THE IMPACT OF RE-INTERPRETED CREW RESOURCE MANAGEMENT (CRM) COMPONENTS ON COMMERCIAL AIRLINE PILOTS' UNSAFE ACTS: EXPLORING THE MEDIATING OR MODERATING ROLES OF SAFETY CLIMATE, FATIGUE, AND PERSONALITY

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submitted by **GİZEM SERİN ATIŞ** in partial fulfillment of the requirements for the degree of **Doctor of Philosophy in Psychology, the Graduate School of Social Sciences of Middle East Technical University** by,

Prof. Dr. Sadettin KİRAZCI
Dean
Graduate School of Social Sciences

Prof. Dr. Bengi ÖNER-ÖZKAN
Head of Department
Department of

Prof. Dr. Bahar ÖZ
Supervisor
Department of Psychology

Examining Committee Members:

Prof. Dr. Tülin GENÇÖZ (Head of the Examining Committee)
Middle East Technical University
Department of Psychology

Prof. Dr. Bahar ÖZ (Supervisor)
Middle East Technical University
Department of Psychology

Prof. Dr. Türker ÖZKAN
Middle East Technical University
Department of Psychology

Assist. Prof. Dr. Didem KADIHASANOĞLU
TOBB University of Economics and Technology
Department of Psychology

Assist. Prof. Dr. Derya AZIK ÖZKAN
Turkish National Police Academy
Department of Psychology

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name: Gizem SERİN ATIŞ

Signature:

ABSTRACT

THE IMPACT OF RE-INTERPRETED CREW RESOURCE MANAGEMENT (CRM) COMPONENTS ON COMMERCIAL AIRLINE PILOTS' UNSAFE ACTS: EXPLORING THE MEDIATING OR MODERATING ROLES OF SAFETY CLIMATE, FATIGUE, AND PERSONALITY

SERİN ATIŞ, Gizem
Ph.D., The Department of Psychology
Supervisor: Prof. Dr. Bahar ÖZ

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Pilot behaviors, i.e. unsafe acts, are the direct causes of aviation accidents. Accident investigation analyses have revealed that several different factors from individual to organizational level contributed to the aviation accident occurrence. Airline companies have implemented Crew resource management (CRM) to prevent unsafe acts to improve flight safety, and CRM has been widely used since its first initiation. To enhance flight safety, it is crucial to measure both unsafe acts and Crew Resource Management (CRM), as this helps analyze their relationship and identify other factors contributing to unsafe behaviors. Existing tools to measure CRM and unsafe acts were dependent on the expert ratings requiring comprehensive training. Therefore, the need for easy-to-use measurement tools has emerged. To fill this gap, Study 1 aimed to develop self-report CRM Competency Scale by conducting interviews with 12 commercial airline pilots. The previously developed Airline Pilot Behavior Inventory was revised to capture wider aspects of unsafe acts. In the main study with 176 commercial airline pilots, factor structures of both tools were explored. Hierarchical regression analysis was conducted to examine the predictors of unsafe acts stressing the predictor roles of CRM competencies, fatigue, safety climate, and personality traits. Results showed importance of CRM competencies, personality traits, and fatigue as the predictors of the pilots' unsafe acts. Results revealed the mediating role of safety climate and fatigue in the relationship between CRM and unsafe acts. Neuroticism, as a personality trait, played a moderating role in the relationship between CRM and unsafe acts.

Keywords: Crew Resource Management, Pilot Behaviors, Commercial Aviation, Fatigue Symptoms, Personality Traits

ÖZ

YENİDEN YORUMLANAN EKİP KAYNAK YÖNETİMİ (EKY) BİLEŞENLERİNİN TİCARİ HAVAYOLU PİLOTLARININ EMNİYETSİZ DAVRANIŞLARI ÜZERİNDEKİ ETKİSİ: GÜVENLİK İKLİMİ, YORGUNLUK VE KİŞİLİĞİN ARACI VE DÜZENLEYİCİ ROLLERİ ÜZERİNE BİR ARAŞTIRMA

