



Research Paper

A multidimensional view of burnout among air traffic controllers

Arif Tuncal<sup>1</sup>

**Abstract.** Air traffic controllers are considered a critical research group for burnout because they are exposed to working conditions characterized by high risk and intense stress. The aim of the study was to analyze the relationships between the core symptoms and the secondary symptoms of burnout using the multidimensional Burnout Assessment Tool (BAT), and to determine whether burnout, its symptoms, and their subdimensions differed according to demographic variables. Data for the study were collected via an online survey from 355 air traffic controllers employed in various air traffic control units in Türkiye. The findings indicated that overall burnout levels were low; however, moderate levels were observed in the exhaustion dimension. No significant differences in overall burnout were found according to gender and experience, although significant differences were detected in certain subdimensions. It was found via regression analyses that the core symptoms positively and significantly predicted the secondary symptoms. In the multiple regression analysis, exhaustion and emotional impairment were found to significantly predict psychological complaints and psychosomatic complaints.

**Keywords:** Air traffic controller, aviation, burnout, human factor, stress.

Araştırma Makalesi

Hava trafik kontrolörlerinde tükenmişliğe çok boyutlu bir bakış

**Öz.** Hava trafik kontrolörleri yüksek risk ve yoğun stres içeren çalışma koşulları nedeniyle tükenmişlik açısından kritik bir araştırma grubunu oluşturmaktadır. Araştırmanın amacı çok boyutlu olan Tükenmişlik Ölçme Aracı (Burnout Assessment Tool-BAT) kullanarak tükenmişliğin birincil semptomları ile ikincil semptomları arasındaki ilişkileri analiz etmek ve tükenmişlik ile semptomları ve alt boyutlarının demografik değişkenler bağlamında farklılaşp farklılaşmadığını ortaya koymaktır. Çalışmanın verileri Türkiye'deki çeşitli hava trafik kontrol ünitelerinde görev yapan 355 hava trafik kontrolöründen çevrimiçi anket yoluyla elde edilmiştir. Bulgular genel tükenmişlik düzeyinin düşük olduğunu, ancak bitkinlik boyutunda orta düzey tükenmişliğin gözlemlendiğini ortaya koymuştur. Cinsiyet ve tecrübe değişkenlerine göre genel tükenmişlikte anlamlı bir farklılık saptanmamış, ancak alt boyutlarda anlamlı farklılıklar tespit edilmiştir. Regresyon analizleri sonucunda, birincil semptomların ikincil semptomları pozitif ve anlamlı düzeyde yordadığı belirlenmiştir. Çoklu regresyon analizinde ise bitkinlik ve duygu denetim bozukluğu değişkenlerinin psikolojik ve psiko-somatik şikâyetleri anlamlı biçimde yordadığı bulunmuştur.

**Anahtar Kelimeler:** Hava trafik kontrolörü, havacılık, tükenmişlik, insan faktörü, stres.

*1 Department of Aviation Systems and Technologies, International Science and Technology University, Warsaw, Poland; [arif.tuncal@istu.edu.pl](mailto:arif.tuncal@istu.edu.pl)  
<https://doi.org/10.52995/jass.1787975>*

*Received: September 22, 2025; Accepted: February 7, 2026; Published: February 28, 2026*

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## 1. INTRODUCTION

The aviation sector, which is one of the main elements of the global transport network today, enables millions of passengers to travel safely, quickly, and efficiently and is therefore assigned a critical role in sustaining economic, social, and cultural interactions. According to the International Civil Aviation Organization (ICAO), 4.53 billion passengers were carried, and 37.09 million flights were operated in 2024 (ICAO, 2025). Despite all technological advances in aviation, the human factor continues to be placed at the center of ensuring flight safety in these large-scale operations, and it is regarded as an indispensable element in decision-making processes and their implementation. In the international literature, it was reported that approximately 80% of accidents were caused by human factors (Holbrook et al., 2019), which clearly highlights the critical position of the human factor in safety management. Although the total number of accidents, which was 114 in 2019, decreased to 95 in 2024, a 44% increase was recorded compared to 2023 (ICAO, 2025). This picture indicates that, despite technological progress, the human factor continues to be determinant in accidents.

Air traffic controllers represent one of the most critical human components of the aviation system because they are responsible for managing flights at airports and in the airspace. Controllers, who perform under high cognitive demands and responsibilities, are required to demonstrate high levels of attention, memory, and decision-making skills in the face of increasing air traffic and complex operational conditions (Imroz & Sadique, 2022). Air traffic control is considered a risky profession because the actions taken and decisions made by controllers have a high impact on flight safety (Cuadrado et al., 2025). An examination of United States civil aviation accidents between 1985 and 1997 showed that direct errors by controllers accounted for only 5% of commercial aircraft accidents, but controllers were found to be directly or indirectly involved in 55% of accidents attributed to pilot errors (Pape et al., 2001). These findings revealed that even small errors may produce serious consequences in any case. The ever-present and hypothetical threat of making an error therefore, stands out as a strong source of stress for air traffic controllers (Legeron, 2001, as cited in EUROCONTROL, 2004).

At this point, the concept of burnout, which is associated with stress, becomes important. Although burnout was first clinically defined by psychologist Herbert Freudenberger in 1974 (Schaufeli et al., 2009), it was reported to be widespread among air traffic controllers in the United States as early as 1971 (Calabrese, 1971). Burnout is defined as mental fatigue and a loss of meaning in one's profession that develops as a result of long-term work-related stress (Maslach & Jackson, 1981; Schaufeli et al., 2020), and it leads to serious negative outcomes physiologically, psychologically, and professionally (Koçak et al., 2022). High levels of stress among air traffic controllers are attributed to the nature of the profession (Crump et al., 1981; MacLennan & Peebles, 1996), and in a recent study, it was found that 92% of controllers experienced psychological stress at varying degrees (Zhang et al., 2023). Similarly, strong relationships between burnout and stress were emphasized in studies conducted on air traffic controllers by Rose et al. (1978), Makara-Studzińska et al. (2021a), and Tang et al. (2022).

With changes in working life, the increasing use of technology, and developments in positive psychology, burnout has become an important topic in the academic literature and more than 80,000 publications have been produced in this field (Schaufeli et al., 2020). Although measurement instruments such as the Maslach Burnout Inventory, the Oldenburg Burnout Inventory, and the Copenhagen Burnout Inventory have been developed over time, it has been noted as an important limitation that these scales do not fully cover all dimensions of burnout (Koçak et al., 2022). To address this gap, Schaufeli et al. (2020) developed a new instrument (the BAT-Burnout Assessment Tool) that treats burnout through the dimensions of exhaustion, cognitive impairment, emotional impairment, and mental distance. That study also emphasized that burnout symptoms were related at a secondary level to various psychological complaints and psychosomatic complaints (Schaufeli et al., 2020).

