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Longitudinal cross-lagged association between posttraumatic stress disorder, post-traumatic growth, and deliberate rumination among healthcare staff 2 years after the COVID-19 pandemic in Hubei Province, China

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Abstract

Background Post-traumatic stress disorder (PTSD) and post-traumatic growth (PTG) are inspiratory areas of psychological research in which deliberate rumination has important implications. However, these relationships have not yet been assessed in the COVID-19 pandemic using longitudinal designs.

Methods In this study, measures of PTSD, PTG, and deliberate rumination were collected from 2,292 healthcare staff members at two-time points six months apart in 2022–2023 from two general hospitals in Hubei Province, China. A cross-lagged analysis was used to simultaneously determine the directional relationships between these three variables.

Results The results suggest that the relationship between PTG and deliberate behavior is bidirectional and mutually reinforcing ($\beta = 0.133$, $P < 0.001$; $\beta = 0.129$, $P < 0.001$). Significant prospective relations were observed between PTG and PTSD ($\beta = 0.054$, $P < 0.01$), and PTSD prospectively predicted changes in deliberate rumination ($\beta = 0.204$, $P < 0.001$). In addition, significant sex differences were observed in the cross-lagged models.

Introduction

The 2019 coronavirus disease (COVID-19) pandemic first broke out in Wuhan, Hubei Province, China, and the ensuing pandemic has triggered multiple profound global public health dilemmas. Hubei Province has been the hardest hit and the focus of public health emergencies. As the core of the public health emergency rescue effort, there is no doubt that the healthcare staff combines the roles of rescuers and survivors, experiencing depletion of physical and mental health conditions and a substantial proportion of psychiatric disorders, especially post-traumatic stress disorder (PTSD) [1, 2]. Nevertheless,

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Conclusion These findings highlighted the noteworthy cross-lagged relationship between PTSD, PTG, and deliberate rumination two years after the COVID-19 pandemic in Hubei Province, China. Therefore, interventions to reduce PTSD, promote PTG, and improve well-being among healthcare staff are important.

Keywords Cross-lagged model, Post-traumatic stress disorder, Post-traumatic growth, Deliberate rumination, Healthcare staff, COVID-19

in addition to the detrimental consequences of PTSD, findings from several other investigations have revealed that individuals might experience positive psychological changes and growth following stressful or traumatic events through cognitive processes such as rumination and post-traumatic growth (PTG) [3–6]. Even if the COVID-19 pandemic emergency status were over, the range of mental health issues would not end immediately, especially since the healthcare staff in Hubei Province may have experienced even more severe psychological trauma in the past two years.

PTSD is a delayed, persistent, and severe psychiatric disorder that usually occurs after individuals experience or witness threatening or catastrophic stress events, such as a public health emergency [7]. With the continuous negative impact of public health emergencies on society and the economy, the current state of the PTSD pandemic among healthcare staff is not promising [8, 9]. This was corroborated by a recent meta-analysis that reviewed 28 cross-sectional articles and observed that the prevalence of PTSD among doctors and nurses was 31% and 38%, respectively, as a result of the global public health emergency worldwide [10]. In addition, emerging evidence suggests that psychiatric symptoms among healthcare staff might persist for a considerable time, with 10–40% of them experiencing PTSD for 1–3 years after major public health emergencies, while PTSD symptoms and levels might fluctuate over time [11–13]. Timely and prolonged symptoms of PTSD among healthcare staff reduce work capacity, increase sickness absence and turnover, affect the quality of medical care, and have sustained negative impacts on health, well-being, and quality of life [14, 15]. However, in the context of public health emergencies, there are limited longitudinal studies on PTSD symptoms among healthcare staff. Altogether, empirical evidence is needed to deepen our understanding of the longitudinal predictors of PTSD symptoms among healthcare staff and to inform interventions for this vulnerable population.

PTG is a distinct positive change that occurs as an individual attempts to struggle with a traumatic event that has destroyed the past and vision of the future [16, 17]. Public health emergencies differ from traditional traumatic events, and PTG issues in this context have been explored by researchers. For instance, even in a high-pressure work environment, 27.3% of healthcare workers indicated moderate or greater degrees of PTG [18]. After experiencing a traumatic event, someone may still remain resilient and even show personal growth. PTG and PTSD usually co-exist and do not conflict with each other, as individuals could grow and sustain distress at the same time [17, 19, 20]. However, evidence of the predictive relationship and patterns of comorbidities between PTG and PTSD has been inconclusive. For instance, several studies have highlighted that PTG is positively connected to PTSD in patients with COVID-19, survivors of earthquakes, and Israeli ex-prisoners of war [21–23]. Several studies have demonstrated that PTG interacts negatively with PTSD [24, 25]; and others have revealed no significant correlation between PTG and PTSD [26]. The relationship between PTG and PTSD among healthcare staff during public health emergencies has not yet been adequately studied. Therefore, it is important to examine the reciprocal predictive relationship between PTG and PTSD.