SERİN ATIŞ, Gizem
Doktora, Psikoloji Bölümü
Tez Yöneticisi: Prof. Dr. Bahar ÖZ

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Pilot davranışları, bir başka deyişle emniyetsiz davranışlar, havacılık kazalarının doğrudan nedenleridir. Kaza analizleri, havacılık kazalarının meydana gelmesinde bireysel düzeyden örgütsel düzeye çeşitli faktörlerin etkili olduğunu göstermektedir. Havayolu şirketleri, emniyetsiz davranışları önlemek ve uçuş emniyetini artırmak amacıyla Ekip Kaynak Yönetimi (EKY) uygulamalarını hayata geçirmiştir ve bu uygulamalar o günden günümüze yaygın bir şekilde kullanılmaktadır. Uçuş emniyetini artırmak için hem emniyetsiz davranışların hem de EKY'nin değerlendirilmesi, bu iki unsur arasındaki ilişkiyi ve emniyetsiz davranışların diğer belirleyicilerini incelemek açısından önemli bir rol oynamaktadır. Mevcut EKY ve emniyetsiz davranış ölçüm araçları, kapsamlı eğitim gerektiren uzman değerlendirmelerine dayanmaktadır. Bu nedenle, zamanla kullanımı daha kolay ölçüm araçlarına duyulan ihtiyaç ortaya çıkmıştır. Bu boşluğu doldurmak amacıyla, Çalışma 1, 12 ticari havayolu pilotuyla yapılan görüşmeler yoluyla CRM Yetkinlik Ölçeğini geliştirmeyi hedeflemiştir. Ayrıca, mevcut Pilot Davranış Envanterinin emniyetsiz davranışları daha geniş bir bakış açısıyla inceleyecek şekilde revize edilmesi amaçlanmıştır. 176 ticari havayolu pilotunun katıldığı ana çalışmada, her iki ölçüm aracının faktör yapıları da incelenmiştir. Emniyetsiz davranışları yordayan değişkenleri değerlendirmek amacıyla hiyerarşik regresyon analizleri uygulanmıştır. Bulgular, CRM yetkinliklerinin, kişilik özelliklerinin ve yorgunluğun pilotların emniyetsiz davranışları ile ilişkisini göstermiştir. Ayrıca, CRM ile emniyetsiz davranışlar arasındaki ilişkide emniyet ikliminin ve yorgunluğun aracı rolü olduğu tespit edilmiştir. Nevrotiklik kişilik özellikleri ise CRM ile emniyetsiz davranışlar arasındaki ilişkide düzenleyici rol oynamıştır.

Anahtar Kelimeler: Ekip Kaynak Yönetimi, Pilot Davranışları, Ticari Havacılık, Yorgunluk Belirtileri, Kişilik Özellikleri

To my beloved family

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CHAPTER 1

INTRODUCTION

Aviation relies heavily on human input despite its high level of automation and advanced safety systems. Although it is seen as one of the safest transportation systems, it is not free from accidents and incidents. Statistics showed that the accident rate in commercial flight operations was 1.87 per million departures in 2023 (International Civil Aviation Organization [ICAO], 2024). Even though the fatal accident rate has decreased over the years, aircraft accidents still result in millions of dollars in damage due to the haul-loss. While technological advancements have significantly improved the reliability and safety of modern aircraft, through innovations in navigation, autopilot systems, and predictive maintenance, human involvement remains integral to ensuring safe operations (Koonse & Debons, 2010). However, this reliance on the human element introduces vulnerabilities to human factors as major contributors to aviation incidents and accidents.

1.1. Human Factors in Aviation

Studies have consistently shown that human factors accounts for approximately 70-80% of all aviation accidents (Shappell et al., 2007; Wiegmann & Shappell, 2001). This statistic highlights the persistent vulnerabilities inherent in human performance, even as systems become increasingly automated. Unlike mechanical failures, which can often be anticipated and mitigated through engineering solutions, human factors are more complex, stemming from cognitive, psychological, and organizational factors.

Human factors in aviation can manifest in various forms, ranging from direct causes (i.e., unsafe acts) to contributing factors that underpin these direct causes, each of which can result in significant adverse outcomes if associated risk factors are not adequately managed (Reason, 1990; Shappell et al., 2007; Wiegmann & Shappell, 2001). Extensive research has been dedicated to investigating both the direct causes and the underlying contributors to aviation accidents. Numerous theoretical models, encompassing a broad spectrum of perspectives—from cognitive to organizational—have been developed to elucidate the role of human factors in aviation incidents. Among these, one of the most prominent frameworks is the Human Factors Analysis and Classification System (HFACS), introduced by Shappell and Wiegmann (2000). This model emphasizes an organizational perspective, positing that aviation accidents result from unsafe acts committed by operators (i.e., pilots), called active failures, which are influenced by breakdowns at multiple levels, including the individual, supervisory, and organizational levels which are called latent failures.