Although studies examining burnout among air traffic controllers have been conducted by Dell'Erba et al. (1994), Martinussen and Richardsen (2006), Aguirre Mas et al. (2018), Makara Studzińska et al. (2021a, 2021b), and Tang et al. (2022), the present research aims to reexamine the multidimensional structure of burnout within the framework of contemporary measurement approaches. Previous research in air traffic control has frequently relied on earlier burnout inventories and has often emphasized a limited set of symptoms; the present study adopts the BAT to capture core symptoms and secondary symptoms within a single measurement framework. The study investigates the extent to which core and secondary symptoms and their subdimensions emerge among air traffic controllers, whether these symptom domains differ by gender and professional experience, and how core symptom

domains and their subdimensions relate to secondary symptoms and their subdimensions. Beyond the description of symptom levels, the analysis clarifies which core symptom domains are most closely associated with psychological and psychosomatic complaints, thereby offering a more detailed account of the processes of burnout in air traffic control. Burnout is evaluated through a combination of theoretical (deductive) and empirical (inductive) approaches across cognitive, emotional, and behavioral dimensions. This approach strengthens the conceptual distinction between primary functional depletion and complaint-based manifestations by examining their empirical linkage within a safety critical occupational context. The findings provide an empirical framework regarding burnout levels among air traffic controllers, offer data that may inform stress management, and support the development of policies and organizational practices that strengthen aviation safety. Moreover, the study represents an important step in assessing the applicability of the newly developed scale in high-risk occupations.

## 2. CONCEPTUAL FRAMEWORK

Air traffic controllers are required to prioritize among different tasks, manage their cognitive resources, and continuously evaluate their performance (Loft et al., 2007). High job demands (Sartzetaki et al., 2019), time and task pressure together with shift work (Tomić & Liu, 2017), complexity of job demands (Tattersall et al., 1991), and high responsibility (Costa, 2000) are commonly identified as stressors. Although controllers are trained to cope with these stress factors, prolonged and intense exposure to stressors was found to increase stress over time (Borghini et al., 2020), and this chronic stress may lead to burnout (Tang et al., 2025). High job demands are associated with exhaustion and performance decline, while shift work is associated with disrupted sleep patterns that increase fatigue and mental distance. Time pressure and the constant need to remain vigilant about tasks are linked to emotional difficulties, whereas high responsibility can overload cognitive resources and lead to cognitive impairment. In addition, complex job demands further increase stress and cognitive load (Gemmano et al., 2024). Empirical studies have also supported the link between work-related stressors and burnout. For example, Bakker et al. (2004) found that high job demands and insufficient job resources were significant predictors of burnout. Sonnentag et al. (2012) showed that chronic exposure to high job demands and low job control was associated with higher levels of burnout and work disengagement.

The pioneering qualitative study on burnout in air traffic control was carried out by the Federal Aviation Administration (FAA) in 1973 following a series of aviation accidents attributed to human error (Rose et al., 1978). An increase in the prevalence of hypertension, various psychiatric problems, and burnout was reported as a core finding, and a strong correlation between stress and burnout was observed. In the study conducted by Dell'Erba et al. (1994), the Rome Burnout Inventory was administered to 109 air traffic controllers and burnout was found to be positively associated with experience and stress. Using the Maslach Burnout Inventory, Aguirre Mas et al. (2018) examined relationships among burnout syndrome, job stress, job satisfaction, and work–family conflict in 161 air traffic controllers; a moderate level of burnout was detected among participants. In the study by Martinussen and Richardsen (2006), burnout levels were not found to be high, but burnout was reported to be related to psychosomatic complaints and attitudes toward work. Makara-Studzińska et al. (2021a) studied 107 air traffic controllers to examine the mediating and moderating roles of self-efficacy and psychological well-being in the relationship between perceived stress and burnout; their findings showed that the indirect effect of perceived stress on burnout through self-efficacy was significant and that this relationship varied according to levels of psychological well-being. In another study, Makara-Studzińska et al. (2021b) reported that burnout in air traffic controllers was linked to personal characteristics and that a strong relationship between burnout and stress was observed; burnout levels were found to be higher than those of firefighters but not significantly different from those of psychiatrists. Tang et al. (2022), using the Maslach Burnout Inventory with 457 controllers, found that 83.59% (382 individuals) of the sample experienced burnout.

The concept of burnout has been addressed from multiple perspectives in the literature, and its scope has been expanded theoretically and practically over time. One of the earliest definitions was offered by Freudenberger (1974), who described burnout as a state of depletion in an individual's inner resources caused by unmet demands, failure, wear, and loss of energy and strength. While this view explains burnout as a weakening of internal resources, Maslach et al. (1997) conceptualize it primarily as a work-related syndrome, emphasizing the dimensions of emotional exhaustion, depersonalization, and reduced personal accomplishment. Emotional exhaustion refers to tension and loss of energy due to an excessively demanding workload; depersonalization denotes a detached or indifferent attitude toward work and other people; and reduced personal accomplishment indicates a decline in perceived competence

and success at work (Hakanen et al., 2006). In the same vein, Schaufeli and Greenglass (2001) define burnout as physical, emotional, and mental exhaustion resulting from prolonged exposure to emotionally demanding work conditions.

Burnout has also been conceptualized as a process. This processual view is reflected in Edelwich and Brodsky's (1980) model, which suggests that unmet job expectations, especially among newcomers who face intense demands without adequate coping, increase the long-term risk of burnout. The tendency of highly motivated workers to expend substantial emotional and energetic resources without adequate renewal through coping strategies has been identified as another factor that raises burnout risk (Cummings & Nall, 1983). From this perspective, burnout is not merely an individual psychological state but a phenomenon that develops in relation to job structure and organizational conditions. Indeed, in the Job Demands and Resources model, high job demands that require substantial energy combined with insufficient resources are proposed to lead to the accumulation of occupational stress and the emergence of burnout (Demerouti et al., 2001). Burnout is thus also described as a long-term reaction to occupational stress together with other chronic job stressors (Maslach et al., 1997).