Rumination was first proposed according to the PTG model and played a critical role in the developmental and evolutionary processes of PTSD and PTG, including intrusive and deliberate rumination [17]. Intrusive rumination usually occurs early after traumatic events, and individuals tend to fall into automatic, uncontrollable, repetitive, and unnecessary thoughts concerning traumatic events, which may exacerbate PTSD symptoms [16, 27, 28]. In addition, it is possible to think positively after traumatic events, try to understand the trauma and find meaning in it, face the situation openly, and think proactively regarding solving problem [29]. To diminish the deleterious consequences of trauma, individuals are asked to produce more deliberate rumination, which catalyzes PTG [30, 31]. The role of deliberate rumination has been corroborated in previous studies, although the results have been inconsistent. For instance, a cross-cultural study revealed that deliberate rumination was predictive of PTG in a Japanese population; however, owing to cultural differences, this effect was not significant in an American population [32]. Surveys have confirmed that deliberate rumination is significantly and positively correlated with PTSD and PTG. In contrast, this relationship was not significant in other studies [33–35]. Nevertheless, only a few studies have examined the role of deliberate rumination among healthcare staff working in emergency departments.

Previous studies have mostly focused on survivors of natural disasters or wars. To date, questions remain

regarding the longitudinal predictive interaction between deliberate rumination, PTG, and PTSD among healthcare staff. Consequently, in this work, we sought to examine the reciprocal and predictive associations between PTSD, PTG, and deliberate rumination from a longitudinal and developmental perspective in a representative prospective program of healthcare staff two years after the COVID-19 pandemic in Hubei Province, China. Our ultimate aim was to understand the different processes of public health emergencies that lead to PTSD, PTG, and deliberate rumination, which is of vital significance for helping healthcare staff make positive changes and effectively respond to the torment caused by traumatic events. We hypothesized that PTG and deliberate rumination were positively correlated at two time points. We openly explored the remaining cross-lagged paths between the three variables without making circumstantial assumptions owing to the paucity of evidence in the existing literature.

Methods

Participants and procedures

Participants

Using a longitudinal design, this study surveyed the mental health of healthcare staff 2 years after the COVID-19 pandemic. Participants were recruited from two general hospitals in Hubei Province, China, through randomized sampling. The inclusion criteria of this survey were as follows: (1) aged ≥ 18 years; (2) certification of a physician or nurse; (3) voluntary participation in this project. The exclusion criteria was as follows: participants with anxiety disorders, depression, PTSD, and so on, who were diagnosed within six months by a general hospital of the second level or above or a hospital specializing in psychiatry, according to the International Classification of Diseases 11th Revision (ICD-11) [36]. The longitudinal survey was conducted from 2022 to 2023 and contained two surveys conducted at 6-month intervals. At the first empirical survey (T1), 2,719 healthcare staff completed questionnaires. In subsequent assessments conducted six months later (T2), the healthcare staff completed the same questionnaire that had been administered at T1. This longitudinal mental health survey project was based on the provision of psychological assistance services to healthcare staff. Participants appreciated the survey, expressed trust in the researchers, and were asked to complete it. Hence, 2,292 healthcare staff members (84.30%) participated in T2.

A few participants were lost to our longitudinal follow-up program because of the departure or voluntary withdrawal of healthcare staff from the survey. The demographic characteristics of participants who completed and those who did not complete the follow-up period are provided in Table S1.

Procedures

All procedures complied with the ethical standards of the 1975 Declaration of Helsinki and were revised in 2008. This longitudinal study was approved by the Ethics Review Committee of Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China (No. 2021-IEC-A006). All participants signed an electronic informed consent form before survey initiation. Participation in this project was entirely voluntary, and the participants had the right to withdraw from the survey at any time without any benefit infringement.

The longitudinal program was divided into three phases. In the first phase, two general hospitals in Hubei Province, China, were selected based on random sampling principles. In the second phase, online questionnaires were sent to healthcare staff through medical offices and nursing departments. In addition, participants were informed that they might be contacted again after six months to participate in a second round of assessments when completing the online questionnaire for the first time (T1). In the third phase, six months after completing the initial survey (T2), online questionnaires were distributed through medical offices and nursing departments.

We used an online survey platform ("SurveyStar," Changsha Ranxing Science and Technology, Shanghai, China) to complete all questionnaires. We constrained the questionnaire to be completed at each Internet Protocol Address to prevent duplication. Moreover, all participant IDs were randomly assigned to the software to ensure the anonymity of the survey. Simultaneously, intelligent logic checks were established to distinguish invalid questionnaires. Eventually, two researchers checked all answers to the valid questionnaires independently and automatically entered them into data files using the software.

Measures

Demographic characteristics questionnaire

A questionnaire on basic demographic characteristics was designed based on a literature review. The questionnaire included information on sex, age, nation, educational background, and occupation-related factors (e.g., type of occupation, department, administrative position, and occupational exposure).

Assessment of PTSD

The PTSD Checklist for DSM-5 (PCL-5) is a self-report assessment scale that measures the presence and severity of PTSD symptoms and preferably exhibits Cronbach's alpha of the Chinese version of the scale [37, 38]. This scale contains 20 items separated into four major PTSD symptom clusters: intrusion, avoidance, negative alterations in cognition and mood, and alterations in arousal

and reactivity. The PCL-5 is applied on a 5-point Likert scale ranging from 0 (not at all) to 4 (extremely) points. The scores for each entry are summed to obtain a total score, with higher total scores associated with more severe PTSD. In this survey, the Cronbach's α of PCL-5 for T1 and T2 were 0.989 and 0.982, respectively, indicating good internal consistency and reliability.

