4%	60	11.3%	91	9.6%
		>6 months	14	3.3%	43	8.1%	57	6.0%
	Persistent	No	350	85.6%	375	72.8%	725	78.5%
		Yes	59	14.4%	140	27.2%	199	21.5%
	Duration	<=1 year	306	74.8%	264	51.3%	570	61.7%
		>1 year & <=10 years	49	12.0%	95	18.4%	144	15.6%
		>10 years	54	13.2%	156	30.3%	210	22.7%
	Severity of PTSS	No symptoms	158	37.2%	108	20.2%	266	27.7%
		Few symptoms	157	36.9%	195	36.4%	352	36.7%
		Partial PTSD	60	14.1%	106	19.8%	166	17.3%
		Full PTSD	50	11.8%	126	23.6%	176	18.3%
Post-trauma comorbid disorders		Anxiety disorders	92	21.7%	197	37.2%	289	30.3%
		Mood disorders	47	11.1%	126	23.6%	173	18.0%
		Substance use disorders	71	16.7%	46	8.6%	117	12.2%
Total			425	100.0%	535	100.0%	960	100.0%

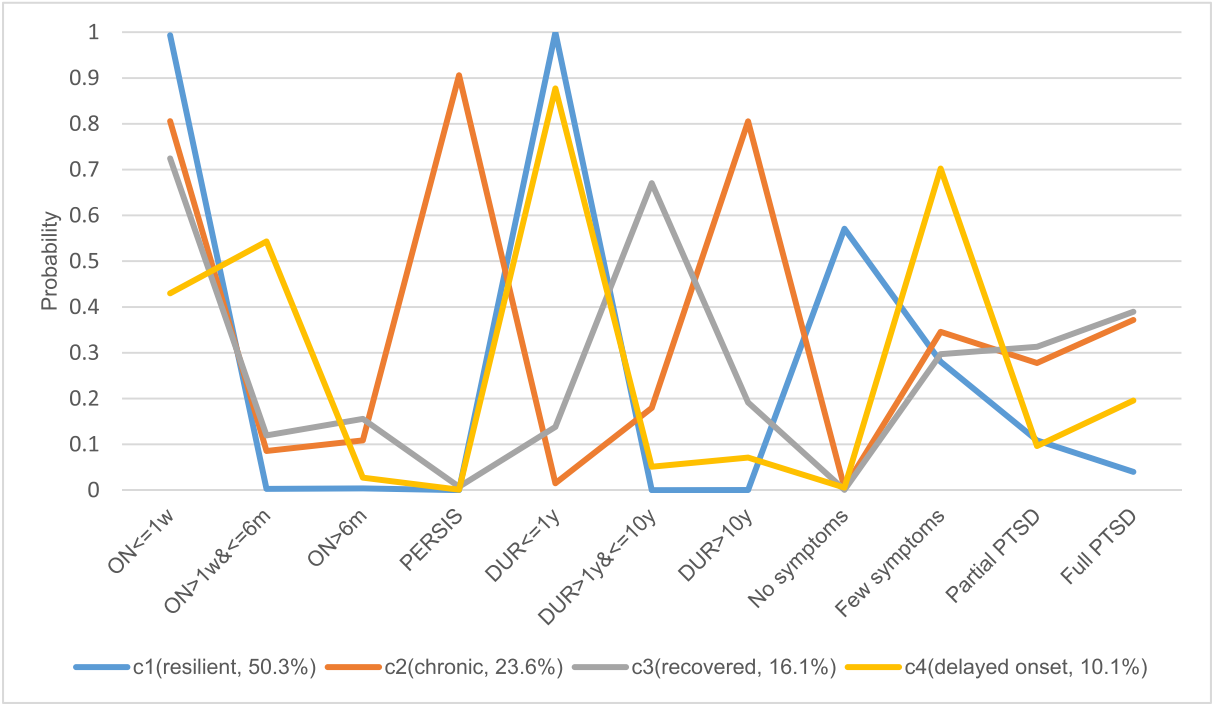

Fig. 1. Trajectory patterns of PTSS (Pattern recognition based on the PTSS time course and severity variables).
ON, delay of onset; PERSIS, persistent; DUR, duration. Note: The probabilities of the items were connected by lines to facilitate examination of the LCA results.