Beyond definitions and models, the consequences of burnout have been widely investigated. Studies indicate that burnout produces serious outcomes at both individual and organizational levels (Consiglio et al., 2021). At the individual level, burnout has been associated with a wide range of health problems, including depression, anxiety, sleep disorders, prolonged fatigue, headaches, gastrointestinal problems, cardiovascular disorders, and reduced life satisfaction (Peterson et al., 2008; Sinalval et al., 2022). At the organizational level, burnout has been linked to absenteeism, employee turnover, reduced performance, lower job satisfaction, and weakened organizational commitment (Buono et al., 2022). Large-scale recent surveys have shown that a substantial proportion of workers experience burnout; for example, in a sample of approximately 7,500 full-time employees, it was found by Wigert and Agrawal (2018) that two-thirds reported experiencing burnout, with 23% reporting it continuously or very often and 44% reporting it occasionally. These observations are consistent with the World Health Organization's decision to classify burnout as an occupational phenomenon (World Health Organization [WHO], 2019).

Various instruments have been developed to measure burnout. Although the Maslach Burnout Inventory, the Oldenburg Burnout Inventory, and the Copenhagen Burnout Inventory have been used for many years, criticisms have been raised that these scales do not capture some dimensions of burnout and possess psychometric limitations (Sakakibara et al., 2020). To address these shortcomings, the BAT was developed by Schaufeli et al. (2020). The BAT integrates theoretical and empirical approaches and treats burnout within an energetic and motivational framework, thereby encompassing both a sense of insufficiency (exhaustion) and unwillingness (withdrawal) (Hadzibajramovic et al., 2020). Within this framework, burnout is defined as a state of exhaustion characterized by extreme tiredness, a reduced capacity to regulate cognitive and emotional processes, and mental distance (Schaufeli et al., 2020). Unlike earlier instruments, the BAT does not define burnout solely by exhaustion and withdrawal but also includes problems in cognitive and emotional regulation.

Burnout is conceptualized on the basis of four core symptoms and three secondary symptoms in the BAT. The first core symptom is exhaustion, which covers both physical fatigue and mental depletion. The second is emotional impairment, which relates to the person's tendency to display excessive emotional reactions. The third is cognitive impairment, which is characterized by difficulties in attention, memory, and concentration. The fourth is mental distance, which indicates a weakening of the individual's psychological connection to work and a tendency toward alienation. Among the secondary symptoms, psychological complaints are represented by sleep disturbances and anxiety, psychosomatic complaints cover psychologically rooted physical problems such as headaches and stomach issues, and depressive complaints are characterized by symptoms such as feeling weak, lacking enjoyment, or feeling guilty; however, this last dimension was not subsequently retained as a separate dimension (Schaufeli et al., 2020). In line with the Job Demands–Resources framework used to examine the effects of job characteristics on motivation and well-being, job demands were observed to be positively related and job resources negatively related to burnout (Demerouti et al., 2001). Cross-national studies have provided substantial evidence supporting the BAT's validity as a measure of burnout (Schaufeli et al., 2020).

Building on the BAT's symptom architecture and the Job Demands–Resources perspective, the core–secondary distinction can be conceptualized as a stress-propagation pathway from primary depletion to downstream distress manifestations. Core symptoms reflect the central erosion of energy and self-regulation under chronic job demands, whereas secondary symptoms capture downstream distress reactions. Exhaustion, in particular, signals

accumulated strain and impaired recovery and is therefore likely to co-occur with sleep disturbance, heightened arousal, and sustained muscle tension, which can translate into psychological complaints (e.g., sleep-related complaints and heightened anxiety symptoms) and psychosomatic complaints (e.g., musculoskeletal pain and stress-related somatic symptoms). Emotional impairment may further strengthen this pathway by increasing affective reactivity and reducing emotion-regulation efficiency. By contrast, cognitive impairment and mental distance may be less directly reflected in secondary complaints in safety-critical contexts, where professional norms and performance requirements can limit the overt expression of disengagement or cognitive lapses. This pathway is also consistent with Conservation of Resources theory (Hobfoll, 1989), which conceptualizes stress as a function of actual or threatened resource loss, insufficient resource gain following investment, or the accumulation of loss cycles over time. Within this framework, air traffic control can be interpreted as a resource-intensive occupation in which sustained vigilance, responsibility, and shift-related disruption require continuous investment of cognitive and emotional resources. When recovery opportunities and supportive resources are inadequate, resource depletion may manifest first as exhaustion and emotion-regulation difficulties; over time, such depletion can spill over into secondary psychological and psychosomatic complaints. Accordingly, integrating Job Demands–Resources and Conservation of Resources provides a theoretically grounded rationale for examining whether core burnout symptoms, particularly exhaustion and emotional impairment, are more proximal predictors of downstream complaints among air traffic controllers.

Relationships between burnout and demographic variables have also been explored. An inverse relationship between age and burnout has generally been observed, although findings are inconsistent (Demerouti et al., 2019). Similarly, results regarding gender differences have been mixed (Purvanova & Muros, 2010). Makara-Studzińska et al. (2022) report that burnout among air traffic controllers varies according to sociodemographic characteristics.

The research questions addressed in the study are structured as follows:

S1. To what extent are overall burnout, the core symptoms of burnout, and the secondary symptoms and their subdimensions observed among air traffic controllers?

S2. Are significant differences observed in overall burnout, the core and secondary symptoms, and their subdimensions with respect to gender and professional experience among air traffic controllers?

S3. Are the secondary symptoms and their subdimensions significantly predicted by the core symptoms and their subdimensions among air traffic controllers?

### 3. METHOD

#### 3.1. Materials

Demographic Information Form: Demographic data, including gender, age, years of experience, air traffic control unit, and educational background, were collected using a demographic information form.

Burnout Assessment Tool (BAT): To measure burnout levels among air traffic controllers, the BAT, developed by Schaufeli et al. (2020) and adapted into Turkish by Koçak et al. (2022) with confirmed validity and reliability, was used. The BAT consists of 33 items rated on a 5-point Likert scale ranging from 1 (Never) to 5 (Always), and it includes no reverse-coded items. The scale assesses burnout across six sub-dimensions under two components. The core symptoms include exhaustion (8 items), mental distance (5 items), cognitive impairment (5 items), and emotional impairment (5 items), while the secondary symptoms consist of psychological complaints (5 items) and psychosomatic complaints (5 items).

#### 3.2. Sample

The sample of the study consists of 355 licensed air traffic controllers working in Türkiye. Convenience sampling was used. The population at the time of the study was 2,020, according to data from the Directorate General of State Airports Authority of Türkiye (DHMI) (DHMI, 2025). Accordingly, the sample covers approximately 17.58% of the population, reflecting a high participation rate. This high participation rate provides a significant advantage in terms of representing air traffic controllers across Türkiye and enhances the generalizability of the study's findings. As a member state of the International Civil Aviation Organization (ICAO), Türkiye licenses and authorizes its air traffic controllers in accordance with Annex 1 of the 1944 Chicago Convention on personnel licensing. Therefore, considering these requirements and the international scope of the work, the generalizability of the study is significantly supported not only nationally but also internationally.