Assessment of PTG

PTG in this survey was evaluated using the revised Chinese version of the Post-traumatic Growth Inventory (PTGI). Tedeschi and Calhoun developed the PTGI, which demonstrated excellent psychometric properties in previous investigations on Chinese populations translated by Wang et al. [17, 39, 40]. The Chinese version of the PTGI comprises five dimensions: new possibilities, personal strengths, relatedness to others, spiritual changes, and appreciation of life. Twenty items were included on a 6-point Likert scale (0–5 points), ranging from no change to a very great degree of change. The score for each item was calculated as the total PTGI score ranging from 0 to 100 points, with higher scores indicating a greater degree of PTG. Conclusively, Cronbach's αs were 0.979 and 0.985 at T1 and T2, respectively, in this survey.

Assessment of rumination

The event-related rumination inventory (ERRI) measures individual cognitive processing during highly stressful events. The Chinese version of the scale has been formalized in Chinese samples and has high reliability and validity [41]. The ERRI contains 20 items categorized into two dimensions: intrusive and deliberate rumination. Each item is rated on a 4-point Likert scale ranging from 0 (not at all) to 3 (almost always) points. All items in the two dimensions were summed to obtain the total ERRI scores. Based on the research needs, only the deliberate rumination index was selected for this study. In this program, Cronbach's α was 0.973 at T1 and 0.971 at T2, indicating that the internal reliability of the deliberate rumination was unimpeachable.

Data analysis

A self-reported assessment was used for all measurements in this study. Although the procedures were controlled using uniform measures and confidentiality was emphasized during the measurement process, common method bias may still exist [42]. Therefore, we conducted Harman's single-factor test to detect the common method bias. This was a longitudinal follow-up program, and the measurement results were tested twice. We explored the overall variance that could be explained by the common factors using an unrotated factor solution. The results showed that no single factor explained more than 50% of the variance, indicating that no signs of significant common method bias were detected in this survey [43].

We used SPSS 26.0 (IBM Corp., Armonk, NY, USA) and Mplus 8.3 for all statistical analyses, and the significance level was set at $P<0.05$ (two-tailed). Descriptive statistics were conducted to measure the sample characteristics and the degree of PTSD, PTG, and deliberate rumination: continuous variables were represented as means ± standard deviations (SDs), and categorical variables were represented as frequencies (percentages). A repeated-measures ANOVA was used to analyze the differences in PTSD, PTG, and deliberate rumination at T1 and T2. Pearson's correlations were analyzed to examine the associations between PTSD, PTG, and deliberate rumination, both cross-sectionally and longitudinally. In our study, temporal associations between PTSD, PTG, and deliberate rumination from T1 to T2 were assessed using cross-lagged panel model (CLPM). All CLPM analyses were conducted using a robust maximum likelihood iteration procedure. Determination of model fit followed standard recommendations according to the below-fit indices: the $\chi 2/df$ index < 3, Comparative Fit Index (CFI) ≥ 0.90, Tucker–Lewis Index ≥ 0.90, root-mean-square error of approximation (RMSEA) ≤ 0.08, and standardized root mean square residual values ≤ 0.08 [44]. In addition, we used a CLPM with multiple group analyses to examine gender differences. An unconstrained free estimation model between the groups was constructed in the first step. A structural weight equivalent model was developed, assuming equal regression coefficients between sexes. Finally, the existence of sex differences depended on the contrasting statistics between the two models above [45]. Indicators indicating the significant differences in paths between sexes include $\Delta\chi 2$ $P<0.05$, ΔCFI > 0.01, and ΔRMSEA > 0.015 [46]. At least two of these were met, and the path differences between sexes were deemed statistically significant.

Results

Descriptive and correlation analysis

In total, 2,292 healthcare staff members completed the longitudinal follow-up online questionnaire at T1 and T2. The demographic characteristics of the participants are provided in Table 1. Among the 2,292 healthcare staff, approximately half were aged 31–40 (51.40%); most were female (83.03%), and 81.02% were nurses. Of these, 277 (12.09%) reported having experienced traumatic events during the previous year. Figure 1 shows a downward trend in PTG levels among the healthcare staff from T1 to T2. In contrast, PTSD and deliberate rumination showed an upward trend. Repeated-measures ANOVA revealed statistically significant differences in

Table 1 Description of the sample characteristics

Variable	Total (*n* = 2,292)
Age,*n*(%)	
20–30	801 (34.95)
31–40	1,178 (51.40)
≧41	313 (13.66)
Gender, n(%)	
Male	387 (16.97)
Female	1,903 (83.03)
Nation, n (%)	
Han nationality	2,247 (98.04)
Minority nationality	45 (1.96)
Type of occupation, n (%)	
Physician	403 (17.58)
Nurse	1,857 (81.02)
Others	32 (1.40)
Department, n (%)	
Medicine department	606 (26.44)
Surgical department	526 (22.95)
Emergency department	58 (2.53)
Intensive care unit	164 (7.16)
Others	938 (40.92)
Administrative position, n (%)	
Yes	192 (8.42)
No	2099 (91.58)
Occupational exposure in the last year, n (%)	
Yes	298 (13.00)
No	1994 (87.00)
Experiencing major traumatic events in the last year, n (%)	
Yes	277 (12.09)
No	2015 (87.91)
PTG at T1, Mean (*SD*)	59.99 (22.00)
PTG at T2, Mean (*SD*)	50.82 (28.09)
PTSD at T1, Mean (*SD*)	13.46 (16.28)
PTSD at T2, Mean (*SD*)	16.65 (17.04)
Deliberate Rumination at T1, Mean (*SD*)	8.13 (7.11)
Deliberate Rumination at T2, Mean (*SD*)	8.61 (7.34)

Note: *SD*, standard deviation

PTSD, PTG, and deliberate rumination scores between the healthcare staff at T1 and T2.