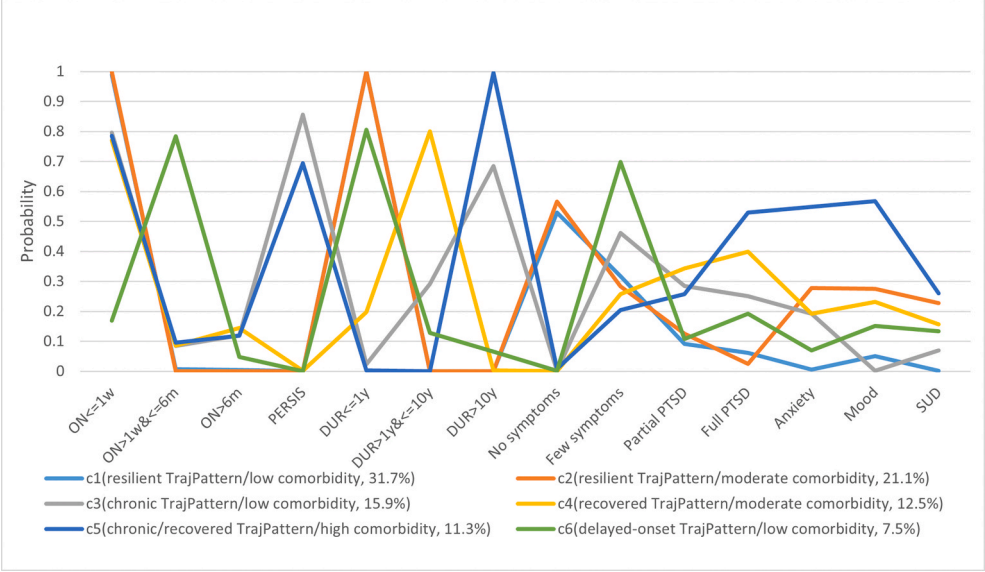

Fig. 2. PTSS trajectory patterns and their post-trauma comorbidity profiles.
ON, delay of onset; PERSIS, persistent; DUR, duration; Anxiety, post-trauma anxiety disorders; Mood, post-trauma mood disorders; SUD, post-trauma substance use disorders; TrajPattern, PTSS Trajectory pattern. Note: The probabilities of the items were connected by lines to facilitate examination of the LCA results.

trajectory patterns and the subgroups of PTSS trajectory/comorbidity, the details of which was descried below.

Both c1 and c2 emerged from the resilient trajectory pattern subgroup (Table 3). However, these two contrasted with each other through c1's low comorbidity and c2's relatively high and extensive comorbidity. Subjects in subgroup c2 were barely affected by any PTSD symptoms yet they developed a moderately high and widespread comorbidity pattern, covering anxiety disorders, mood disorders and substance use disorders.

Another high-comorbidity subgroup was c5. It was dominated by the chronic trajectory pattern (70.5%, Table 3) with PTSS lasting more than 10 years (Suppl. 7). This class was further characterized by a predominance of full PTSD outcome (63.6%, Suppl. 8), as well as the most severe post-trauma comorbidity of all six classes, which spread across the anxiety, mood and substance use disorders.

In contrast, subgroup c3, which was also dominated by the chronic trajectory pattern (87.7%, Table 3), showed only low comorbidity. Specifically, they developed localized comorbidity, particularly with anxiety disorders, despite enduring a full PTSD diagnosis (22.1%, Suppl. 8) or partial PTSD (30.5%) for more than 10 years (74.7%, Suppl. 7). On

Table 3
Contingency table between the subgroups of PTSS trajectory pattern and PTSS trajectory pattern/comorbidity.

