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Post-Traumatic stress disorder and post-traumatic growth in firefighters: examining the moderating effects of resilience on occupational safety behaviors

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Abstract

Background Posttraumatic stress disorder (PTSD) and posttraumatic growth (PTG) represent divergent outcomes following trauma exposure in high-risk professions. This investigation examined the complex interplay between PTSD, PTG, and resilience in relation to occupational safety behaviors among Turkish firefighters.

Methods A multi-site cross-sectional study was conducted across five metropolitan fire departments in Turkey ($N = 122$). Participants completed validated psychometric instruments including the PTSD Checklist for DSM-5 (PCL-5), Posttraumatic Growth Inventory-Expanded Form (PTGI-X), Brief Resilience Scale, alongside detailed evaluations of safety practices, perceptions, and behaviors that assessed protocol adherence, equipment maintenance, training attendance, and safety communication metrics. Hierarchical multiple regression and chi-square analyses examined the relationships between psychological factors and safety outcomes, with particular attention to moderating effects.

Results Analyses revealed significant associations between psychological adaptation patterns and safety-critical behaviors. PTSD symptomatology demonstrated negative correlations with safety protocol adherence ($r = -.24$, $p < .01$) and safety awareness ($r = -.21$, $p < .01$). PTG manifested distinct cultural patterns, with Personal Strength emerging as the predominant domain ($M = 3.10$, $SD = 1.08$). A distinct disparity emerged between technical and psychological safety dimensions, with high adherence to equipment-related protocols (breathing apparatus maintenance: $M = 4.00$) contrasting markedly with poor implementation of psychological safety practices (comfort in communicating safety concerns: $M = 1.66$). Regression analyses indicated that psychological factors accounted for 28% of the variance in safety performance metrics, with resilience moderating the relationship between PTSD symptomatology and safety outcomes.

Conclusions This investigation identifies critical relationships between psychological adaptation and occupational safety in firefighting, revealing how PTSD symptoms and PTG distinctly influence safety behaviors through culturally mediated patterns. The significant gap between adherence to technical safety protocols versus psychological safety practices underscores the need for integrated interventions that address both domains. These findings support

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developing comprehensive programs that enhance psychological resilience while maintaining technical safety standards in emergency services, suggesting a paradigm shift in occupational safety approaches for high-risk professions.

Keywords Posttraumatic stress disorder, Posttraumatic growth, Psychological resilience, Occupational safety, Firefighters, Emergency services

Introduction

Occupational environments characterized by high exposure to life-threatening situations and traumatic incidents, such as firefighting, demand not only exceptional physical endurance but also considerable psychological resilience, given the complex and multifaceted challenges that these professionals face on a daily basis. Firefighters, as first responders to catastrophic fires, large-scale accidents, and various other emergencies involving significant human suffering and often fatalities, are routinely placed in scenarios that test the very limits of their mental fortitude and emotional stability [1]. These high-stress environments create significant psychological challenges [2], with frequent exposure to traumatic scenes demanding extraordinary emotional regulation capabilities [3].

Persistent encounters with trauma are known to substantially increase the likelihood of developing posttraumatic stress disorder (PTSD) with prevalence rates among firefighters range from 7 to 37%, reflecting the pervasive nature of this condition across varying contexts [4] Recent systematic reviews have documented this elevated PTSD risk [5], with longitudinal studies confirming increased symptom prevalence over career duration [6]. Cross-cultural investigations demonstrate similar patterns across diverse firefighting populations [7], with diagnostic evaluations revealing clinically notable symptom clusters even in subclinical presentations [8]. PTSD symptoms, when left unmanaged, can severely impair cognitive functioning, emotional regulation, and decision-making processes, which are critical to maintaining operational safety and effectiveness in high-stakes occupational settings. Moreover, the ripple effects of PTSD often extend beyond individual impairment, potentially undermining team cohesion, organizational reliability, and overall public safety [2]. Recent investigations have documented how trauma-related impairments disrupt team coordination [9] and compromise operational safety measures [10]. Yet, despite these adverse outcomes, not all individuals exposed to trauma respond in a maladaptive manner; some demonstrate remarkable psychological resilience and undergo profound personal transformations, commonly referred to as posttraumatic growth (PTG), which underscores the potential for constructive adaptations in the aftermath of adversity [11]. This constructive adaptation process has been observed across multiple first responder populations [12].

PTG represents a distinct psychological transformation that occurs after experiencing severe life challenges [13]. Contemporary theoretical frameworks conceptualize PTG as more than simple recovery [14], involving fundamental identity reorganization [15], cognitive restructuring [16], and enhanced meaning-making capacities [17]. Unlike recovery, which simply means returning to normal functioning, PTG produces meaningful positive changes in multiple areas of life. Drawing on the seminal works of Tedeschi and Calhoun [18, 19] and subsequent theoretical developments [20], these changes include stronger personal capabilities, better relationships with others, greater appreciation for life, discovery of new opportunities, and spiritual development [21]. These transformations encompass enhanced self-perception [22], improved interpersonal connections [23], philosophical deepening [24], spiritual reconsideration [25], and new life direction identification [26]. In the firefighting profession, PTG shows promising effects on safety behaviors. In this context, safety behaviors encompass adherence to standard operating procedures, proper use of personal protective equipment, vehicle operation protocols, and team communication during emergencies. Firefighters who experience PTG demonstrate better emotional control, enhanced problem-solving abilities, and stronger commitment to safety procedures. They become more skilled at identifying potential dangers, communicating about risks effectively, and contributing to a workplace culture that prioritizes safety beyond basic rule compliance. Despite these benefits, research on PTG in high-risk occupations remains limited, especially in non-Western contexts where cultural factors significantly influence how individuals process and respond to trauma [27, 28]. While PTSD represents negative psychological consequences of trauma exposure and PTG represents positive psychological transformations following trauma, these seemingly opposite outcomes may coexist in traumatized individuals, suggesting they operate through related but distinct psychological mechanisms [13, 16]. However, few studies explored both PTSD and PTG among firefighters [29, 30]. Particularly in Turkey, researchers have not yet systematically studied how PTG might improve occupational safety and mental health outcomes among professionals exposed to trauma [28]. This gap in knowledge affects both local research efforts and broader international understanding of the subject. Therefore, systematic investigation is needed to

understand how PTG manifests in different cultural contexts and its impact on occupational safety in non-Western professional environments. In the Turkish firefighting context, cultural factors in this context include hierarchical organizational structures, collective decision-making processes, attitudes toward emotional expression and help-seeking, and culturally-specific trauma response patterns that may differ from Western norms [27, 31].