1.1.1. Unsafe Acts of Pilots

Before mentioning the critical preconditions of the unsafe acts of pilots in the following sections, it is crucial to understand the details of unsafe acts. From a general point of view, unsafe acts are classified into two distinct categories as errors and violations (Reason, 1990). Errors are defined as actions that fail to achieve their intended outcomes, which can be either mental or physical in nature. Unsurprisingly, errors dominate accident databases as the direct causes of accidents and incidents, reflecting the error-prone nature of humans (Shappell et al., 2007; Wiegmann & Shappell, 2001). Violations, in contrast, are deliberate deviations from the rules and regulations that are essential for safe operations (Reason, 1990). While categorizing unsafe acts into errors and violations provides us with an insight into the causes of accidents and incidents, further subdividing these categories based on their specific characteristics offers a more comprehensive understanding of their underlying preconditions.

The division of errors and violation in the aviation accidents and incidents were conducted by Shappell and Wiegmann (2000). Based on aviation accidents analysis, they divided *errors* into three categories: skill-based errors, decision errors and perceptual errors. They also divided violations into two categories: routine and exceptional violations. *Skill-based errors* in aviation context commonly occur with little or no conscious thoughts. Just like steering wheel in a car, skill-based errors in a flight operation occur in automatic behaviors, and unintentional behaviors in nature. Inadvertently omitted procedures, breakdowns in visual scan, poor flight control techniques, and over-control of the aircraft can be examples of skill-based errors.

Decision errors, on the other hand, are intentional in nature. Pilots intentionally decide to act yet the action itself is not appropriate for the situation. These kinds of errors are also known as honest mistakes. This can occur due to lack of knowledge in the novel situations, poor choices and problem-solving problems (Shappell et al., 2007; Wiegmann & Shappell, 2001). *Perceptual errors* occur unintentionally when visual information is degraded in the environment. Spatial disorientation, visual illusion or misjudging the altitude, airspeed or distance can lead to the perceptual errors (Shappell et al., 2007; Wiegmann & Shappell, 2001).

Violations, on the contrary to errors, occur less frequently due to the catastrophic results (Wiegmann & Shappell, 2001). *Routine violations* are habitual in their nature and usually disregarded by the authorities (Reason, 1990). Often, they are seen and "bending the rules". *Exceptional violations*, on the other hand, are neither the indicators of the typical behaviors nor disregarded by the authorities. They are hard to identify and deal with since they are not typical in their nature (Shappell et al., 2007; Wiegmann & Shappell, 2001).

Although definitions of unsafe acts provided insight on the nature of the direct causes of aviation accidents, the examination of aviation accidents reveals the significant role both errors and violations play, not only in their frequency but also in their contribution to the chain of events leading to accidents. Understanding the prevalence and impact of these unsafe acts is essential for identifying patterns and mitigating risks in aviation operations. Numerous aviation accident analyses have been conducted to get the frequencies of unsafe acts in accidents. The results have revealed that approximately 57% of them were caused by skill based errors, 37% were caused by decision errors, 7% were caused by perceptual errors, and 23% were caused by routine violations (Kelly & Efthymiou, 2019; Lenné et al., 2008; Ma et al., 2023; Shappell et al., 2007; Wiegmann & Shappell, 2001). Although accident investigation analyses have provided insight into the frequency of unsafe acts causing accidents, measuring unsafe acts of pilot can be tricky for researchers. The frequency of unsafe acts can be measured in different ways, all of which have some advantages and disadvantages.

1.1.2. Measuring Unsafe acts

Unsafe acts of pilots can be measured by using different methods. Accident investigation analyses are one of the methods to examine the frequency and types of unsafe acts resulting in aviation accidents. However, considering the rare nature of accidents, the resultant types might be the ones that were combined with several contributors and resulting in accidents (Martinussen & Hunter, 2018). Therefore, accident investigation analyses might provide a limited spectrum of unsafe acts.