Pearson's correlation coefficients among the key variables of PTSD, PTG, and deliberate rumination in the T1 and T2 cohorts are provided in Table 2. In addition, all correlations between PTSD, PTG, and deliberate rumination at T1 and T2 were positive and significant.

Cross-lagged panel model

Figure 2 describes the results of the CLPM for PTSD, PTG, and deliberate rumination. The model was saturated, and the model fit statistics were not reported. The correlations between PTSD, PTG, and deliberate rumination at T1 and T2 were significant and positive in the cross-sectional and longitudinal directions. In addition, the results revealed that there were four significant crossed-lagged paths between PTSD, PTG, and deliberate rumination: PTSD at T1 significantly predicted deliberate rumination at T2 ($\beta = 0.204$, $P < 0.001$); PTG at T1 significantly predicted PTSD at T2 ($\beta = 0.054$, $P < 0.01$); PTG at T1 significantly predicted deliberate rumination at T2 ($\beta = 0.133$, $P < 0.001$); and deliberate rumination at T1 significantly predicted PTG at T2 ($\beta = 0.129$, $P < 0.001$). The results indicated that, while there was a causal relationship between PTG and deliberate rumination, PTG was only a unidirectional predictor of subsequent PTSD, and PTSD was only a unidirectional predictor of subsequent deliberate rumination.

Cross-lagged panel model for male and female

As a supplementary analysis, we performed multiple group analyses according to sex to evaluate sex differences in the CLPM. We construct a free estimation model without intergroup constraints in the first instance (Model 1). Then, we assumed equal regression coefficients between genders and constructed a structural weight equivalence model (Model 2). Model 1 was compared with Model 2 to test for sex differences in the cross-lagged paths between PTSD, PTG, and deliberate rumination. The results demonstrated that the cross-lagged panel model between PTSD, PTG, and deliberate rumination differed significantly: $\Delta\chi^2 P = 0.000$, $\Delta CFI = 0.01$, and $\Delta RMSEA = 0.054$.

The results showed that several cross-lagged paths were significant in male samples. As described in Fig. 3, PTSD at T1 positively predicted deliberate rumination at T2 ($\beta = 0.229$, $P < 0.001$). Moreover, PTG at T1 positively predicted PTSD at T2 ($\beta = 0.047$, $P < 0.01$). Furthermore, deliberate rumination at T1 positively predicted PTG at T2 ($\beta = 0.144$, $P < 0.001$). However, in the CLPM for males, the bidirectional predictive relationship between PTG and deliberate rumination disappeared. PTG at T1 was not significant in predicting deliberate rumination at T2 ($\beta = 0.028$, $P > 0.05$).

For females, Fig. 4 showed that PTSD at T1 positively predicted deliberate rumination at T2 ($\beta = 0.202$, $P < 0.001$). Furthermore, PTG at T1 was positively associated with PTSD and deliberate rumination at T2 ($\beta = 0.061$, $P < 0.01$; $\beta = 0.158$, $P < 0.001$, respectively). Additionally, deliberate rumination at T1 positively predicted PTG at T2 ($\beta = 0.127$, $P < 0.001$). Nevertheless, the association between PTSD and PTG at T1 was not significant in the CLPM for female participants ($\beta = 0.026$, $P > 0.05$).

Discussion

In this study, we aimed to examine the reciprocal and predictive associations between PTSD, PTG, and deliberate rumination from a longitudinal and developmental perspective. This study is unique in that it completed a