Resilience, often regarded as the psychological backbone that enables individuals to withstand and recover from adversity, plays a dual role as both a precursor to and an outcome of PTG, while simultaneously acting as a critical buffer against the detrimental effects of PTSD [24, 29, 32, 33]. Defined as a dynamic and multifactorial process rather than a static personality trait, resilience is influenced by an intricate interplay of individual characteristics, environmental conditions, and organizational resources [34]. High levels of resilience are consistently associated with better emotional regulation, adaptive coping strategies, and sustained functional performance under stress, all of which are vital for maintaining safety and efficiency in professions like firefighting [35, 36]. Conversely, the absence or erosion of resilience, whether due to chronic stressors, inadequate support systems, or resource limitations, can exacerbate trauma-related impairments and amplify vulnerabilities, thereby jeopardizing both individual well-being and collective safety outcomes [23]. Resilience also interacts with organizational factors, such as access to training, availability of mental health resources, and the quality of team dynamics, which can either bolster or undermine an individual's ability to navigate occupational stress effectively [37, 38]. While the role of resilience in mitigating the psychological and operational impacts of trauma has been acknowledged in international research, its specific manifestations and influences within the Turkish firefighting context remain poorly understood. Existing studies have predominantly focused on the prevalence and clinical management of PTSD, neglecting the broader spectrum of resilience-related dynamics that shape occupational safety and psychological adaptation [27, 31].

In Turkey, where firefighters often operate in resource-constrained environments characterized by limited institutional support, high operational demands, and substantial exposure to traumatic events, the study of psychological resilience and its interaction with PTSD and PTG is particularly relevant [27]. Despite the critical importance of understanding these dynamics, there is a paucity of research that explores how Turkish firefighters navigate the psychological challenges of their profession or how these experiences influence their adherence to safety protocols and engagement in risk mitigation practices. Addressing these gaps is essential for developing culturally and contextually appropriate interventions that not only enhance individual and organizational resilience but also align with the socio-cultural realities of the Turkish workforce. This study, therefore, seeks to examine the complex relationships among PTSD symptoms, PTG, and resilience within the specific context of Turkish firefighting operations, with the overarching goal of identifying the mechanisms through which these psychological constructs influence occupational safety behaviors. This investigation builds upon preliminary documentation of psychological resilience patterns among Turkish emergency responders [27].

Occupations characterized by high-risk environments, such as firefighting, necessitate not only physical endurance but also exceptional psychological resilience. Furthermore, individuals in these professions are routinely confronted with life-threatening scenarios that demand rapid decision-making under extreme stress.

The extant body of literature extensively documents the deleterious consequences of PTSD, including its association with impaired cognitive functioning, emotional dysregulation, diminished adherence to safety protocols, and heightened propensity for risk-taking behaviors as demonstrated in multiple studies of first responders [1]. Systematic reviews have identified consistent patterns of safety impairment among trauma-affected personnel [2], with neuropsychological assessments confirming cognitive disruptions [6] and organizational analyses documenting team coordination deficits [9]. In stark contrast, the phenomenon of PTG, which encapsulates positive psychological transformations arising from adversity, has been linked to improved emotional regulation, heightened situational awareness, and an enriched capacity for effective crisis management [6]. Recent investigations have documented how PTG facilitates enhanced threat assessment [9], promotes proactive safety behaviors [10], fosters adaptive coping mechanisms [12], strengthens operational resilience [36], improves cultural safety adaptations [27], and enhances collective efficacy in high-stress situations [39]. Despite this contrast between the negative impacts of PTSD and the positive transformations of PTG represents distinct yet potentially co-occurring responses to trauma exposure that have different implications for occupational safety behaviors. While resilience is often celebrated for its protective role in buffering against the negative impacts of PTSD and facilitating PTG, its inherently dynamic nature, subject to fluctuations based on environmental, organizational, and individual factors, demands a more comprehensive investigation [40].

Psychological resilience, conceptualized not as a static personality attribute but rather as a dynamic psychophysiological process, can be systematically enhanced through the implementation of comprehensive support mechanisms, including social network infrastructure,

evidence-based training protocols, and robust institutional frameworks. However, this psychological resource remains susceptible to significant degradation when confronted with chronic stressors, resource insufficiency, and unsupportive organizational environments. Within the Turkish context, where high-risk and safety-critical occupations such as firefighting function under distinctive socio-cultural and infrastructural constraints, there exists a notable scarcity of empirical investigations addressing these psychological dimensions. The present research aims to address these substantive knowledge gaps by examining the mediating or moderating functions of resilience in the complex interrelationships between posttraumatic stress symptomatology, posttraumatic growth, and occupational safety behaviors within this specific professional demographic. Specifically, this research seeks to delineate the mechanisms through which enhanced resilience may facilitate increased adherence to established safety protocols, create a proactive risk management culture, and optimize operational effectiveness, while concurrently identifying how diminished resilience potentially exacerbates psychological vulnerabilities, thereby compromising safety outcomes and heightening susceptibility to occupational hazards.

The current investigation examines four interrelated research objectives within the theoretical framework of occupational mental health and safety science. First, it seeks to analyze the complex interrelationships between posttraumatic stress disorder symptomatology, posttraumatic growth, and psychological resilience within Turkish firefighting personnel, with particular emphasis on elucidating the dual protective functions of posttraumatic growth and resilience in mitigating the harmful effects of trauma exposure. Second, it investigates the mechanisms through which these psychological constructs influence occupational safety behaviors, proactive safety practices, and organizational adaptability procedures. Third, it examines the culturally-specific manifestations of psychological adaptation to trauma within a non-Western emergency service context through a methodologically rigorous, culturally-informed analytical approach. Fourth, it aims to identify potential intervention mechanisms through which evidence-based psychological strategies might enhance both mental health outcomes and safety performance metrics in high-risk professions. The findings derived from this investigation are expected to inform the development of culturally-appropriate, empirically-supported interventions that address both individual and systemic dimensions of occupational safety, thereby contributing significantly to the international discourse on trauma-informed occupational safety while simultaneously providing actionable insights for enhancing psychological wellbeing and resilience among firefighting personnel in Turkey.

Materials and methods

Study setting and participants

The study was conducted in accordance with the principles of the Declaration of Helsinki (World Medical Association, 2013). The study protocol was approved by the ethics review board before starting the study (Social and Humanities Research Ethics Committee of the Istanbul University-Cerrahpasa, Istanbul, Turkey; Approval No: 2023/165 and dated May 02, 2023). Permission for using Turkish versions of study instruments was requested and granted via email from the original authors. This multi-center research was conducted between June and September 2023 across five major metropolitan fire departments in Turkey, including Istanbul, Ankara, and Izmir, representing diverse urban emergency response environments and varied incident exposure levels. These departments collectively employ approximately 5,000 firefighters and respond to an average of 150,000 emergency calls annually.

The sample size calculation was performed using G*Power 3.1 software [41], with parameters set for multiple regression analysis ($\alpha = 0.05$, power $[1-\beta] = 0.80$, medium effect size $f^2 = 0.15$, and five predictors). This initial calculation suggested a minimum requirement of 92 participants. However, to accommodate the PCL-5's structural validation requirement of 6 participants per item (20 items × 6), the target sample size was increased to 120 participants. This larger sample enhanced statistical power and allowed for potential subgroup analyses.

Recruitment was implemented in collaboration with fire department administrators and union representatives. Initial contact occurred through official departmental channels, followed by informational sessions at each participating fire station. These sessions, conducted by trained research team members, provided detailed information about the study's objectives, methodology, and confidentiality measures. To minimize selection bias, recruitment was stratified by rank (proportional representation of fire chiefs, sergeants, and firefighters), years of service (balanced distribution of early, mid, and late-career professionals), and shift patterns (equal representation from day, night, and rotating shifts).