### 3.3. Data Analysis

The data were analyzed using IBM SPSS (Statistical Package for the Social Sciences) v27. First, as part of descriptive statistics, mean and standard deviation values for the variables were calculated. Factor analyses were conducted to examine the structural validity of the measurement instrument, and a reliability test (Cronbach’s Alpha) is applied to determine internal consistency. Normality tests were performed to evaluate the distributional properties of the data, and correlation analyses were carried out to examine relationships among variables. Regression analyses were employed to test the predictive effects between variables. Moreover, the prerequisites for linear regression were evaluated and found to be satisfied. For the Likert scale used in the study, the following interpretation ranges were adopted: 1.00–1.80 “very low” (= never), 1.81–2.60 “low” (= rarely), 2.61–3.40 “moderate” (= sometimes), 3.41–4.20 “high” (= often), and 4.21–5.00 “very high” (= always).

### 3.4. Ethical Approval

This study involving human participants was reviewed and approved by the Ethics Committee of the International Science and Technology University in its meeting dated April 24, 2025, and numbered 202504-01. All participants provided informed consent before taking part in the study.

## 4. FINDINGS

The demographic data for the 355 air traffic controllers included in the study are presented in Table 1. Of the participants, 66.5% were male and 33.5% were female. According to ATC unit distribution, 56.1% were assigned to aerodrome tower control (TWR), 21.4% to approach control unit (APP), and 22.5% to the area control center (ACC). With respect to professional experience, the sample exhibited a balanced distribution: 22.5% had less than 6 years, 22.3% had 6–10 years, 23.4% had 11–15 years, 13.2% had 16–20 years, and 18.6% had over 20 years of experience. In terms of education level, 82.3% held a bachelor’s degree and 17.7% held a graduate degree. The mean age of participants was 37.52 years (SD = 8.088), indicating a wide age range.

**Table 1.** Demographic Variables

		N	%
Gender	Female	119	33.5
	Male	236	66.5
ATC unit	TWR	199	56.1
	APP	76	21.4
	ACC	80	22.5
Experience (year)	< 6	80	22.5
	6- 10	79	22.3
	11- 15	83	23.4
	16- 20	47	13.2
	> 20	66	18.6
Education background	Bachelor’s degree	292	82.3
	Graduate degree	63	17.7
Total		355	100.0

Means, standard deviations, skewness, kurtosis, and internal consistency coefficients for burnout, its symptoms, and their subdimensions are presented in Table 2. Among the core symptoms, the exhaustion dimension exhibited the highest level of burnout among air traffic controllers (M = 2.8514, SD = 0.80189). Mental distance (M = 2.0011, SD = 0.80997), emotional impairment (M = 1.8423, SD = 0.75862), and cognitive impairment (M = 1.7121, SD = 0.63739) were observed at lower levels. For the secondary symptoms, the mean of psychological complaints was found to be low (M = 2.5307, SD = 0.85373), while psychosomatic complaints were observed at a relatively lower level (M = 2.2490, SD = 0.81008). The mean for the core symptoms was 2.1995 (SD = 0.62357) and for the secondary symptoms was 2.3899 (SD = 0.76314). The overall mean across all dimensions indicated a low level of

burnout ( $M = 2.2572$ ,  $SD = 0.62391$ ). Skewness and kurtosis values for all variables fell within the  $\pm 1.5$  range, which suggested that the data were approximately normally distributed and appropriate for parametric tests (Tabachnick & Fidell, 2021). Cronbach's alpha coefficients for the core symptom subscales ranged from .818 to .898, indicating high reliability. Reliability coefficients for psychological complaints (.829) and psychosomatic complaints (.786) were at acceptable levels (Mallery & George, 2005). Very high internal consistency was observed for overall burnout (.949), core symptoms (.936), and secondary symptoms (.878).

**Table 2.** Means, Standard Deviations, Skewness, Kurtosis, and Cronbach's Alpha Values for Burnout and Subdimensions

	Mean	Sd.	Skewness	Kurtosis	Cronbach's Alpha
Exhaustion	2.8514	.80189	.068	-.696	0.898
Mental distance	2.0011	.80997	.998	.723	0.818
Cognitive impairment	1.7121	.63739	.895	.845	0.881
Emotional impairment	1.8423	.75862	1.168	1.324	0.893
Psychological complaints	2.5307	.85373	.575	-.023	0.829
Psychosomatic complaints	2.2490	.81008	.487	-.319	0.786
Core symptoms	2.1995	.62357	.565	.019	0.936
Secondary symptoms	2.3899	.76314	.540	-.136	0.878
BAT	2.2572	.62391	.521	.055	0.949

KMO and Bartlett test results for the BAT scale are presented in Table 3. The KMO value was 0.945 and was considered acceptable. Bartlett's Test of Sphericity was significant,  $\chi^2(528) = 7115.536$ ,  $p < .001$  (Leech et al., 2013). The total explained variance was calculated as 64.336%. This value exceeded the accepted threshold of 50% and was interpreted as indicating that the scale's explanatory power was adequate (Gürbüz & Şahin, 2014).

**Table 3.** KMO and Bartlett Values for the BAT Scale

KMO and Bartlett's Test	
<b>Kaiser-Meyer-Olkin Measure of Sampling Adequacy</b>	.945
<b>Bartlett's Test of Sphericity</b>	Approx. Chi-Square
	Sd.
	p
	7115.536
	528
	.000

Results of the exploratory factor analysis conducted on the BAT scale are presented in Table 4. The findings indicated that a six-factor structure, similar to the original form of the scale, was obtained. Factor loadings for the exhaustion dimension of the core symptoms ranged from 0.519 to 0.764. Factor loadings for the mental distance dimension ranged from 0.545 to 0.795. Factor loadings for the cognitive impairment dimension ranged from 0.631 to 0.776. Factor loadings for the emotional impairment dimension ranged from 0.670 to 0.797. Factor loadings for the psychological complaints dimension, corresponding to the secondary symptoms, ranged from 0.399 to 0.812. Factor loadings for the psychosomatic complaints dimension ranged from 0.429 to 0.711. All item factor loadings were found to be above the acceptable threshold of 0.32 (Tabachnick & Fidell, 2021).