			Subgroups of PTSS trajectory pattern/comorbidity						Total
			c1	c2	c3	c4	c5	c6	
Subgroups of PTSS trajectory pattern	c1	Count	367	138	0	5	0	0	510
		% within TrajPattern	72.0%	27.1%	0.0%	1.0%	0.0%	0.0%	100.0%
		% within TrajPattern/comorbidity	100.0%	100.0%	0.0%	4.6%	0.0%	0.0%	55.6%
	c2	Count	0	0	135	0	62	0	197
		% within TrajPattern	0.0%	0.0%	68.5%	0.0%	31.5%	0.0%	100.0%
		% within TrajPattern/comorbidity	0.0%	0.0%	87.7%	0.0%	70.5%	0.0%	21.5%
	c3	Count	0	0	19	104	25	8	156
		% within TrajPattern	0.0%	0.0%	12.2%	66.7%	16.0%	5.1%	100%
		% within TrajPattern/comorbidity	0.0%	0.0%	12.3%	95.4%	28.4%	13.1%	17.0%
	c4	Count	0	0	0	0	1	53	54
		% within TrajPattern	0.0%	0.0%	0.0%	0.0%	1.9%	98.1%	100.0%
		% within TrajPattern/comorbidity	0.0%	0.0%	0.0%	0.0%	1.1%	86.9%	5.9%
Total		Count	367	138	154	109	88	61	917
		% within TrajPattern	40.0%	15.0%	16.8%	11.9%	9.6%	6.7%	100.0%
		% within TrajPattern/comorbidity	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

For subgroups of PTSS trajectory pattern: c1, resilient; c2, chronic, c3, recovered, c4, delayed-onset.
For subgroups of PTSS trajectory pattern/comorbidity: c1, resilient TrajPattern/low comorbidity; c2, resilient TrajPattern/moderate comorbidity; c3, chronic TrajPattern/low comorbidity; c4, recovered TrajPattern/moderate comorbidity; c5, chronic/recovered TrajPattern/high comorbidity; c6, delayed-onset TrajPattern/low comorbidity; TrajPattern, PTSS trajectory pattern.

the other hand, subgroup c4 comprised predominantly the recovered trajectory pattern (95.4%, Table 3), but showed moderate comorbidity covering all three categories of comorbid disorders.

The last subgroup c6, had relatively low comorbidity and comprised the delayed-onset trajectory pattern. In 95.1% of the cases, the PTSS were delayed by 1 week–6 months, 4.9% more than 6 months (Suppl. 5).

Sociodemographic characteristics and trauma types of the subgroups of PTSS trajectory pattern/comorbidity.

In the final step, sociodemographic characteristics as well as trauma types were analysed for the above subgroups of PTSS trajectory pattern/comorbidity (PTSS trajectory/comorbidity). Table 4 described these attributes in detail.

- *Sex/gender*

In general, compared to men, women showed more of the severe outcomes of trauma exposure ($\chi 2$ (5) = 66.006, P < 0.001), in terms of PTSS trajectory patterns as well as their post-trauma comorbidity profiles. One extreme example was c5. As the subgroup with the most severe outcomes, it also had the highest F:M (Female:Male) ratio of 3.9 (Table 4), in comparison with the overall ratio of 1.3. On the other hand, the healthiest class, c1, was characterized by the lowest F:M ratio of 0.7.

- *Age of trauma exposure*

Even though the average age of subjects in different classes was similar at the time of the interview, their age of trauma exposure was significantly different (k-w test, $p < 0.001$). It was especially low in c5 (mean = 14.0 years) and c2 (mean = 19.0 years), the classes with the most prominent comorbidity patterns, with or without PTSD symptoms, respectively.

- *Socioeconomic status*

Subjects' socioeconomic status as indicated by HI was significantly associated with the mental health outcomes (k-w test, $p = 0.038$). The lower the HI was, the more severe the outcomes were in terms of PTSS trajectory patterns/comorbidity.