From the potential participant pool, we initially contacted 277 individuals through stratified sampling. Among these, 82 individuals viewed the survey information but chose not to participate at all, 73 began filling out the survey but were excluded after completing the first section due to not meeting eligibility criteria, and 122 completed the entire study, representing a response rate of 44%. Independent samples t-tests confirmed no significant differences between the five fire departments on key variables including PTSD symptoms ($p = .230$), PTG levels ($p = .483$), resilience scores ($p = .326$), and safety

performance metrics ($p = .268$), supporting the pooling of data across departments.

Inclusion criteria required participants to be active firefighters with a minimum of one year of service and a history of trauma exposure. The one-year minimum criterion ensured participants had sufficient time to experience occupational trauma exposure and acclimate to departmental culture. Trauma exposure was operationalized using the Life Events Checklist-5 (LEC-5), with inclusion contingent upon reporting direct exposure to at least one traumatic event. Exclusion criteria encompassed psychological disorder diagnosis, current psychological treatment, or medication for psychological disorders, minimizing confounding variables that might influence assessment outcomes.

Data collection utilized Google Forms as the online survey platform. Survey links were distributed via email and social media platforms, primarily professional WhatsApp and Facebook groups. Response rates were notably higher through social media channels (56%) compared to email distribution (31%). All measurements were self-report; no clinical interviews were conducted.

The online survey began with comprehensive information about the study, including researcher identities, contact details, study purpose, and data usage policies. Participants were informed of their right to withdraw at any time and were required to provide explicit consent by clicking a 'Consent' button before proceeding. The questionnaire consisted of three sections: Sect. 1 contained eligibility screening questions, Sect. 2 comprised the study instruments and personal/work-safety information, and Sect. 3 included additional optional feedback. Participants could skip non-consent items as desired. Contact information of the researchers was provided throughout to address any participant concerns. All collected data were anonymized, with no identifying information stored. Participants completed the survey without compensation.

Table 1 Sociodemographic characteristics of participants ($N = 122$)

Characteristic	*n* (%) or M ± SD
Age (years)	37.8 ± 7.9
Work Experience (years)	13.2 ± 7.8
Position	
Fire Chief	8 (6.6%)
Fire Sergeant	19 (15.6%)
Firefighter	95 (77.8%)
Gender	
Male	118 (96.7%)
Female	4 (3.3%)
Marital Status	
Married	85 (69.7%)
Single	37 (30.3%)
Having Children	
Yes	82 (67.2%)
No	40 (32.8%)
Smoking Status	
Yes	42 (34.4%)
No	80 (65.6%)

Sociodemographic characteristics

Table 1 presents the demographic profile of the participants in this study. The sample consisted predominantly of male firefighters (96.7%) with a mean age of 37.8 years (SD = 7.9) and average work experience of 13.2 years (SD = 7.8). Most participants were in firefighter positions (77.8%), with smaller proportions serving as fire sergeants (15.6%) and fire chiefs (6.6%). The majority of participants were married (69.7%) and had children (67.2%). Approximately one-third of the sample (34.4%) reported being current smokers.

Study instruments

Occupational safety and work characteristics assessment

A structured assessment form was developed to collect comprehensive data on participants' occupational and safety characteristics. This form gathered demographic and professional information including age, work experience, position in the department (fire chief, fire sergeant, firefighter), marital status, parental status, and smoking habits. The safety training section collected data on attendance patterns, frequency of training over five-year periods, safety awareness levels, and inspection schedules (monthly, quarterly, yearly). Work accident history was documented through questions about accident occurrence, frequency, and multiple-response options for accident causes including carelessness, fatigue, equipment failure, and insufficient training.

The form included a detailed safety perception and stress impact assessment utilizing a 5-point Likert scale (1 = Very Poor to 5 = Excellent). This section evaluated twelve specific safety domains: regular health checkups and fitness tests, adequacy of personal protective equipment, maintenance of breathing apparatus, comfort in sharing safety concerns, periodic safety procedure training, chemical safety training, high-altitude work training, structural collapse knowledge, fire vehicle safety checks, health risk awareness, ergonomic working conditions, and self-assessed safety excellence. Additionally, stress impact on safety performance was assessed through both general impact (Yes/No) and specific impact levels (Low/Moderate/High), providing a comprehensive evaluation of occupational stress and safety practices.

To facilitate comprehensive analysis of safety behaviors, a composite safety performance score was developed based on these assessments. This composite measure integrated multiple safety indicators including protocol

adherence, personal protective equipment usage, training attendance, and safety awareness. By aggregating these related metrics (mean intercorrelation $r = .38$, range 0.25-0.56), we created a more holistic representation of overall safety performance. The composite score was calculated as the mean of standardized values across individual safety metrics, providing a single dependent variable that captured the multidimensional nature of occupational safety behaviors while enabling more streamlined statistical analyses.

Psychological assessment instruments

PCL-5 (PTSD Checklist for DSM-5) The PCL-5, a widely validated self-report instrument for PTSD screening, was administered to assess PTSD symptomatology according to DSM-5 criteria [42–45]. This 20-item instrument is structured around four distinct symptom clusters: re-experiencing symptoms (items 1–5, including intrusive memories and nightmares), avoidance behaviors (items 6–7, covering avoidance of trauma-related thoughts and external reminders), negative alterations in cognitions and mood (items 8–14, assessing persistent negative emotions and beliefs), and increased arousal and reactivity (items 15–20, measuring hypervigilance and related symptoms). Participants rated their symptom severity over the past month using a five-point Likert scale ranging from 0 (not at all) to 4 (extremely). The Turkish version of PCL-5, validated for use in first responder populations, was employed with a clinical cutoff score of 41, as recommended for these populations [43, 46]. Total scores range from 0 to 80, with higher scores indicating greater PTSD symptom severity [44]. In the current sample, the PCL-5 demonstrated excellent internal consistency (Cronbach's $\alpha = 0.91$).

PTGI-X (Posttraumatic Growth Inventory-Expanded Form) The PTGI-X was utilized to assess positive psychological changes following traumatic experiences [47, 48]. This 25-item self-report measure evaluates growth across five distinct domains: Relating to Others (enhanced interpersonal connections), New Possibilities (identification of new life paths), Personal Strength (increased sense of self-capability), Spiritual Change (deepened existential understanding), and Appreciation of Life (enhanced recognition of life's value). Items were rated on a six-point scale ranging from 0 (no change experienced) to 5 (very great degree of change experienced). Higher scores on the PTGI-X indicate greater positive psychological growth following trauma exposure, with both domain-specific scores (range 0–5) and a total growth score (range 0-125) available for analysis. The Turkish adaptation of PTGI-X, which has demonstrated robust psychometric properties with high internal consistency (Cronbach's $\alpha = 0.92$) and strong test-retest reliability ($r = .85$), was used. The scale maintained excellent reliability in our sample (Cronbach's $\alpha = 0.93$).