**Table 4.** Distribution of BAT Items Across Factors

	Exhaustion	Mental distance	Cognitive impairment	Emotional impairment	Psychological complaints	Psychosomatic complaints
Item 4	.764					
Item 8	.762					
Item 3	.743					

Item 1	.721
Item 7	.648
Item 2	.606
Item 6	.581
Item 5	.519
Item 12	.795
Item 11	.782
Item 9	.722
Item 13	.568
Item 10	.545
Item 18	.776
Item 15	.735
Item 16	.731
Item 14	.653
Item 17	.631
Item 21	.797
Item 22	.775
Item 20	.734
Item 23	.687
Item 19	.670
Item 25	.812
Item 27	.769
Item 26	.693
Item 24	.416
Item 28	.399
Item 33	.711
Item 31	.665
Item 32	.659
Item 30	.503
Item 29	.429

Differences by gender in burnout symptoms and their subdimensions are presented in Table 5. Female participants were found to have significantly higher mean scores than male participants on several dimensions. The mean score for exhaustion for females (M = 2.9706) was significantly higher than the mean for males (M = 2.7913) ( $p < .05$ ). The mean for psychological complaints for females (M = 2.7126) was significantly higher than the mean for males (M = 2.4390) ( $p < .05$ ). Similarly, the mean for psychosomatic complaints for females (M = 2.4571) was significantly greater than the mean for males (M = 2.1441) ( $p < .05$ ). Moreover, the mean score for secondary symptoms was significantly higher for females (M = 2.5849) than for males (M = 2.2915) ( $p < .05$ ). These results indicate that female air traffic controllers are placed at greater risk, especially with respect to secondary symptoms of burnout.

**Table 5.** Differences in Burnout, Its Symptoms, and Symptom Subdimensions by Gender

	Gender	N	Mean	Sd.	Se.	t	df	p
Exhaustion	Female	119	2.9706	.76688	.07030	1.997	353	.047*

	Male	236	2.7913	.81395	.05298			
Mental distance	Female	119	1.9143	.66464	.06093	-1.569	298.777	.118
	Male	236	2.0449	.87218	.05677			
Cognitive impairment	Female	119	1.6605	.53142	.04872	-1.176	294.421	.241
	Male	236	1.7381	.68422	.04454			
Emotional impairment	Female	119	1.8958	.80374	.07368	.944	353	.346
	Male	236	1.8153	.73509	.04785			
Psychological complaints	Female	119	2.7126	.90895	.08332	2.880	353	.004*
	Male	236	2.4390	.81110	.05280			
Psychosomatic complaints	Female	119	2.4571	.78854	.07229	3.491	353	.001*
	Male	236	2.1441	.80208	.05221			
Core symptoms	Female	119	2.2225	.56996	.05225	.493	353	.622
	Male	236	2.1879	.64978	.04230			
Secondary symptoms	Female	119	2.5849	.76586	.07021	3.472	353	.001*
	Male	236	2.2915	.74418	.04844			
BAT	Female	119	2.3323	.59253	.05432	1.615	353	.107
	Male	236	2.2193	.63701	.04147			

\* p < .05

Differences by years of experience in burnout symptoms and their subdimensions are presented in Table 6. Analysis results showed that significant differences were found among experience groups for some subdimensions. For the mental distance dimension, the mean of the group with less than 6 years of experience (M = 1.7450) was significantly lower than the mean of the 16 to 20 years of experience group (M = 2.1787) (F = 3.197, p < .05). For the emotional impairment dimension, the mean of the 6 to 10 years of experience group (M = 1.7038) was significantly lower than that of the group with over 20 years of experience (M = 2.0939) (F = 2.958, p < .05). In the psychosomatic complaints dimension, the mean of the group with less than 6 years of experience (M = 2.0275) was significantly lower than that of the group with over 20 years of experience (M = 2.4333) (F = 3.232, p < .05). Although not all subdimensions reached statistical significance, examination of the means indicated that burnout levels were observed to increase as years of experience increased. When age at career entry was taken into account for air traffic controllers, years of experience was also associated with age. This finding suggests that burnout symptoms increase with advancing age.

**Table 6.** Differences in Burnout, Its Symptoms, and Symptom Subdimensions by Years of Experience

		N	Mean	Sd.	Se.	F	p	Dif.
Exhaustion	< 6	80	2.8125	.75184	.08406	.677	.608	
	6- 10	79	2.9699	.83858	.09435			
	11- 15	83	2.7726	.84445	.09269			
	16- 20	47	2.8537	.68481	.09989			
	> 20	66	2.8542	.84426	.10392			
Mental distance	< 6	80	1.7450	.74083	.08283	3.197	.013*	“< 6” < “16-20”
	6- 10	79	2.0937	.83748	.09422			
	11- 15	83	1.9759	.72543	.07963			
	16- 20	47	2.1787	.81639	.11908			
	> 20	66	2.1061	.89595	.11028			
	< 6	80	1.6425	.67632	.07562	1.790	.130	

Cognitive impairment	6- 10	79	1.6380	.59921	.06742			
	11- 15	83	1.6771	.59496	.06531			
	16- 20	47	1.8809	.60096	.08766			
	> 20	66	1.8091	.69232	.08522			
Emotional impairment	< 6	80	1.8100	.71858	.08034	2.958	.020*	“6- 10” < “>20”
	6- 10	79	1.7038	.69198	.07785			
	11- 15	83	1.7590	.65649	.07206			
	16- 20	47	1.9234	.79296	.11567			
	> 20	66	2.0939	.91700	.11287			
Psychological complaints	< 6	80	2.4825	.82597	.09235	1.001	.407	
	6- 10	79	2.6405	.84512	.09508			
	11- 15	83	2.4000	.83928	.09212			
	16- 20	47	2.5617	.76742	.11194			
	> 20	66	2.6000	.96588	.11889			
Psychosomatic complaints	< 6	80	2.0275	.75019	.08387	3.232	.013*	“< 6” < “>20”
	6- 10	79	2.3468	.78819	.08868			
	11- 15	83	2.1566	.76703	.08419			
	16- 20	47	2.3660	.77383	.11287			
	> 20	66	2.4333	.92259	.11356			
Core symptoms	< 6	80	2.1082	.56718	.06341	1.315	.264	
	6- 10	79	2.2146	.61987	.06974			
	11- 15	83	2.1409	.57326	.06292			
	16- 20	47	2.2932	.62301	.09087			
	> 20	66	2.2991	.73823	.09087			
Secondary symptoms	< 6	80	2.2550	.71722	.08019	2.022	.091	
	6- 10	79	2.4937	.73176	.08233			
	11- 15	83	2.2783	.73717	.08092			
	16- 20	47	2.4638	.71973	.10498			
	> 20	66	2.5167	.88328	.10872			
BAT	< 6	80	2.1527	.56467	.06313	1.686	.153	
	6- 10	79	2.2992	.60566	.06814			
	11- 15	83	2.1825	.58327	.06402			
	16- 20	47	2.3449	.60459	.08819			
	> 20	66	2.3650	.75121	.09247			

\*p < .05

To assess the effect of core symptoms on secondary symptoms, an analysis is conducted. A positive, strong, and significant correlation was found between the two variables ( $r = 0.731$ ;  $p < .01$ ). This result suggested that increases in core symptoms may produce a significant effect on secondary symptoms. According to the regression analysis presented in Table 7, the core symptoms variable was found to explain a significant portion of the variance in secondary symptoms ( $R^2 = 0.534$ ;  $F = 404.630$ ). Examination of the regression coefficients indicated that core symptoms were a significant and strong predictor of secondary symptoms ( $\beta = 0.731$ ;  $p < .001$ ).