Another method for measuring unsafe acts is conducting natural observations. Natural observations can help researchers to capture a wide range of unsafe acts committed by pilots which are committed but not resulted in accidents. Natural observations are commonly used by organizations to evaluate pilots' flight performance. However, these observations are mainly confidential in organizations and only authorized personnel can reach the evaluations. In addition, these observations can raise questions regarding the observers' reliability and pilots' performance under observation. For example, observers' evaluations on poor, good or standard performance can be different which might affect the evaluations. Also, pilot performance can be affected by being observed (Mavin & Roth, 2014). Therefore, observers should be carefully trained to increase observer reliability, which could be costly. In addition to this, video recordings rather than in-person observers can be used to evaluate pilot performance in terms of committing unsafe acts (Caponecchia et al., 2014).

The other method for measuring unsafe acts is using flight simulators, which also requires trained observers or video recordings. Simulator studies can be easily applied in laboratory situations by individual researchers. Carefully designed scenarios can help researchers to identify the frequency and types of unsafe acts. However, high-fidelity simulators are generally accessible to airline companies since they are high-cost machines providing real-flight experience. Therefore, using low-fidelity simulators can be an option for researchers which can bring the reliability and generalizability problems with them (Martinussen & Hunter, 2018).

The last method for measuring the unsafe acts of pilots is using self-report measurement tools. Self-report measures can be easily applied to a large number of participants by asking them the frequency of committing certain examples of unsafe acts. Large examples of unsafe acts can be presented to the pilots at once without requiring observer training and costly simulators. Serin (2016) developed a self-report measure for the frequency of unsafe acts committed by commercial airline pilots, called Airline Pilot Behavior Inventory (APilotBI), which showed good reliability.

This tool was developed based on the theory consisting of 46 examples of unsafe acts. Although APilotBI was developed with the contributions of subject matter experts, since it was developed theoretically, it needs to be revised based on interviews regarding pilots' experiences on unsafe acts. However, literature suggested that self-report measures can be vulnerable to socially desirable responding in which participants answer the questions in line with the researchers expectations and societal expectations rather than the actual situation (Lajunen & Summala, 2003; Yılmaz et al., 2022). However, when the participants ensured anonymity the drawbacks of self-report might be eliminated (Lajunen & Summala, 2003).

Although all measurement methods for unsafe acts can be some advantages and disadvantages, using low-cost user-friendly methods such as self-reports might help researchers to examine the unsafe acts and possible contributors of unsafe acts committed by commercial airline pilots. Numerous studies employing different measurement tools have revealed the contributors of unsafe acts.

1.1.3. The Contributors of Unsafe Acts in Aviation Accidents

Analyses of aviation accidents have provided researchers with valuable insights into the types of unsafe acts committed by pilots that lead to accidents. Equally important is understanding the deeper failures at various levels that contribute to these occurrences. These failures may manifest at the individual level, such as deficiencies in crew resource management (CRM), pilot fatigue, or detrimental personality traits, and at the organizational level, such as an inadequate safety climate. Investigations of accident reports have revealed that failures in CRM contributed to approximately 11% of aviation accidents. Similarly, adverse mental states, such as fatigue, and physical or psychological limitations, including pernicious personality traits, were contributing factors in approximately 11% of accidents. At the organizational level, failures related to the safety climate accounted for at least 0.4% of aviation accidents (Shappell et al., 2007; Von Thaden et al., 2006; Wiegmann & Shappell, 2001). While the organizational-level contributions may appear minor, the combination of breakdowns across different levels can lead to catastrophic outcomes. Therefore, it is crucial to examine their potential contributions to unsafe acts in greater detail.

Accident investigations have also revealed details of the contributors of pilots' unsafe acts as well as the frequencies in accidents. Lenné and collegues (2008) analyzed 169 general aviation accidents in Australia. They reported that skill-based errors and decision errors were the leading causes of the general aviation accidents occurred in Australia. They also found that both skill-based errors and decision errors were significantly associated with latent failures including adverse mental states of pilots such as mental fatigue, personnel readiness and physical/mental limitations. Although CRM as a whole was not significantly associated with unsafe acts, loss of situation awareness as a component of CRM was found to be related to the unsafe acts of pilots. Similarly, Guo and collegues (2021) reported that loss of situational awareness was the most observed causal factor to unsafe acts in general aviation accidents occurred between 2010 and 2019 followed by ineffective resource management. They also reported that poor personal ready state such as high levels of fatigue was positively associated with errors and violations. In addition, Ma and collegues (2023) also reported that failures in communication and coordination, high levels of mental fatigue, pernicious personality traits, and deficiencies in safety climate such as ineffective equipment maintenance, operational planning and time pressure were important contributors to unsafe acts.