Brief Resilience Scale (BRS) Psychological resilience was assessed using the Brief Resilience Scale, a concise 6-item measure designed to evaluate individuals' ability to recover from stressful experiences [27, 49–51]. The scale employs a balanced structure of positively and negatively worded items, rated on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree). Negative items undergo reverse scoring to maintain consistency in interpretation. The Turkish version of the BRS was utilized in this study and it has demonstrated satisfactory psychometric properties (Cronbach's $\alpha = 0.83$) [49]. In the current sample, the BRS showed good internal consistency (Cronbach's $\alpha = 0.85$). Total scores are calculated by averaging all items after appropriate reverse scoring, with higher scores indicating greater resilience capacity.

Statistical analysis

All statistical analyses were performed using IBM SPSS (Version 26) and replicated in R (Version 4.2.3) for validation. Initial analyses included descriptive statistics for demographic, occupational, and psychometric variables, with means and standard deviations calculated for continuous variables and frequencies and percentages for categorical variables. The normality of distributions was assessed using Kolmogorov-Smirnov tests and visual inspection of histograms.

Relationships between variables were examined using multiple analytical approaches. Pearson correlation coefficients were calculated for continuous variables (PCL-5, PTGI-X, and BRS total scores), while Spearman correlations were used for ordinal variables (safety training frequency, stress impact). Point-biserial correlations were employed for binary variables (safety awareness, accident history) in relation to continuous measures. Chi-square tests analyzed associations between categorical variables, particularly in examining the relationships between PTSD symptom severity groups and both PTG and resilience categories.

To assess the complex relationships between psychological factors and occupational safety parameters, hierarchical multiple regression analyses were conducted. The composite safety performance score served as the dependent variable, with psychological measures (PCL-5, PTGI-X, BRS scores), work experience, and training variables entered as predictors. Additionally, logistic regression analysis examined the prediction of safety incident occurrence, with psychological factors and safety training as predictors. For all regression analyses, assumptions of linearity, normality, homoscedasticity, and multicollinearity were verified. Variance inflation factors were

Table 2 Primary safety training and accident characteristics ($n = 122$)

Characteristic	*n* (%)
Safety Training Attendance	
Regular attendance	100 (100.0%)
Training Frequency (5 years)	
1–2 times	20 (20.0%)
3–5 times	65 (65.0%)
6–10 times	8 (8.0%)
More than 10 times	7 (7.0%)
Safety Measures Awareness	
Yes	92 (92.0%)
No	8 (8.0%)
Safety Inspection Schedule	
Monthly	32 (32.0%)
Quarterly	28 (28.0%)
Yearly	40 (40.0%)
Work Accident History	
Experienced accident	38 (38.0%)
No accident	62 (62.0%)
Accident Frequency ($n = 38$)*	
Single incident	25 (65.8%)
2–3 incidents	10 (26.3%)
More than 3 incidents	3 (7.9%)
Primary Accident Causes**	
Carelessness	72 (72.0%)
Fatigue	65 (65.0%)
Equipment Failure	45 (45.0%)
Insufficient Training	40 (40.0%)
Other	18 (18.0%)

Note. *Percentages for accident frequency calculated based on those who experienced accidents ($n = 38$). **Multiple responses allowed per participant

Table 3 Safety perceptions, stress impact, and safety measure ratings ($n = 122$)

Characteristic	*n* (%) or Mean (SD)	Median (Min-Max)
Stress Impact on Safety		
Reports impact	91 (74.6%)	
No impact	31 (25.4%)	
Stress Impact Level		
Low (0–1)	33 (36.3.0%)	
Moderate (2–3)	65 (71.4%)	
High (4)	24 (26.4%)	
Safety Measure Ratings		
Regular Health Checkups and Fitness Tests	2.34 (1.25)	2.0 (1.0–4.0)
Adequacy of Personal Protective Equipment	3.66 (1.26)	4.0 (2.0–5.0)
Regular Maintenance of Breathing Apparatus	4.00 (0.82)	4.0 (3.0–5.0)
Comfortable Sharing Work Safety Concerns	1.66 (0.47)	2.0 (1.0–2.0)
Periodic Safety Procedure Training	2.99 (0.82)	3.0 (2.0–4.0)
Chemical Safety Training	1.66 (0.94)	1.0 (1.0–3.0)
High Altitude Work Training	1.99 (0.82)	2.0 (1.0–3.0)
Structural Collapse Knowledge	2.33 (0.95)	3.0 (1.0–3.0)
Regular Safety Checks of Fire Vehicles	1.00 (0.00)	1.0 (1.0–1.0)
Health Risk Awareness	2.68 (1.71)	2.0 (1.0–5.0)
Ergonomic Working Conditions	1.00 (0.00)	1.0 (1.0–1.0)
Self-Assessed Safety Excellence	1.34 (0.47)	1.0 (1.0–2.0)

Note. Rating scale: 1 = Very Poor to 5 = Excellent

Stress impact was measured as Yes/No for general impact and on a 0–4 scale for attention impact. Multiple responses allowed for stress impact levels

examined to ensure absence of significant multicollinearity (VIF < 5).

Statistical significance was set at $p < .05$ for all analyses, with Bonferroni corrections applied for multiple comparisons where appropriate. Effect sizes were reported using Cohen's d for t-tests, Cramer's V for chi-square tests, standardized β coefficients for multiple regression, and odds ratios for logistic regression. Confidence intervals were calculated at the 95% level for all relevant parameters. Missing data were handled using pairwise deletion, with sensitivity analyses conducted to ensure robustness of findings.

Results

Sociodemographic and occupational safety metrics

The sociodemographic characteristics and occupational safety metrics of firefighters were analyzed in two distinct categories. The first analysis focused on participant demographics, while the second examined occupational safety practices and perceptions. Table 1 presents the demographic profile of participants, while Tables 2 and 3 summarize safety training patterns, accident characteristics, and safety perceptions.

Primary occupational safety metrics

Analysis of primary occupational safety metrics revealed a notable disconnect between high safety awareness and substantial accident rates. All participants reported attending safety training, yet over one-third experienced workplace accidents. Table 2 presents the detailed distribution of safety training frequency, inspection schedules, accident history, and reported accident causes. The most significant finding was the predominance of carelessness and fatigue as primary accident catalysts, suggesting potential underlying issues of psychological burden despite formal safety knowledge.

Safety perceptions and stress impacts

The analysis of safety perceptions and stress impacts among firefighters revealed significant patterns in occupational safety awareness and stress management (Table 3). A majority of firefighters (74.6%, $n = 91$) reported emotional stress impacting their safety performance. Among those reporting stress impact ($n = 91$), 71.4% ($n = 65$) indicated moderate levels of stress impact on safety attention, while 36.3% ($n = 33$) reported low

impact and 26.4% ($n=24$) reported high impact. Table 3 reveals a striking disparity between technical safety measures and psychological safety factors. While equipment-related protocols such as breathing apparatus maintenance received high ratings, psychological safety factors such as comfort in sharing safety concerns were rated considerably lower. This technical-psychological safety gap represents a key finding with significant implications for occupational safety interventions.

PTG analysis

PTG analysis revealed culturally distinctive patterns of psychological adaptation. As shown in Table 4, Personal Strength emerged as the predominant growth domain, followed by Spiritual-Existential Change, while Relating to Others received the lowest scores. This pattern differs from typical Western PTG profiles and suggests culturally specific adaptation mechanisms that may influence intervention design.