- *Specific trauma types*

Except for accident, which was the only non-interpersonal trauma,

Table 4
Sociodemographic characteristics and trauma types of the PTSS trajectory pattern/comorbidity subgroups (N = 917).

	Subgroups of PTSS trajectory pattern/comorbidity							Test statistic
	c1	c2	c3	c4	c5	c6	Total	*p*-value
Total, N	291	193	146	114	104	69	917	.
Men, %	58.3%	47.8%	33.1%	33.0%	20.5%	34.4%	44.3%	0.000
Age, mean (s.d.)	53.9(10.9)	51.5(10.1)	52.6(10.6)	51.8(9.0)	52.2(9.7)	53.4(9.3)	52.9(10.4)	0.199
Age of trauma exposure, mean (s.d.)	29.3(15.1)	19.0(9.4)	25.0(16.5)	20.9(12.9)	14.0(9.1)	25.8(16.1)	24.4(14.9)	0.000
SES, mean (s.d.)	3.5(1.2)	3.5(1.2)	3.1(1.3)	3.3(1.4)	3.1(1.3)	3.4(1.3)	3.4(1.3)	0.038
Accident, N and %	107	37	43	26	17	20	250	
	25.1%	22.3%	22.9%	19.3%	14.9%	27.8%	22.7%	0.390
Combat/war, N and %	31	15	23	10	6	12	97	
	7.3%	9.0%	12.2%	7.4%	5.3%	16.7%	8.8%	0.036
Witnessing trauma to others, N and %	210	74	70	43	29	19	445	
	49.2%	44.6%	37.2%	31.9%	25.4%	26.4%	40.4%	0.000
Violent crime, N and %	63	21	27	29	30	11	181	
	14.8%	12.7%	14.4%	21.5%	26.3%	15.3%	16.4%	0.003
Sexual abuse, N and %	16	19	25	27	32	10	129	
	3.7%	11.4%	13.3%	20.0%	28.1%	13.9%	11.7%	0.000

SES, socioeconomic status; PTSS, PTSD symptoms; s.d., standard deviation; c1, resilient TrajPattern/low comorbidity; c2, resilient TrajPattern/moderate comorbidity; c3, chronic TrajPattern/low comorbidity; c4, recovered TrajPattern/moderate comorbidity; c5, chronic/recovered TrajPattern/high comorbidity; c6, delayed-onset TrajPattern/low comorbidity; TrajPattern, PTSS trajectory pattern.

all other trauma types, such as combat/war, witnessing trauma to others, violent crime, and sexual abuse were significantly associated with the classes of PTSS trajectory pattern/comorbidity ($\chi 2$ tests, with various p-values, Table 4). However, there were some notable differences. Sexual abuse was positively associated with the severity of PTSS trajectory/comorbidity. Violent crime showed a similar tendency but to a lesser degree. Witnessing trauma to others was negatively associated with the severity of outcomes. Combat/War was overrepresented in the two low comorbidity non-resilient PTSS trajectory subgroups but underrepresented in the two higher comorbidity non-resilient PTSS trajectory subgroups.

4. Discussion

The current study examined trajectory and comorbidity patterns of PTSS after trauma exposure by means of LCA. We found that the whole spectrum of PTSS follows four trajectory patterns, namely resilient, chronic, recovered and delayed-onset, similar to the robust PTSD trajectories that had been demonstrated in longitudinal studies (Bonanno, 2004; Bonanno et al., 2011; Bonanno and Diminich, 2013). The most important finding of our study is the heterogeneity of these PTSS trajectory patterns in terms of their post-trauma comorbidity profiles. When the post-trauma comorbid disorders were considered, the four PTSS trajectory patterns split respectively and paired up with either low, moderate or high comorbidity. Notably, the differentiation of post-trauma comorbidity was seen for both the resilient and the chronic PTSS trajectory patterns, suggesting the post-trauma comorbidity profiles were partially independent of the PTSS trajectories.