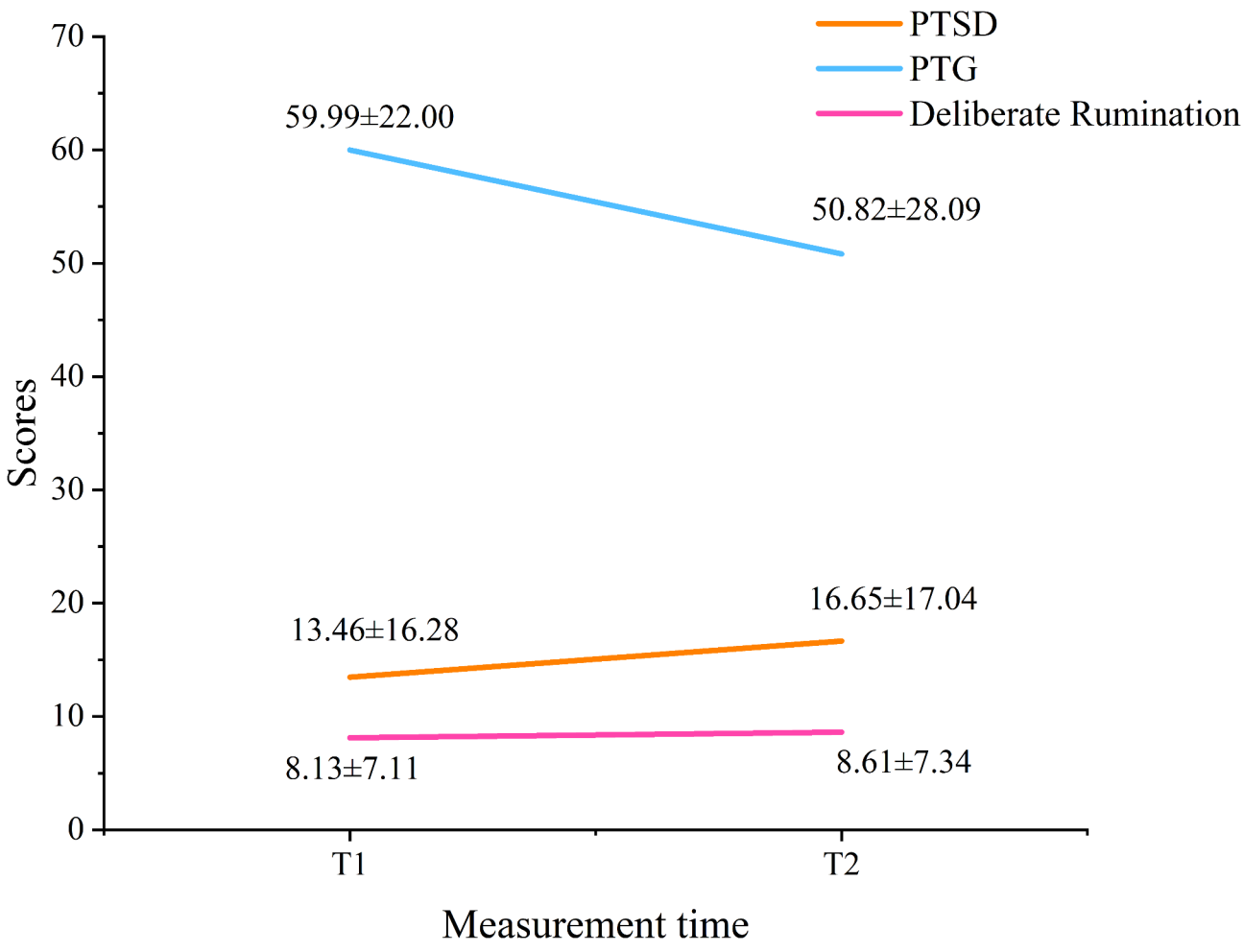

Fig. 1 The scores of PTSD, PTG and deliberate rumination at T1 and T2 among healthcare staff

Table 2 Correlations between all model variables

	1	2	3	4	5	6
1. PTSD at T1	1					
2. PTG at T1	0.044*	1				
3. Deliberate Rumination at T1	0.630**	0.240**	1			
4. PTSD at T2	0.500**	0.071**	0.071**	1		
5. PTG at T2	0.064**	0.357**	0.188**	0.256**	1	
6. Deliberate Rumination at T2	0.340**	0.192**	0.368**	0.661**	0.410**	1

Note: * $P<0.05$; ** $P<0.01$

follow-up and explored the cross-lagged paths between PTSD, PTG, and deliberate rumination among healthcare staff in the context of the COVID-19 pandemic based on a longitudinal program in Hubei Province, China, with highly representative. We observed a bidirectional causal association between PTG and deliberate rumination among the healthcare staff. However, the bidirectional predictive association was not significant between PTSD and PTG, and only a unidirectional predictive connection was observed between PTSD and deliberate rumination. We observed significant differences in the relationships between PTSD, PTG, and deliberate rumination between male and female individuals. However, evidence of sex differences in the connection between PTSD, PTG, and deliberate rumination is virtually absent, and more studies are needed to explore whether sex differences have a prospective impact on this connection and its mechanism of action. These findings enhance our understanding of previous cross-sectional research related to mental health among healthcare staff during a public health emergency, which has crucial implications for understanding the interconnections between PTSD, PTG, and