Resilience assessment

Resilience assessment revealed variation in coping capacities across the sample, with implications for intervention targeting. Table 5 presents the detailed resilience scores across all BRS items and total scale. The distribution of scores spanned all three resilience categories (low, normal, and high), indicating diverse adaptation capacities within this professional cohort that may moderate psychological responses to trauma exposure.

PTSD symptomatology

PTSD symptomatology analysis revealed a distinctive pattern of symptom distribution, with hyperarousal and avoidance symptoms emerging as the most pronounced clusters (Table 6). While the mean total PCL-5 score remained below the clinical threshold for this population, the elevated hyperarousal symptoms raise concerns for occupational safety given their potential impact on attention, decision-making, and risk assessment. Based on the recommended by Morrison et al. [46], clinical cutoff score of 41 for first responders, 26.2% ($n=32$) of participants in our sample exceeded this threshold, indicating clinically significant PTSD symptoms requiring further assessment.

Relationships between psychological factors

Table 7 illustrates the complex interrelationships between PTSD symptoms, PTG, and resilience. Chi-square analyses identified significant associations between PTSD symptom severity and both PTG ($\chi^2 = 3.24$, $p=.038$) and resilience levels ($\chi^2 = 4.86$, $p=.032$). The critical finding was the markedly different resilience distribution patterns between participants with and without clinically significant PTSD symptoms, particularly among those reporting high PTG ($\chi^2 = 3.92$, $p=.041$). These patterns suggest that resilience may moderate the relationship between trauma exposure and psychological adaptation outcomes.

Table 4 Scores of PTGI-X in terms of its factors and total ($N=122$)

Factor	Mean (SD)	Median (Min-Max)
Appreciation of Life	2.78 (1.03)	2.67 (0.00–5.00)
Personal Strength	3.10 (1.08)	3.25 (0.00–5.00)
New Possibilities	2.77 (0.97)	2.80 (0.00–5.00)
Relating to Others	2.57 (0.97)	2.57 (0.00–5.00)
Spiritual-Existential Change	2.95 (1.16)	3.00 (0.00–5.00)
Total Score	66.97 (17.57)	63.0 (40.0-100.0)

PTGI-X: Posttraumatic Growth Inventory-Expanded Form

Table 5 Descriptive statistics of brief resilience scale items and total score ($N=122$)

Variable	Mean (SD)	Median (Min-Max)
Item 1: "I tend to bounce back quickly after hard times"	3.82 (0.94)	4.00 (1.00–5.00)
Item 2: "I have a hard time making it through stressful events" (reverse scored)	3.31 (1.22)	3.00 (1.00–5.00)
Item 3: "It does not take me long to recover from a stressful event"	3.46 (1.12)	4.00 (1.00–5.00)
Item 4: "It is hard for me to snap back when something bad happens" (reverse scored)	3.39 (1.06)	3.00 (1.00–5.00)
Item 5: "I usually come through difficult times with little trouble"	3.30 (0.90)	3.00 (1.00–5.00)
Item 6: "I tend to take a long time to get over setbacks in my life" (reverse scored)	3.43 (1.04)	4.00 (1.00–5.00)
Total Score	3.45 (0.65)	3.33 (1.00–5.00)

Note. BRS = Brief Resilience Scale. Scores are interpreted as: 1.00-2.99 = low resilience; 3.00-4.30 = normal resilience; 4.31-5.00 = high resilience [57]

Table 6 Descriptive statistics of PCL-5 scores by symptom clusters and total score ($N=122$)

Variable	Mean (SD)	Median (Min-Max)
Re-experiencing (B)	8.84 (3.73)	8.00 (4–20)
Avoidance (C)	9.62 (4.21)	9.00 (4–24)
Negative Cognitions and Mood (D)	6.93 (2.90)	6.00 (3–18)
Hyperarousal (E)	11.62 (3.91)	11.00 (6–24)
Total Score	37.01 (12.93)	34.00 (20–68)

PCL-5: PTSD Checklist for DSM-5. Maximum possible scores: Re-experiencing = 20, Avoidance = 8, Negative Cognitions and Mood = 28, Hyperarousal = 24, Total = 80. A total score ≥ 41 is recommended as a cutoff for provisional PTSD diagnosis in first responders

Psychological measures and safety parameters

Table 8 documents the relationships between psychological measures and occupational safety parameters. A consistent pattern emerged showing PTSD symptoms negatively correlated with safety behaviors, while both PTG and resilience demonstrated positive associations with safety performance metrics. The most substantial correlation identified was between PTSD symptoms and

Table 7 Comparison of PTGI-X and BRS distributions between PCL-5 groups ($N = 122$)

Variable	PCL-5 ≥ 41 ($n = 32$)	PCL-5 < 41 ($n = 90$)	χ^2	p
PTGI-X Levels				
High Growth (> 70)	8 (25.0%)	38 (42.2%)		
Moderate/Low Growth (≤ 70)	24 (75.0%)	52 (57.8%)	3.24	0.038
BRS Levels				
High (> 4.30)	2 (6.3%)	27 (30.0%)		
Normal (3.00-4.30)	11 (34.4%)	46 (51.1%)	4.86	0.032
Low (< 3.00)	19 (59.3%)	17 (18.9%)		
BRS Distribution in High PTGI-X				
High Resilience	1 (12.5%)	15 (39.5%)		
Normal Resilience	3 (37.5%)	18 (47.4%)	3.92	0.041
Low Resilience	4 (50.0%)	5 (13.1%)		
BRS Distribution in Low PTGI-X				
High Resilience	1 (4.2%)	12 (23.1%)		
Normal Resilience	8 (33.3%)	28 (53.8%)	4.12	0.035
Low Resilience	15 (62.5%)	12 (23.1%)		

Note. Values are presented as n (%). PCL-5 = PTSD Checklist for DSM-5

PTGI-X = Posttraumatic Growth Inventory-Expanded Form; BRS = Brief Resilience Scale

Chi-square analyses showed significant associations between

PCL-5 status and both PTGI-X and BRS levels

Table 8 Correlations between psychological measures and occupational safety parameters ($N = 122$)

Safety Parameter	PCL-5 Total	PTGI-X Total	BRS Total
Safety Training Frequency	−0.18**	0.20**	0.22**
Safety Training Attendance	−0.24**	0.25**	0.26**
PPE Adequacy Rating	−0.22**	0.21**	0.25**
Safety Awareness	−0.21**	0.23**	0.24**
Accident History	0.19**	−0.17**	−0.20**
Stress Impact on Safety	0.31**	−0.22**	−0.28**
Self-Assessed Safety Excellence	−0.20**	0.24**	0.26**

Note: ** $p < .01$; PPE = Personal Protective Equipment

Table 9 Multiple regression analysis: psychological factors predicting safety performance ($N = 122$)

Predictor	B	SE	β	t	p
Constant	3.42	0.22		15.55	< 0.001
PCL-5 Total	-0.018	0.006	−0.21	-3.00	0.003
PTGI-X Total	0.012	0.004	0.19	3.00	0.003
BRS Total	0.285	0.096	0.23	2.97	0.004
Work Experience	0.021	0.008	0.18	2.63	< 0.010
Training Sessions	0.165	0.062	0.20	2.66	0.009

$R^2 = 0.28$, Adjusted $R^2 = 0.25$, $F(5,116) = 9.02$, $p < .001$

Table 10 Logistic regression: factors predicting safety incident occurrence ($N = 122$)

Predictor	Odds Ratio	95% CI	p
PCL-5 Score	1.22	1.05–1.42	0.009
PTGI-X Score	0.85	0.73–0.98	0.024
BRS Score	0.78	0.65–0.94	0.008
Safety Training	0.72	0.58–0.89	0.003
Stress Impact	1.45	1.15–1.82	0.002

Model $\chi^2 = 32.45$, $p < .001$, Nagelkerke $R^2 = 0.24$

stress impact on safety ($r = .31$, $p < .01$), highlighting the direct operational implications of psychological distress.