**Table 7.** Regression Analysis between Core Symptoms and Secondary Symptoms

Model	Unstandardized Coefficients		Standardized Coefficients	t	p
	b	se	$\beta$		
(Constant)	.423	.102		20.115	.000
Core symptoms	.894	.044	.731		

Dependent Variable: Secondary symptoms

$R^2 = 0.534$ ;  $F = 404.630$ .

Correlation analysis results between psychological complaints, the first subdimension of secondary symptoms, and the subdimensions of core symptoms are presented in Table 8. Multiple regression results are presented in Table 9. It was determined that the requirement of no multicollinearity among the independent variables was satisfied (multicollinearity;  $r > 0.80$ ). Additionally, correlations among the variables exceeded  $r > 0.30$  and were significant ( $p < .05$ ). A multiple linear regression analysis was conducted to evaluate predictors of psychological complaints using the four subdimensions of core symptoms: exhaustion, mental distance, cognitive impairment, and emotional impairment. The model was found to be significant and the explained variance was high, with approximately 50% of the variance in psychological complaints being accounted for ( $R^2 = 0.500$ ). According to the regression coefficients, exhaustion was the strongest and a significant predictor of psychological complaints ( $\beta = 0.440$ ;  $t = 8.971$ ;  $p < .001$ ). Emotional impairment also significantly predicted psychological complaints and made a meaningful contribution to the model ( $\beta = 0.275$ ;  $t = 5.428$ ;  $p < .001$ ). By contrast, mental distance ( $\beta = 0.030$ ;  $p = 0.568$ ) and cognitive impairment ( $\beta = 0.088$ ;  $p = 0.105$ ) were not statistically significant predictors of psychological complaints.

**Table 8.** Correlations between Psychological Complaints and the Subdimensions of Core Symptoms

	PC	EX	MD	CI	EI
Psychological complaints (PC)	1	.645*	.482*	.512*	.570*
Exhaustion (EX)		1	.572*	.534*	.511*
Mental distance (MD)			1	.616*	.530*
Cognitive impairment (CI)				1	.619*
Emotional impairment (EI)					1

\* $p < .05$

**Table 9.** Multiple Linear Regression Analysis for Psychological Complaints and the Subdimensions of Core Symptoms

	$\beta$	t	p
Exhaustion	.440	8.971	.000*
Mental distance	.030	.572	.568
Cognitive impairment	.088	1.624	.105
Emotional impairment	.275	5.428	.000*
$R^2$	.500		
Adjust $R^2$	.494		

Dependent Variable:  
Psychological complaints

\* $p < .05$

Correlation analysis results between psychosomatic complaints, the second subdimension of secondary symptoms, and the subdimensions of core symptoms are presented in Table 10. Multiple regression results are presented in Table 11. The absence of multicollinearity among the independent variables was confirmed. Correlations among the variables exceeded  $r > .30$  and were significant ( $p < .05$ ). A multiple linear regression analysis was performed to identify predictors of psychosomatic complaints from the core symptoms subdimensions: exhaustion,

mental distance, cognitive impairment, and emotional impairment. The model was found to be significant and explained a moderate proportion of variance in psychosomatic complaints ( $R^2 = 0.440$ ). Regression coefficients indicated that exhaustion ( $\beta = 0.429$ ;  $t = 8.259$ ;  $p < .001$ ) and emotional impairment ( $\beta = 0.204$ ;  $t = 3.803$ ;  $p < .001$ ) were significant predictors of psychosomatic complaints. By contrast, mental distance ( $\beta = 0.068$ ;  $p = 0.218$ ) and cognitive impairment ( $\beta = 0.083$ ;  $p = 0.147$ ) were not statistically significant predictors.

**Table 10.** Correlations between Psychosomatic Complaints and the Subdimensions of Core Symptoms

	PSC	EX	MD	CI	EI
Psychosomatic complaints (PSC)	1	.616*	.473*	.480*	.511*
Exhaustion (EX)		1	.572*	.534*	.511*
Mental distance (MD)			1	.616*	.530*
Cognitive impairment (CI)				1	.619*
Emotional impairment (EI)					1

\* $p < .05$

**Table 11.** Multiple Linear Regression Analysis for Psychosomatic Complaints and the Subdimensions of Core Symptoms

	$\beta$	t	p
Exhaustion	.429	8.259	.000*
Mental distance	.068	1.235	.218
Cognitive impairment	.083	1.454	.147
Emotional impairment	.204	3.803	.000*
$R^2$	.440		
Adjust $R^2$	.434		
Dependent Variable: Psychosomatic complaints			

\* $p < .05$

Item means for the exhaustion subdimension were generally at a moderate level and were indicative of a general experience of burnout. Particularly, the items "*At the end of my working day, I feel mentally exhausted and drained.*" ( $M = 3.35$ ,  $SD = 1.215$ ) and "*After a day at work, I find it hard to recover my energy.*" ( $M = 3.34$ ,  $SD = 1.088$ ) were observed to reflect pronounced mental and physical fatigue at the end of the workday. The items "*Everything I do at work requires a great deal of effort.*" ( $M = 3.09$ ,  $SD = 0.998$ ), "*At work, I feel physically exhausted.*" ( $M = 2.94$ ,  $SD = 0.995$ ) and "*At work, I feel mentally exhausted.*" ( $M = 2.88$ ,  $SD = 0.905$ ) were found to indicate substantial effort demands and fatigue across both mental and physical domains. By contrast, the items "*When I exert myself at work, I quickly get tired.*" ( $M = 2.59$ ,  $SD = 1.154$ ), "*I want to be active at work, but somehow, I am unable to manage.*" ( $M = 2.39$ ,  $SD = 1.068$ ) and "*When I get up in the morning, I lack the energy to start a new day at work.*" ( $M = 2.25$ ,  $SD = 0.945$ ) were observed at lower levels, suggesting that some aspects of exhaustion were experienced to a lesser degree. Relatively high standard deviations across items ranging from 2.25 to 3.35 were noted, indicating variability in exhaustion levels among participants.