4.1. Trajectory patterns of PTSS

Several attempts to explore the heterogeneity issue of resilient vs pathological adjustments to trauma have been made in longitudinal studies on PTSS. For instance, Cukor et al. reported the stable trajectory of partial PTSD, when PTSS were categorised into three ordinal levels, namely no PTSD, partial PTSD and full PTSD (Cukor et al., 2010). Bonanno et al. also explored this issue, treating PTSS as a continuous variable and implementing latent growth mixture modelling to model dynamic changes; consequently, the trajectory of minimal-impact resilience and the trajectory of recovery from moderate-to-severe pathology (within 1–2 years) were identified (Bonanno et al., 2011; Bonanno and Diminich, 2013). Similarly, several groups have also confirmed a chronic trajectory with moderate symptoms (Armour et al., 2012; Cheng et al., 2019; Fan et al., 2015; Zhou et al., 2018).

Our results were generally consistent with observations from longitudinal studies of either PTSD or PTSS, despite their being based on retrospective information from cross-sectional examinations. Each of our PTSS trajectory patterns consisted of a set of PTSD symptom categories: the resilient trajectory pattern had mostly no symptoms with transitional and minimal pathology (mainly few symptoms with minor portions of partial/full PTSD), the delayed onset pattern was dominated by the outcome of few symptoms, with small portions of partial and full PTSD, and the chronic or recovered trajectory pattern consisted of few symptoms, partial and full PTSD categories almost equally. These results were consistent with observations of minimal-impact resilience, chronically moderate symptomatology (Bonanno et al., 2011; Bonanno and Diminich, 2013) and recovery from moderate-to-severe symptomatology (Armour et al., 2012; Cheng et al., 2019; Fan et al., 2015; Zhou et al., 2018). They suggested that the four trajectory patterns (resilient, chronic, recovered and delayed onset) are not unique to certain levels of symptomatology, but common to various levels of PTSS.

4.2. Updates from the post-trauma comorbidity analysis

In general, other than the delayed onset (low comorbidity), all the other PTSS trajectory patterns diverged in their comorbidity profiles, with low, moderate or high comorbidity. The majority of the resilient trajectory pattern subgroup continued with extremely low comorbidity, suggesting resilience in the long run. It is noteworthy that most of those who suffered long and persistently with PTSS also remained relatively low in comorbidity. On the other hand, the majority of those who suffered from PTSS relatively long but recovered showed intermediately high and widespread comorbidity, suggesting that comorbidity is partially independent of the PTSS trajectory patterns. In addition, smaller portions of either the resilient or the chronic/recovered trajectory patterns developed extensive and relatively high comorbidity covering all three mental disorder clusters, further indicating that the post-trauma comorbidity profiles are partially independent of the PTSS trajectory patterns.

4.3. Sociodemographic characteristics and trauma types

Our results further showed that several factors, namely sociodemographic characteristics and trauma types, were associated with the various PTSD symptom trajectory pattern/comorbidity outcomes. In line with previous observations, our study showed that female sex (Tekin et al., 2016; Cowden Hindash et al., 2019), early trauma exposure (Dunn et al., 2017; Lippard and Nemeroff, 2020), and low socioeconomic status (Ayazi et al., 2012; Chiu et al., 2011) were associated with more severe outcomes of PTSS and subsequent comorbidity. Correspondingly, male sex, late trauma exposure and high socioeconomic status were associated with relatively better outcomes. Moreover, the analysis of trauma types was consistent with the observation that interpersonal trauma is associated with more severe outcomes of PTSD (Santiago et al., 2013), but suggested that this only applies when the interviewees themselves or their loved ones are victims of trauma. Results also suggested that the association between interpersonal trauma and severity of outcomes is valid not only for PTSD symptoms but also for the post-trauma comorbidity.