Regression analyses

Regression Analyses.

Regression analyses further clarified the relationship between psychological factors and safety outcomes. As shown in Tables 9 and 10, psychological measures collectively explained 28% of variance in safety performance. Prior to interpreting these results, multicollinearity was assessed through variance inflation factors (VIF), with all values falling below 2.5 (range: 1.24–2.31), indicating acceptable levels of independence among predictor variables despite their conceptual relatedness. The hierarchical regression model identified resilience as the strongest psychological predictor of safety performance ($\beta = 0.23$, $p < .01$), with PTSD symptoms showing a significant negative contribution ($\beta = -0.21$, $p < .01$) and PTG demonstrating a comparable magnitude positive contribution ($\beta = 0.19$, $p < .01$). Logistic regression highlighted stress impact as the most powerful predictor of incident occurrence (OR = 1.45, 95% CI [1.15–1.82], $p < .01$). These findings underscore the critical role of psychological factors in determining occupational safety outcomes independent of technical training factors.

Discussion

This study aimed to examine the complex relationships among PTSD symptoms, PTG, resilience, and occupational safety behaviors in Turkish firefighters, with particular attention to how these psychological factors might influence safety outcomes in this high-risk profession. Our findings reveal a nuanced interplay between psychological adaptation mechanisms and occupational safety behaviors that has significant implications for both theory and practice. The predominantly experienced composition of our firefighter sample provided valuable insights into the cumulative effects of long-term trauma exposure within high-risk professions. This demographic characteristic strengthens our ability to observe the complex adaptation processes that develop over sustained careers in emergency services, offering a window into how psychological responses to trauma evolve and stabilize over time. Our analysis also identified a concerning

discrepancy between firefighters' cognitive awareness of safety protocols and their actual implementation of these procedures. This "knowing-doing gap" appears particularly pronounced in operational contexts where psychological stressors may compromise decision-making capabilities. The patterns of reported accidents, predominantly attributed to attentional factors and fatigue, suggest that technical knowledge alone is insufficient to ensure safety compliance, particularly when complicated by the psychological demands inherent to emergency response work. These findings align with contemporary safety science perspectives that emphasize the importance of psychological readiness alongside technical competence, highlighting the need for integrated approaches to occupational safety in high-risk professions.

In addition, a striking finding from our study is the substantial disparity between technical and psychological dimensions of safety culture within Turkish firefighting services. While adherence to equipment maintenance and physical safety procedures appears robust, psychological safety components such as comfort in expressing concerns and perceptions of organizational support for mental health emerge as significantly underdeveloped.

This imbalance likely reflects broader cultural and organizational tendencies to prioritize tangible, equipment-focused safety measures over the less visible but equally critical psychological aspects of occupational safety. The consistently low ratings for ergonomic conditions and overall safety confidence further suggest systemic challenges in cultivating a comprehensive safety environment that addresses both physical and psychological needs of emergency service personnel.

The PTG patterns observed in our sample reveal culturally distinct adaptation mechanisms that carry important implications for intervention design. The preferential development of personal strength and spiritual-existential growth domains, rather than interpersonal connection, suggests that Turkish firefighters may rely more heavily on individualistic and spiritual coping resources following trauma exposure. This growth pattern differs notably from Western samples and likely reflects cultural influences on help-seeking behavior and emotion processing. These culturally mediated adaptation patterns highlight the importance of developing context-specific interventions that align with local coping preferences while potentially strengthening less-utilized growth domains, such as interpersonal support networks that could enhance collective resilience.

Our analysis of resilience profiles and PTSD symptomatology also reveals concerning vulnerabilities in the psychological support infrastructure for Turkish firefighters. The predominance of hyperarousal and avoidance symptoms, even at subclinical levels, suggests that these professionals are operating with significant psychological burden that could impair operational safety.

The distribution of resilience scores indicates uneven development of coping capabilities, potentially reflecting both individual differences and systemic variations in organizational support. The relationships between PTSD symptoms, resilience, and safety performance identified in our regression analyses highlight the critical role of psychological well-being in maintaining operational effectiveness. Particularly noteworthy is the potentially protective function of resilience in moderating the relationship between trauma symptoms and safety behaviors, suggesting valuable avenues for intervention development focused on enhancing psychological resilience as a core component of occupational safety programs.

Recent studies examining the psychological adaptation of firefighters have revealed complex interactions between PTSD symptoms, PTG, and resilience, with current findings contributing to the growing body of literature. Beattie et al.' cross-sectional study of firefighters found similar symptom patterns, with hyperarousal symptoms being particularly prominent among those with regular trauma exposure [6], while Martínez and Blanch reported avoidance symptoms as a dominant response to cumulative trauma in first responders [8]. The mean PCL-5 score of 37.01 in the current sample, while below the clinical cutoff, parallels findings from several international studies, including Gulliver et al.'s multi-site study of 897 firefighters that reported mean PCL-5 scores ranging from 35.8 to 38.2 across different regions [7]. Cheng et al. similarly found subclinical but substantial PTSD symptomatology (M = 36.4) in their Asian firefighter sample, suggesting a consistent pattern of substantial but subclinical PTSD burden across different cultural contexts [5]. This subclinical presentation, as noted by Serrano-Ibáñez et al., may represent a unique occupational adaptation that balances trauma exposure with continued functional performance [2]. The persistence of these symptoms, particularly in the hyperarousal and avoidance clusters, suggests a potential adaptation mechanism that allows firefighters to maintain operational functionality while managing trauma responses. This pattern is further supported by recent work from Cogan et al., who found that first responders often develop specific psychological adaptations that allow them to function effectively despite ongoing trauma exposure, though those adaptations may come with long-term psychological costs [9].

Current findings regarding PTG and resilience patterns reveal intriguing cultural variations that contribute to the broader understanding of trauma adaptation in different cultural contexts. The dominance of Personal Strength (M = 3.10) followed by Spiritual-Existential Change (M = 2.95) in the PTG findings presents a notable

contrast to Western studies, such as Ryan et al.'s large-scale study of European firefighters that found Relating to Others as the primary growth domain [25].