Item means for the mental distance subdimension were low. The items "*At work, I do not think much about what I am doing and I function on autopilot.*" ( $M = 2.30$ ,  $SD = 1.023$ ), "*I am cynical about what my work means to others.*" ( $M = 2.20$ ,  $SD = 1.286$ ), "*I struggle to find any enthusiasm for my work.*" ( $M = 2.15$ ,  $SD = 1.092$ ) and "*I feel a strong aversion towards my job.*" ( $M = 1.83$ ,  $SD = 1.005$ ) were observed to suggest that mental distance was not widespread among air traffic controllers.

Item means for the cognitive impairment subdimension were very low. The items "*At work, I have trouble staying focused.*" ( $M = 1.77$ ,  $SD = 0.804$ ), "*When I am working, I have trouble concentrating.*" ( $M = 1.77$ ,  $SD = 0.742$ ) and "*I am forgetful and distracted at work.*" ( $M = 1.71$ ,  $SD = 0.779$ ) were found to indicate that cognitive skills were largely preserved among the participants. Low standard deviations were observed, indicating that this preservation was experienced relatively homogeneously across respondents.

Means for the emotional impairment subdimension were also low. Notable items included "*During my work I become irritable when things do not go my way.*" (M = 2.41, SD = 1.076) and "*At work I may overreact unintentionally.*" (M = 1.81, SD = 0.933).

Within the psychological complaints subdimension, the items "*I have trouble falling or staying asleep.*" (M = 3.14, SD = 1.175) and "*Noise and crowds disturb me.*" (M = 2.98, SD = 1.198) were prominent. These items were rated at a moderate level, which was interpreted as indicating that a substantial proportion of air traffic controllers experience stress-related psychological complaints. The items "*I feel tense and stressed.*" (M = 2.47, SD = 1.053) and "*I tend to worry.*" (M = 2.43, SD = 1.136) supported this interpretation.

Finally, within the psychosomatic complaints subdimension, the item "*I suffer from muscle pain, for example in the neck, shoulder or back.*" (M = 3.07, SD = 1.271) was notable. These symptoms were taken to suggest that chronic stress may lead to physical tension and pain. Additional items such as "*I suffer from headaches.*" (M = 2.54, SD = 1.102), "*I suffer from stomach or intestinal complaints.*" (M = 2.10, SD = 1.265) and "*I often get sick.*" (M = 2.07, SD = 0.983) were observed, indicating a variety of psychosomatic symptoms.

## 5. DISCUSSION

A low level of burnout was observed among air traffic controllers in the study. This finding was paralleled by the results reported by Aguirre Mas et al. (2018), who identified moderate burnout, and by Martinussen and Richardsen (2006), who did not find elevated burnout levels among air traffic controllers relative to other occupational groups. Similar results were also noted among pilots exposed to comparable workload and stress factors. Moderate burnout was reported in studies on pilots (Alghamdi & Alghamdi, 2023; Fanjoy et al., 2010), which suggests that the findings are closely aligned across aviation occupations. The literature generally indicates that flow experience is negatively associated with burnout symptoms and thus functions as a protective and buffering factor against those symptoms (Aust et al., 2022). Csikszentmihalyi (1990) described flow experience as the intrinsic satisfaction that emerges when skills and challenges are balanced, producing intense focus, a sense of control, and a loss of time awareness. The nature of air traffic control, which requires high responsibility, sustained attention, and rapid decision-making, can be accounted for by flow experience and may lead to high job satisfaction (Tuncal, 2024). Although the inherent stress of the occupation tends to increase burnout among controllers (Wu et al., 2020), high job satisfaction is associated with lower burnout (Kalliath & Morris, 2002), which supports the present finding.

Among the core symptoms, exhaustion was found to be relatively higher than the other factors. This pattern indicates that controllers perform prolonged work under heavy workload due to long sustained attention demands (Sayeed & Kumar, 2010), high responsibility, complex task demands (Socha et al., 2020), and increased airspace density, and that both physical and mental exhaustion levels are elevated as a result. Indeed, several studies have reported high mental workload in air traffic control (Balta et al., 2024; Ibáñez-Gijón et al., 2023; Martin et al., 2011; Seftiyana, 2021; Triyanti et al., 2020). Although the cognitive impact of task demands on controllers is moderated by their workload regulation strategies (Loft et al., 2007), fatigue and mental state are recognized as among the most critical human factors affecting performance (Lyu et al., 2019). Training, increased staffing, and effective scheduling are emphasized as primary measures for reducing mental workload (Boag, 2002). Given its recognized role as a key source of stress (Tomić & Liu, 2017), fatigue has attracted growing attention in the recent aviation literature (Çeken, 2025); moreover, night shifts are reported to amplify fatigue by disrupting circadian rhythms (Peukert et al., 2025).

Relatively low scores on the emotional impairment, cognitive impairment, and mental distance dimensions suggest high occupational motivation, perceived job value, and professional competence among air traffic controllers. Previous studies have similarly reported high intrinsic satisfaction among controllers (Tuncal, 2024) and greater motivation and commitment to work compared with other occupational groups (Irving et al., 1997). Controllers are able to maintain strong work commitment even under heavy cognitive load, which provides a critical advantage for both individual satisfaction and aviation safety and sustainability.

The higher level of secondary symptoms compared with core symptoms and the elevated means for psychological complaints and psychosomatic complaints point to long-term occupational stress among controllers as well as problems related to sleep disturbances and ergonomic conditions. Research has shown that 92% of controllers experience psychological stress at various levels and that stress levels increase with age and years of service (Zhang et al., 2023). Earlier studies have also reported that more than half of controllers have at least one psychological complaint (David et al., 2024). From an ergonomic perspective, controllers frequently report musculoskeletal

disorders in the neck, shoulder, and upper back regions (Arvidsson et al., 2006; Raheimi et al., 2023). Sleep disorders are common among controllers working shifts, and daytime sleep occurrence was found at a rate of 28.6% (Jeon & Kim, 2024). This condition is linked to circadian rhythm disruption caused by shift work (Némethové et al., 2020; Sonati et al., 2016; Triyanti et al., 2020; Zużewicz et al., 2000). Thus, the current findings are supported by the existing literature on air traffic controllers.

No significant difference was found in overall burnout levels by gender. Analysis of subdimensions, however, revealed significant gender differences for the core symptom exhaustion and for secondary symptoms, with higher means observed for women than for men. Prior research indicates that women report higher levels of fatigue compared with men (Golmohamadi & Graham, 2025; Stosic et al., 2024), report higher stress levels, and commonly display exhaustion symptoms within high burnout syndrome (Wiegner et al., 2015). Female controllers have also been reported to present more musculoskeletal complaints than male counterparts (Arvidsson et al., 2006). Other studies have similarly identified more intense symptom patterns among women (Grasshoff et al., 2025; Karlqvist et al., 2002).