4.4. Resilience in the context of PTSS trajectories and their post-trauma comorbidities

The current study investigated not only the trajectories of full PTSD, but also those of the subcategories of resilience, namely in terms of no/few PTSD symptoms to partial PTSD. This gives a unique opportunity to study the heterogeneity issue of resilience in examination of PTSS trajectory and comorbidity outcomes. Therefore, the following discussion will look at the current results from the perspective of resilience in the context of PTSS trajectories and their post-trauma comorbidities.

4.4.1. Initial model of resilience based on PTSS trajectories

The current results of PTSS trajectory patterns corroborate findings from previous longitudinal studies of PTSD/PTSS trajectories. They further indicated that four classes of continuum PTSS trajectories exist after trauma exposure, and that the PTSD trajectories found in longitudinal studies are probably the extreme ends of these response continuums.

Additionally, when comparing pathological levels, namely severity of PTSS, persistence, time to remit and onset delay, there seems to be a pathology spectrum of higher order encompassing these four trajectory patterns: chronic > recovered > delayed onset > resilient. Consequently, the boundary between the healthy versus pathological adjustment patterns becomes murky. Resilience can be viewed here as gradually decreasing levels of pathology on four series of PTSS trajectory patterns. Thus, resilience against PTSS appears to be a continuum construct with four relatively independent mechanisms. The first resilience mechanism is the base defence, and in most situations, it succeeds in preventing the PTSS from emerging at all. The second mechanism occurs the least. It delays the onset of symptoms, keeps the level of symptoms low and facilitates their remission as quickly as possible. The third mechanism promotes individuals' recovery from the pathological

status, which takes a relatively long time. The last one co-exists with the pathological symptoms over the long run, while it subdues the number of symptoms.

4.4.2. Resilience as a complex construct with multiple domains

As discussed, the post-trauma comorbidity profiles were partly independent of the PTSS trajectory patterns. Therefore, when post-comorbidities were also considered, the model of resilience needs to be updated as a complex construct with multiple domains and further subdomains (Fig. 3). One of the resilience domains protects trauma-exposed individuals from developing PTSD symptoms through four sub-mechanisms, and the other one against the emergence of comorbidity. Accordingly, resilience can be further operationalized as positive adjustments after trauma exposure on a continuous scale, either based on the severity of PTSS trajectory patterns or based on comorbidity profiles. Correspondingly, orders of resilience against PTSS or post-trauma comorbidity can be arranged as illustrated in Fig. 3.

This model allows the co-existence of resilience with post-trauma mental disorders at different levels. It contains the idea that even at the most pathological states of mental health, there is still a certain degree of resilience, although probably at a minimal level.

4.5. Limitations

As common to other self-report based retrospective studies (Kaestle, 2015), the results of the current study could be biased due to effects such as recall bias and telescoping effects. Recall bias is a systematic error due to individuals' differences in accuracy in retrieving information from the past (Porta, 2014); the telescoping effect or bias refers to the recalling effect that remote events are perceived as being more recent than they are and close events viewed further away than they are (Janssen et al., 2006). These biases may be further emphasized by the question design in the study. For example, the delayed-onset trajectory has been suggested to connote a process of gradual exacerbation of pathology (Bonanno and Diminich, 2013). Yet this was not captured by our questions, since this category of PTSS were collected retrospectively as static. Moreover, the cross-sectional nature has rendered small degree of uncertainty to the PTSS trajectories, especially for PTSS that had lasted relatively short but were still present by the time of interview thus yielding some undesirable overlapping of the duration and persistence items. However, additional statistical analysis has confirmed that this uncertainty is not significant to the overall pattern recognition and interpretation since only few cases were involved (results not shown). Finally, DSM-IV instead of DSM-V was used for the current study.