The Turkish sample showed Relating to Others as the lowest domain (M = 2.57), a finding that aligns with Li et al.'s meta-analysis of PTG patterns across cultures, which emphasized how collectivistic versus individualistic cultural contexts shape growth trajectories [24]. Susanti et al.'s comparative study of Asian first responders similarly found stronger emphasis on personal and spiritual growth domains, supporting the observations in the Turkish context [26].

The relationship between PTSD severity and PTG in the current sample, where only 25% of those with clinical PTSD levels showed high PTG compared to 42.2% in the sub-clinical group, adds nuance to the current understanding of trauma adaptation and supports Bonumwezi et al.'s longitudinal findings that moderate levels of distress were associated with optimal growth outcomes [11]. The resilience findings, showing predominantly normal to low levels (M = 3.45) with 59.3% of high-PTSD participants showing low resilience, reflect an emerging understanding of resilience dynamics in high-risk professions. This pattern aligns with Heydari et al.'s systematic review suggesting that chronic trauma exposure may progressively erode resilience resources, particularly without robust organizational support systems [36]. The complex interactions among these psychological factors in the current sample support theoretical frameworks proposed by Shmeleva et al. and Sehlikoğlu et al., suggesting that PTSD, PTG, and resilience operate in a dynamic equilibrium rather than as independent processes, with cultural factors playing a crucial role in shaping these interactions [28, 39]. These findings underscore the importance of considering cultural context in understanding trauma responses and developing appropriate interventions for emergency service personnel. The patterns of association identified between PTSD symptoms, PTG, and resilience in this sample align with emerging research on the complex interrelationships between these constructs. Recent investigations with Turkish trauma survivors following the 2023 earthquakes have identified similar patterns of concurrent posttraumatic stress and growth, suggesting that these constructs represent related but distinct adaptation processes rather than opposite ends of a single continuum [52]. Our findings of independent contributions from these constructs to safety outcomes, combined with acceptable multicollinearity metrics, support Schubert et al.'s systematic review conclusions that PTSD, PTG, and resilience operate through partially distinct psychological mechanisms despite their conceptual overlap [53]. This distinction is particularly evident in the differential strength of associations between these psychological factors and specific safety parameters, with resilience showing stronger relationships with proactive safety measures while PTSD symptoms more strongly predicted stress-related safety impairments.

The relationship between occupational stress and safety perceptions among firefighters is a complex interplay of various factors, including leadership styles, personal protective equipment management, and the overall safety climate within fire departments. Firefighters face significant occupational stress due to the high-risk nature of their work, which can adversely affect their safety perceptions and behaviors. This relationship is influenced by both individual and organizational factors, which can either mitigate or exacerbate the impact of stress on safety perceptions [54]. The finding of current study that 74.6% of participants reported emotional stress impacting their safety performance, with 53.3% indicating moderate and 19.7% reporting high-level impacts, aligns with recent comprehensive investigations in the field.

These findings parallel Farinha et al.'s large-scale study of 1,200 first responders, which found that 70–80% of personnel reported stress-related impacts on operational performance, with particular emphasis on safety-critical decision-making [1]. The significant disparity we observed between technical safety measures (breathing apparatus maintenance: M = 4.00) and psychological safety factors (comfort in sharing safety concerns: M = 1.66) reflects a broader pattern identified in recent literature. This disparity is further illuminated by Dillard et al.'s findings that while technical safety protocols are often well-established and monitored, psychological safety measures frequently lack similar organizational emphasis and support structures [10]. The notably low ratings for ergonomic working conditions (M = 1.00) and self-assessed safety excellence (M = 1.34) in this study align with recent work by Shin et al., who documented similar patterns in Asian firefighting services and linked these factors to increased operational risk and reduced incident reporting [3]. The cumulative impact of these findings is particularly significant when considered alongside findings from other studies investigating stress-safety relationships in emergency services. For example, research with similar first responder populations has demonstrated that persistent psychological stress not only directly impacts safety behaviors but also creates a feedback loop where safety concerns further amplify stress levels, potentially creating a deteriorating cycle of reduced safety performance [8]. This pattern is especially relevant in the Turkish context, where Çınaroğlu et al.'s recent analysis of emergency service organizational structures identified significant gaps in psychological support systems despite high operational demands [31]. The interplay between stress and safety perceptions in the current findings also supports emerging theoretical frameworks proposed by Serrano-Ibáñez

et al., suggesting that occupational safety in high-risk professions cannot be effectively addressed without concurrent attention to psychological well-being and stress management [2]. These relationships appear particularly pronounced in cultural contexts where organizational hierarchies may inhibit open discussion of psychological challenges, as noted in recent work by Bakirci et al. examining Turkish emergency service cultures [27].

The examination of safety training patterns and occupational accident characteristics in current study reveals multifaceted challenges in the implementation of safety protocols within Turkish firefighting services. While universal participation in safety training (100%) initially suggests organizational commitment to safety protocols, the frequency distribution of training sessions, with 65% receiving only 3–5 sessions over five years, indicates possible systemic inadequacies in continuous professional development. This temporal insufficiency becomes particularly significant when contextualized within recent empirical investigations; Horn et al.'s comprehensive analysis of 2,800 firefighters across multiple jurisdictions demonstrated that optimal safety outcomes correlate with minimum quarterly training interventions, suggesting the observed frequency falls considerably below international benchmarks [29]. The disparity between high safety awareness (92%) and substantial accident rates (38%) in the current sample represents what Righi et al. termed the "implementation-knowledge gap," a phenomenon increasingly recognized in high-risk occupational settings [32]. The predominance of carelessness (72%) and fatigue (65%) as primary accident catalysts aligns with recent findings by Wagner et al., who documented similar causal patterns across emergency service populations, particularly in resource-constrained environments [55].

The examination of safety training patterns and occupational incident characteristics in the current study reveals complex challenges in the implementation of safety protocols within the Turkish fire service. While universal participation in safety training (100%) initially suggests organizational commitment to safety protocols, the frequency distribution of training sessions suggests possible systemic inadequacies in continuing professional development. These temporal shortcomings become particularly significant when placed in the context of recent empirical research; Horn et al.'s comprehensive analysis of 2,800 firefighters across multiple jurisdictions showed that optimal safety outcomes correlated with at least quarterly training sessions, suggesting that the observed frequency falls substantially below international benchmarks [29]. The disparity between high safety awareness (92%) and substantial accident rates (38%) in the current sample represents what Righi et al. termed the "implementation-knowledge gap," a phenomenon increasingly recognized in high-risk occupational settings [32]. The predominance of inattentiveness (72%) and fatigue (65%) as primary accident catalysts is consistent with recent findings by Wagner et al., who documented similar causal patterns in emergency service populations, particularly in resource-constrained settings [55]. This pattern is particularly notable when considered alongside the longitudinal analysis by Shmeleva et al., which found significant correlations between training frequency, psychological resilience, and accident prevention outcomes [39]. The distribution of inspection schedules-monthly (32%), quarterly (28%), and yearly (40%)-further illuminates organizational variances that may influence safety outcomes, particularly when examined through the theoretical framework proposed by Lopez and subsequently validated by Matheson et al., suggesting that inspection frequency directly modulates safety culture development and accident prevention efficacy [56, 57]. These findings are made more relevant when considered in the broader context of emerging research on organizational safety culture in emergency services, particularly the recent work by Sehlikoğlu et al., investigating the intersection of cultural factors, organizational resources, and safety outcomes in Turkish emergency response systems [28].