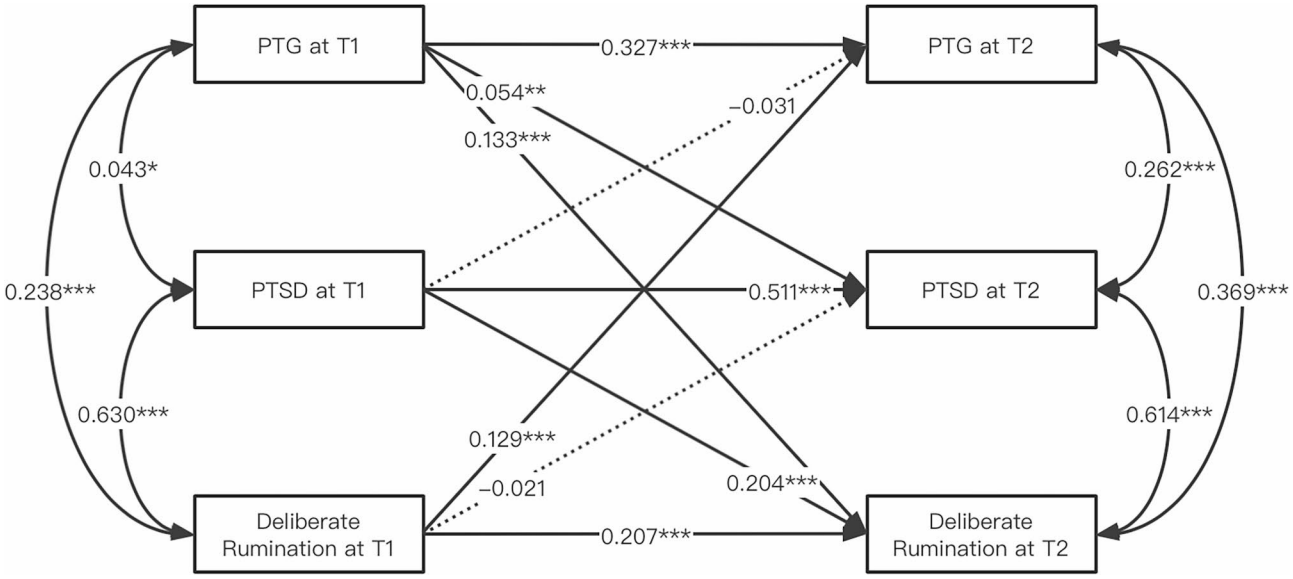

Fig. 2 Cross-lagged panel model of associations between PTSD, PTG and deliberate rumination

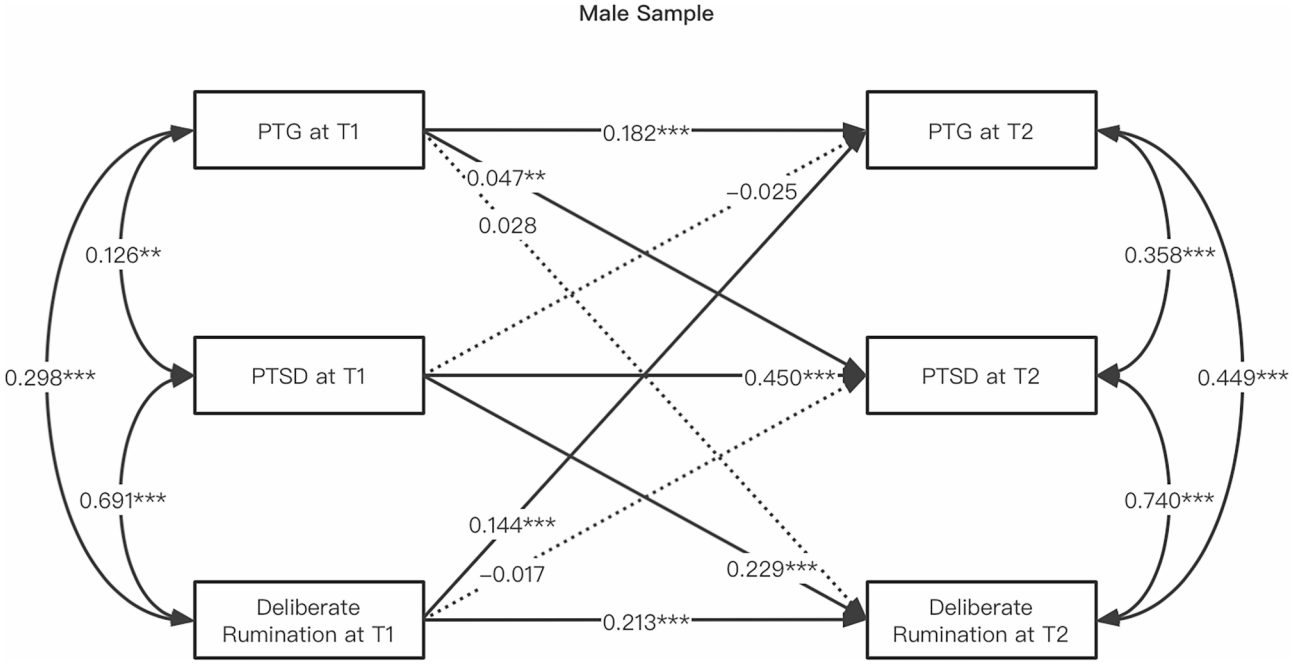

Fig. 3 Cross-lagged panel model of associations between PTSD, PTG and deliberate rumination for male

deliberate rumination. This investigation contributes to and informs the arrangement of prevention and intervention projects targeting mental health among healthcare staff experiencing emergency public health events.

In contrast to previous cross-sectional investigations, this study identified a causal connection between PTG and deliberate rumination among healthcare staff from T1 to T2, suggesting that PTG and deliberate rumination mutually influence subsequent development. Similar results in other studies have reported that deliberate rumination in the previous stage is a statistically significant predictor of PTG, with statistical growth in the subsequent stage [28]. Other studies have confirmed that PTG at 3.5 years predicted deliberate rumination at 4.5 years in adolescents following the Wenchuan earthquake in China. Additionally, from 4.5 to 5.5 years, deliberate rumination significantly foreshadowed PTG, even though this predictive effect was observed to be unstable [47]. This slight difference from the findings of our study may be attributed to the different traumatic events and the