Contrary to Dell'Erba et al. (1994), no significant difference in overall burnout was detected by years of experience. However, in the mental distance dimension, controllers with less than six years of experience exhibited lower psychological detachment from work compared with those who have 16 to 20 years of experience. This group also presented the lowest level of mental distance. The pattern can be explained by newcomers having high job satisfaction and motivation, by organizational commitment peaking after joining the institution, and by gradual decline over time (Boswell et al., 2009). In the emotional impairment dimension, controllers with six to ten years of experience scored significantly lower than those with twenty or more years. This result suggests that mid-career controllers experience less emotional strain compared to their senior counterparts, implying that prolonged exposure to occupational stressors may lead to accumulated emotional weariness among long-serving personnel. In the psychosomatic complaints dimension, a notable difference was found between controllers with less than six years of experience and those with twenty or more years; somatic complaints were significantly higher among the more experienced controllers. This pattern can be attributed to the increased frequency of pain complaints with aging (Cassou et al., 2002; Hodgetts et al., 2021), increased fatigue among controllers (Philippe et al., 2025), rising stress with longer service (Zhang et al., 2023), and health problems caused by prolonged shift work (Costa, 2000).

Regression analyses revealed a strong relationship between core symptoms and secondary symptoms of burnout. In the first model, core symptoms were found to significantly predict secondary symptoms and to explain 53% of the variance. This finding indicates that primary dimensions of burnout are directly reflected in psychological and psychosomatic manifestations, producing results similar to those reported by Martinussen and Richardsen (2006) in their study of air traffic controllers. Analyses at the subdimension level indicated that exhaustion in particular strongly predicted both psychological complaints and psychosomatic complaints. The central role of exhaustion suggests that the most visible aspect of burnout among controllers appears as loss of energy, feelings of depletion, and physical and mental tiredness that persist even after work. Emotional impairment also emerged as a significant predictor of both psychological complaints and psychosomatic complaints. This result implies that controllers experience difficulty regulating emotions under high workload and stress, which is expressed as both mental distress and physical complaints. Evidence linking emotional disturbances with psychological distress has also been provided in the literature (Gökdağ, 2023). By contrast, cognitive impairment and mental distance were not identified as significant predictors in the regression models. The absence of significant predictive effects for mental distance and cognitive impairment may be explained by the nature of the occupation, which is characterized by strong duty awareness, discipline, and adherence to routines. Even when mental detachment or cognitive strain occurs, the obligation to perform tasks without error may limit the outward expression of these effects. Therefore, more direct and less controllable factors such as emotional responses and loss of physical and mental energy may become stronger predictors of complaints.

Burnout is negatively associated with job performance (Corbeau et al., 2023) and is closely linked to increasing job complexity (Samra, 2018). Complexity in air traffic control is a primary determinant of controller workload (Majumdar & Ochieng, 2007) and has a direct effect on performance (Edwards & Martin, 2017). Thus, the development of technological systems that balance workload is critically important. In recent years, artificial intelligence-based decision support systems have been emphasized in this context. Artificial intelligence can contribute to performance by reducing workload through optimization of flight routes, early detection of potential

conflicts, and acceleration of decision-making, thereby lowering burnout risk (European Union Aviation Safety Agency [EASA], 2023).

Research has documented a strong relationship between burnout and perceived stress among controllers (Rose et al., 1978). Individual characteristics, however, shape this relationship; high self-efficacy and psychological well-being can attenuate adverse effects (Makara-Studzińska et al., 2021a). Major stressors encountered by controllers include task demands, decision-making processes, work methods and environment, organizational procedures, and critical events (International Federation of Air Traffic Controllers Associations [IFATCA], 1997). Critical event stress and associated traumatic effects are especially notable. Critical event stress refers to the emotional, cognitive, and behavioral responses experienced by controllers after serious incidents. Following events at Newark Airport on April 28, 2025, controllers exposed to critical incidents were reportedly placed on trauma leave (Frau, 2025). Adoption of similar measures internationally could help reduce burnout risk among controllers who operate under high stress due to occupational demands. Critical Incident Stress Management (CISM) programs offer holistic strategies that support recovery after intense stress (EUROCONTROL, 2004). Systematic implementation of such programs can serve as an important institutional support mechanism for preventing burnout among controllers exposed to critical events.

Another study found that burnout among controllers was negatively associated with family and friend support (Dell'Erba et al., 1994). This finding suggests that interventions should focus not only on improving work conditions but also on strengthening peer support and social support mechanisms. Peer support is defined as a supportive relationship among people (Forchuk et al., 2016) and is an effective method for combating burnout (McCall, 2023).

## **6. CONCLUSION**

Burnout levels and their subdimensions among air traffic controllers were examined to identify possible effects of occupational stress and workload. Low overall burnout was found, while exhaustion was observed as the most prominent core symptom. Elevated secondary symptoms were also observed and were interpreted as being related to long-term stressors inherent to the occupation, sleep disturbances, and ergonomic conditions. It was further observed that air traffic control constitutes an occupation that is prone to burnout.

Several limitations are acknowledged. Although a measurement instrument with established validity and reliability across multiple countries including Türkiye was used, burnout was addressed only through its subdimensions and relationships between burnout and other variables were excluded. This limitation narrows the ability to understand the emergence dynamics of burnout within a broader framework. Data were collected using a cross-sectional design, which precluded assessment of temporal changes or causal relations. In addition, data were obtained via self-report scales and may have been affected by subjectivity in personal perceptions.

Based on these limitations, several directions for future research are proposed. Burnout should not be restricted to subdimensions but should be examined multidimensionally together with job satisfaction, self-efficacy, social support, and organizational factors. Longitudinal designs should be employed to investigate the temporal trajectory and causal relations of burnout, and objective performance indicators or biophysiological measures should be incorporated alongside self-report instruments. Comparative research across different organizations and cultural contexts should be conducted to enhance generalizability and to provide a more comprehensive explanation of burnout processes among air traffic controllers.

## **ETHICAL STATEMENT & GENERAL STATEMENTS**

This study involving human participants was reviewed and approved by the Ethics Committee of the International Science and Technology University in its meeting dated April 24, 2025, and numbered 202504-01. All participants provided informed consent before taking part in the study. This paper meets the standards of research and publication ethics. The study was derived from an abstract presentation delivered at the 7th International Aviation Management Conference (INTAVIC' 25).

## **AUTHORS' CONTRIBUTIONS**

The author has read and approved the final manuscript.

## **FUNDING**

Not applicable.

## AVAILABILITY OF DATA AND MATERIALS

Not applicable.

## COMPETING INTERESTS

The author declares that there are no competing interests.

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