The complex interplay among psychological adaptation, organizational safety protocols, and operational outcomes observed in this study suggests several critical implications for both theoretical understanding and practical intervention strategies. The current findings regarding the relationship between psychological resilience and safety protocol adherence contribute to an emerging theoretical framework, initially proposed by Heydari et al. and subsequently extended by Dillard et al., suggesting that psychological well-being fundamentally moderates the effectiveness of technical safety training [10, 36]. This theoretical perspective gains additional support from the current observation that participants with higher resilience scores systematically exhibit better safety performance metrics, irrespective of training frequency. These relationships appear particularly pronounced in cultural contexts where organizational hierarchies may influence both the implementation of safety protocols and the reporting of safety concerns, as documented in recent analyses by Bakirci et al. and Çınaroğlu et al. [27, 31]. The cumulative evidence suggests that effective safety interventions must address both technical competencies and psychological resources, particularly in high-stress occupational environments characterized by routine exposure to traumatic incidents.

This research reveals several notable methodological strengths that enhance its contribution to the existing literature on psychological adjustment and occupational safety in emergency services. The multi-site design, which involves five major metropolitan fire departments,

provides a robust geographic distribution that strengthens the generalizability of the findings within the Turkish context. The use of validated psychometric instruments (PCL-5, PTGI-X, and BRS) with demonstrated cross-cultural validity enhances the reliability of the psychological assessments of this study. Furthermore, the comprehensive examination of multiple psychological constructs (PTSD, PTG, and resilience) within a single occupational cohort enables a nuanced analysis of their interactive effects on safety behaviors, addressing a significant gap in the existing literature. Integrating technical safety and mental health metrics offers a balanced, multidimensional perspective on occupational safety, exceeding the scope of traditional single-dimensional methods, while the advanced statistical framework enables a deeper understanding of complex interactions among these variables.

Nevertheless, several methodological limitations warrant careful consideration when interpreting these findings. The cross-sectional design, while efficient for initial pattern identification, precludes definitive causal inference regarding the temporal dynamics between psychological adaptation and safety outcomes. The reliance on self-report measures, despite being an effective method for large-scale data collection, introduces potential common variance and social desirability bias, particularly in cultural contexts where psychological disclosure may be stigmatized. While we utilized the standard four-cluster model of PTSD symptoms following DSM-5 guidelines, recent research by Ahmadi et al. and Boehme et al. has suggested that a 7-factor hybrid model may better capture PTSD symptomatology in first responders [58, 59]. Future research with Turkish firefighters should consider exploring these alternative factor structures to enhance measurement precision in this population. The sample size, while adequate for primary analyses, may limit statistical power to identify subtle interaction effects, particularly in subgroup analyses. Moreover, the exclusion of firefighters with diagnosed psychological disorders, while methodologically sound for controlling confounding variables, may confound the understanding of the full spectrum of psychological adaptation in this population. The limited use of objective safety metrics and incident reports is a further constraint, as self-reported safety behaviors may not fully capture operational reality.

Future research topics arise in the context of methodological considerations and current findings. Longitudinal studies examining the temporal dynamics between psychological adjustment and safety behaviors would greatly enhance the understanding of causal relationships. Such studies should include objective safety metrics and incident reports, in addition to psychological measures, to provide a more robust analysis of behavior-outcome relationships. The development of culturally specific and up-to-date instruments to assess the psychological well-being of Turkish first responders is another important research topic to address the potential limitations of instruments that have been validated primarily in Western contexts. Mixed analytical approaches, including qualitative analysis of firefighters' experiences, could provide deeper insights into the cultural and organizational factors that influence psychological adjustment and safety behaviors. Investigations of organizational-level interventions that target the observed technical-psychological safety gap would be particularly valuable, especially studies that examine the effectiveness of integrated training programs that address both technical competencies and psychological resilience. In addition, comparative studies of different first responder workforces could elucidate occupation-specific patterns of psychological adjustment and their impact on safety outcomes. The examination of potential biological markers of stress and resilience, coupled with psychological measures, represents an innovative direction for future research that may provide more objective measures of adjustment processes. In addition, the role of organizational culture in moderating the relationship between psychological adaptation and safety behaviors warrants detailed examination, particularly considering hierarchical organizational structure determining the characteristic of emergency services.

Conclusions

This research provides substantial findings about the relationship between psychological adaptation and occupational safety among Turkish firefighters. The results of this research indicate that posttraumatic stress symptoms significantly influence safety behaviors, while higher levels of resilience serve as a protective mechanism that is associated with PTG, which manifests in a culturally determined pattern. Specifically, Turkish firefighters show stronger personal and spiritual growth compared to interpersonal development, reflecting cultural patterns in trauma adaptation. The marked disparity between technical safety protocols and psychological safety resources underscores a systemic challenge in emergency services, where reliable equipment maintenance protocols contrast sharply with limited psychological support mechanisms. This technical and psychological gap, combined with widespread reports of stress interfering with safety performance, highlights the need for integrated safety approaches. Overall, these findings advance theoretical understanding of trauma adaptation in high-risk occupations and provide practical implications for the advancement of occupational safety. The evidence supports the development of culturally responsive safety programs that address both technical competencies and psychological resilience, thereby promoting emergency

service operations while protecting the well-being of the workforce.

Abbreviations

PTSD	Posttraumatic stress disorder
PTG	Posttraumatic growth
PCL-5	PTSD Checklist for DSM-5
PTGI-X	Posttraumatic Growth Inventory-Expanded Form
BRS	Brief Resilience Scale

Supplementary Information

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Supplementary Material 1

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Author contributions
A.E.B contributed to collect data. V.S. contributed to coordinated and supervised data collection. A.C. and N.D. contributed to the data analysis. A.E.B, A.C., and N.D. contributed to drafted the initial manuscript, and critically reviewed and revised the manuscript. V.S and A.C. critically reviewed and revised the manuscript. All authors contributed to design the study and provided technical assistance. All authors critically reviewed the manuscript and approved the final version.

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Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declerations

Ethics approval and consent to participate
The study protocol was approved by the ethics review board before starting the study (Social and Humanities Research Ethics Committee of the Istanbul University-Cerrahpasa, Istanbul, Turkey; Approval No: 2023/165 and dated May 02, 2023). In this study, adherence to the ethical principles outlined in the Declaration of Helsinki was stringently upheld, ensuring the protection of participant rights and welfare at every stage of the research process. Informed consent was obtained from all participants prior to their involvement in the study. The online survey provided comprehensive study information and explicit notice of voluntary participation rights. Electronic informed consent was documented through a mandatory 'Consent' button that participants clicked before proceeding. All collected data were anonymized with no identifying information stored, and participants completed the survey without compensation.

Generative AI and AI-assisted technologies in the writing process
During the preparation of this work the authors used Claude, ChatGPT, Scispace, and QuillBot AI in order to perform efficient proofreading, grammar checks, and enhancement of overall readability of the manuscript. After using these tools, the authors reviewed and edited the content as needed and they take full responsibility for the content of the publication.

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Competing interests
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