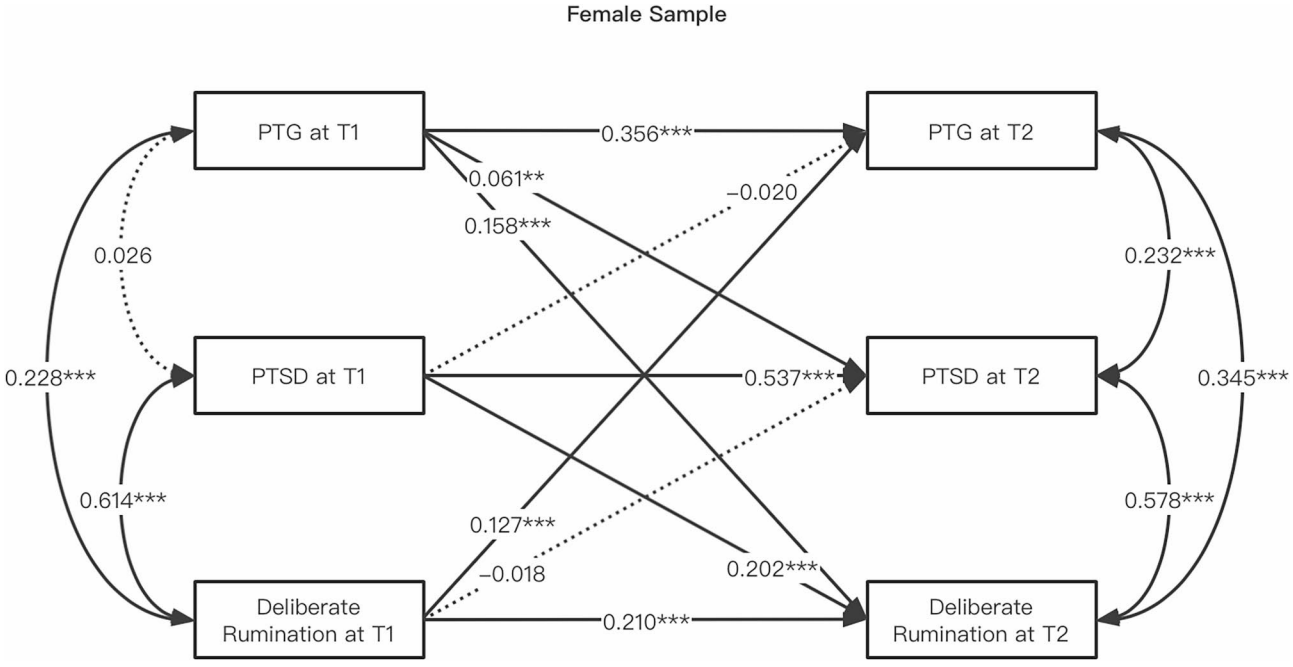

Fig. 4 Cross-lagged panel model of associations between PTSD, PTG and deliberate rumination for female

fact that the individuals in the sample who experienced trauma were healthcare staff and adolescents; there were distinctly different sample characteristics. Taken on the whole, our findings are paralleling with the model of PTG, the core of PTG includes both constructive and illusory cognitive aspects, which could influence the cognitive processes of trauma victims [48, 49]. From one perspective, deliberate rumination as a form of reconstructing the meaning of experience could promote personal strength, an appreciation of life, spiritual change, and the discovery of new possibilities or improved relationships with others as factors of PTG. From another perspective, the constructive aspect of PTG could help trauma survivors face traumatic experiences, actively consider the negative outcomes of traumatic events, and facilitate the likelihood of world recognition, which will further promote the development of deliberate rumination.

When we investigated the cross-lagged pathway between PTSD and PTG, we observed that greater degrees of PTG at T1 predicted greater severity of PTSD at T2. However, this predictive effect was unidirectional, and the predictive pathway of PTSD from the previous stage to subsequent PTG was not significant. Previous cross-sectional studies documenting PTSD associated with PTG have observed this relationship to be positive, with PTSD mediating the relationship between exposure and PTG [50]. However, of the few longitudinal cross-lagged studies on PTSD and PTG, only one was consistent with our findings. In a longitudinal study of former prisoners of war couples, the initial PTG levels in their wives at T1 were observed to predict symptom avoidance at T2 [51]. On the contrary, other studies have reported inconsistent results. They confirmed that PTSD in the former stage was associated with PTG in the latter phase of a public health emergency [52–54]. For instance, T2 anxiety and PTSD were noticeably and positively related to T3 PTG levels in an American population during a public health emergency. In addition, among former Israeli prisoners of war, veterans, and earthquake survivors, previous studies have confirmed the one-way predictive effect of PTSD on PTG [55–57]. We attribute the reasons for these differences to the specificity of this study unfolding in the context of public health emergencies, as distinct from war or natural disasters, and the complex societal roles assumed by healthcare staff in public health emergencies. Moreover, studies have elaborated that PTG is considered to have self-transcendent, constructive, illusory, self-deceptive, or dysfunctional aspects, as reported by Tedeschi and Calhoun [49]. From a long-term perspective, perceptions of PTG may develop into cognitive avoidance strategies owing to the illusory component of PTG interacting with cognitive avoidance strategies [48]. Distress might help trauma survivors seek meaning. However, this does not alleviate the worry and rejection that accompany pain, which leads to increased PTSD symptoms. In future studies, the connection between every symptom cluster of PTSD and PTG should be explored further.