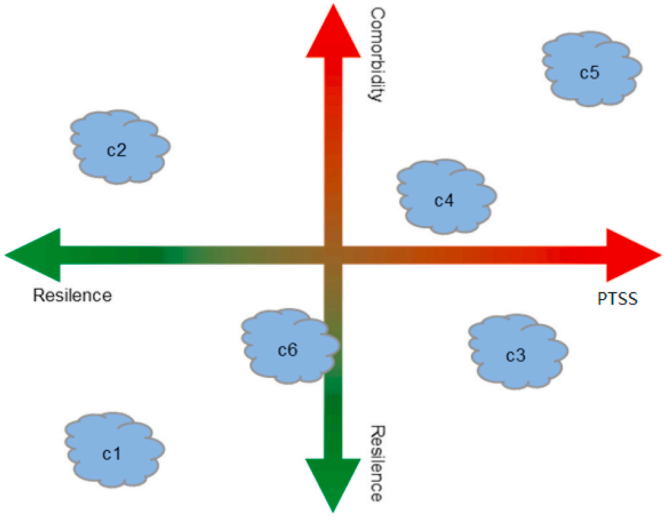

Fig. 3. The resilience model.
Resilience against PTSS: c1/c2 > c6 > c4 > c3 > c5; resilience against post-trauma comorbidity: c1 > c3/c6 > c4 > c2 > c5. c1, resilient TrajPattern/low comorbidity; c2, resilient TrajPattern/moderate comorbidity; c3, chronic TrajPattern/low comorbidity; c4, recovered TrajPattern/moderate comorbidity; c5, chronic/recovered TrajPattern/high comorbidity; c6, delayed-onset TrajPattern/low comorbidity; TrajPattern, PTSS trajectory pattern.

However, even with these limitations, the present cross-sectional study may still offer valuable information concerning PTSD symptom trajectories, since longitudinal studies can be hampered by other shortcomings, such as convenience samplings and short follow-up periods (normally a couple of years) (Santiago et al., 2013). This is probably due to their much higher expenditure of time and resources, especially when long term follow-ups are involved. Thus, the cross-sectional design may offer an economically pragmatic alternative to overcoming these constraints and providing a more precise portrayal of PTSD symptom trajectories over the course of a lifetime. For example, the longer lasting recovered trajectory could easily be misclassified as chronic if only followed for relatively short periods of time.

5. Conclusion

To conclude, this study found four PTSD symptom trajectories, consistent to those shown in longitudinal PTSD or PTSD symptom study. The retrospective study design made it possible to evaluate the long-term post-trauma comorbidity, which provided new perspectives to assess the resilience vs pathology of these trajectories. Our results showed that the full picture of mental adjustment processes to trauma exposure was more diverse than the previously proposed PTSD trajectories, with heterogenous comorbidity profiles for the individual trajectories of PTSD symptoms. This knowledge is novel and challenges our understanding of resilience versus pathology of mental adjustments to trauma. We proposed a complex model of resilience based on these results, where resilience has multiple domains and co-exists with psychopathology.

Contributors

Yanhua Xu: Designed the study, conducted all statistical analyses and wrote the manuscript.

Caroline Vandeleur: Participated in data collection and data management; revised the manuscript.

Mario Müller: Participated in data collection and data management; consultation on methodology; revised the manuscript.

Erich Seifritz: Supervision; revised the manuscript.

Birgit Kleim: Consultation on the design of the study; revised the manuscript.

Roland von Känel: Consultation on the design of the study; revised the manuscript.

En-Young N. Wagner: Revised the manuscript.

Marie-Pierre F. Strippoli: Participated in data collection and data management; revised the manuscript.

Enrique Castelao: Participated in data collection and data management.

Mehdi M. Gholamrezaee: Participated in data collection and data management.

Martin Preisig: Supervision; conceived and designed CoLaus|PsyCoLaus cohort study; revised the manuscript.

Vladeta Ajdacic-Gross: Designed the study; revised the manuscript.

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Ethical standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

Declaration of competing interest

The authors declare no conflict of interest.

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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.2021.01.049.

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