In terms of our primary research question, although deliberate rumination was not found to influence PTSD, PTSD was found to significantly facilitate deliberate

rumination. These findings are perhaps not surprising, with very inconsistent results reported in previous longitudinal studies. Some previous studies have revealed that deliberate rumination does not significantly predict subsequent PTSD, which were consistent with the results of our study [58–60]. Counterintuitively, among Wenchuan earthquake survivors, one study found results inconsistent with our study, with deliberate rumination at T2 being a significant predictive pathway for subsequent PTSD at T3 [28]. Of the predictors considered, deliberate rumination at T1 had a predictive effect on PTSD symptoms at T2 among survivors of the Chilean earthquake and tsunami [60]. Furthermore, we found few longitudinal studies demonstrating the predictive effect of PTSD on deliberate rumination, and in our study, this cross-lagged path was demonstrated to be significant for the first time. According to the theory of shattered world assumption and the model of PTG, we speculate that shortly after traumatic events, the focus of trauma survivors on negative thoughts and feelings will increase, thus activating existing negative self-patterns as well as negative expectations for the future [61, 62]. These self-patterns lead survivors to engage in intrusive rumination shortly after the traumatic event and eventually lead to PTSD. While this could provide trauma cues to trauma survivors and possibilities for promote cognitive processing of traumatic events, which successively leads to recent deliberate rumination. Perhaps there is a more complex relationship and dynamic evolution between PTSD and deliberate rumination, but more long-term longitudinal evidence is needed to confirm the association.

Despite the World Health Organization declared that the COVID-19 pandemic no longer constitutes a public health emergency of international concern, the mental health problems it caused have not disappeared. PTSD, PTG, and other mental health problems might still coexist or evolve for a long time after the traumatic event. In particular, healthcare staff, as a special group with high levels of chronic fatigue and stress for more than two years, might experience more severe PTSD. Therefore, measures must be taken to help healthcare staff eliminate or improve psychological problems such as PTSD. Specifically, the development of robust social support resources and adaptive capabilities among healthcare staff can be facilitated through the establishment of supportive relationships, encouragement of collaboration and mutual assistance, enhancement of organizational and work environments, and improving of psychological resilience. These measures contribute to promoting PTG, thereby mitigating the incidence of PTSD. In addition, cognitive-behavioral therapy can assist healthcare staff in identifying and altering negative cognitive patterns, reducing intrusive rumination, and increasing deliberate rumination, thereby enhancing healthcare staff's PTG and further reducing the risk of PTSD.

There are several limitations in current investigation that should be recognized. Initially, the context of the COVID-19 pandemic is unique, and the role of healthcare staff is also extraordinary, which may be different from that of survivors of other natural disasters or wars. Besides, due to the large population base in China, the management measures for the public health emergency also have certain particularity. As such, the consequences of this research should be extrapolated to other samples with caution. Secondly, the small number of male participants limited the extrapolation of the research results, and in the future, emphasis should be placed on achieving a balanced gender ratio among participants to improve the extrapolation of research results. In addition, the current study included only twice surveys, and it is unclear whether these variables will be associated at future time points. Future research is necessary to set up three or more time points to explore the development trajectories of PTSD, PTG, and deliberate rumination among healthcare staff, and to further explore the differences in development trajectories among different individuals on this basis. Finally, temporal associations between PTSD, PTG, and deliberate rumination were assessed using CLPM. A limitation of the CLPM lies in its inability to separate between-person effects from within-person effects [63, 64]. Researchers may consider employing a random intercept CLPM in future studies to further analyze the temporal associations among variables.

In spite of these limitations, present study still has several strengths that deserve recognition. Using a longitudinal design, this is the first large sample longitudinal survey to evaluate the cross-lagged combination between PTSD, PTG, and deliberate rumination among healthcare staff and conducting this study in Hubei Province, China, two years after the COVID-19 pandemic provides better representation. Second, we explored gender differences to advance our understanding of PTSD, PTG, and deliberate rumination among healthcare staff. More importantly, the findings obtained present important theoretical and practical implications. To be specific, this study laid a theoretical foundation for future research, suggesting that long-term longitudinal studies could explain the predictive relationships and dynamic trends. Qualitative studies are also recommended to ascertain more inner cognition concerning PTSD and PTG. It also provides the authorities and managers with a direction for possible future implementation of assistance as well as treatment in guiding intentional rumination and promoting PTG.

Conclusions

Collectively, this study, based on a longitudinal project in Hubei Province, China, initially provided novel evidence for more profound understanding of the cross-lagged paths between PTSD, PTG and deliberate rumination among healthcare staff two years after the COVID-19 pandemic. These discoveries are important as they inform the formulation of mental health intervention strategies for healthcare staff. In particular, to continuously monitor the combined pattern and evolution trend of PTSD, PTG and deliberate rumination, and carry out comprehensive management and intervention, in order to alleviate the psychological pain and promote their growth among healthcare staff.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12888-025-06540-w .

Supplementary Material 1: **Appendix A. supplementary dataTable S1** The demographic characteristics of the participants who completed and did not complete follow-up.

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Author contributions

JW and PZ designed the study. JW wrote original draft. LZ, SJY, and WNF completed writingreview & editing. JW, LZ, ZJX, SJY, YL, and JXT collected research data. LZ, ZJX, YFL, and WNF completed data curation. LZ, ZJX, YFL, and WNF provided methodological guidance. JW, SJY, YL, JXT, YF, and WNF conducted data analysis and performed data visualization. ZJC and LTL completed review and revised the manuscript. All authors read and approved the final manuscript.

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Data availability

Data will be made available on request (Wenning Fu).

Declarations

Ethics approval and consent to participate

All methods in this study were conducted in accordance with the principles stated in the Declaration of Helsinki. This study was approved by the Research Ethics Committee of Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China (No. 2021-IEC-A006). Informed consent was obtained from all participants.

Competing interests

The authors declare no competing interests.

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