In another accident analyses study, Kelly and Efthymiou (2019) analyzed 50 controlled flight into terrain (CFIT) accidents from 2007 to 2017. They reported that failures in situation awareness, leadership, assertiveness, communication characterized by miscommunication and not sharing the critical information, pre-flight planning and briefings in both pre-flight and in-flight are the contributor factors to the unsafe acts of the pilots resulting in CFIT accidents. They also stated that organizational training programs, operational tempo planning, and perceptions of equipment, all of which reflect the organizational safety climate, were identified as the contributors of pilots’ unsafe acts. In addition, Li and collegues (2008) analyzed 41 civil aviation accidents occurred between 1999 and 2006. Failures in CRM were significantly associated with skill-based errors, decision errors and violations. However, they did not identify significant contributors regarding the safety climate.

All these retrospective accident investigation studies showed that failures in the components of CRM, pilots fatigue levels, pernicious personality traits and some aspects of safety climate in the organizations were identified as contributors to committing unsafe acts which, in turn, resulted in catastrophic consequences. Accident analyses are crucial for identifying pilots' unsafe behaviors and the factors contributing to them. However, considering that accidents are rare events, the factors identified through accident analyses may underestimate the frequency of pilots' unsafe behaviors and the factors influencing them. Several researchers stressed the importance of focusing on how the things go right rather than focusing on the accidents to find its causes (Carayon et al., 2015; Hollnagel, 2018). Thus, Thoroman and collegues (2019) analyzed 16 near-misses reports to find out what is done right to prevent adverse events. Situational awareness, communication between flight crew and with ATCs, application of procedures, and automation system understanding and taking actions when needed were found as protective factors at individual levels. They also stated that existing procedures of airline companies, update of trainings and procedures when needed, stressing the importance of adherence to standard procedures, and providing appropriate information to operational personnel such as pilots were identified as protective factors at the organizational level implying the importance of positive safety climate.

Both retrospective and prospective studies provided valuable information about which factors could contribute to commuting unsafe acts of pilots. Effective CRM application (Guo et al., 2021; Kelly & Efthymiou, 2019; Lenné et al., 2008; Li et al., 2008; Ma et al., 2023), fatigue (Li et al., 2008; Ma et al., 2023) and pernicious personality traits (Ma et al., 2023) were found to be significant factors that contribute to commuting unsafe acts. In addition to individual factors, organizational climate was found to be the important factor that contributes to the occurrence of unsafe acts. Therefore, analyzing the relationship between these variables and pilots' unsafe actions can offer valuable insights for enhancing flight safety and preventing accidents from a comprehensive perspective.

HFACS emphasized the importance of unsafe acts of pilots as well as stressing the importance of latent failures from different levels. It has been emphasized that for an accident to occur, pilots' unsafe acts must combine with deficiencies at different levels. Therefore, it is crucial not only to investigate the unsafe acts of pilots but also to examine the factors influencing these acts and to identify potential relationships (Reason, 1990; Shappell & Wiegmann, 2000; Wiegmann & Shappell, 2001). Examples of this can be seen in major aviation accidents such as the Tenerife disaster. The Tenerife accident is still regarded as one of the largest and deadliest accidents in aviation history. Although the direct cause of this accident was the captain's decision to initiate takeoff based on the assumption that clearance had been granted—a clear case of poor decision-making—several contributing factors can be identified. These include communication breakdowns both within the cockpit and with air traffic control (ATC), reduced visibility, and the First Officer's failure to communicate the lack of takeoff clearance to the captain (Weick, 1990). Thus, focusing solely on pilots' unsafe behaviors in aviation accidents would mean addressing only the visible part of the iceberg while neglecting the impact of the underlying deficiencies contributing to these acts (Hobbs & Williamson, 2002).

1.2. Crew Resource Management: Definition and Evolution in Commercial Aviation

CRM, which could be considered as a precondition for unsafe acts of the pilots, is defined as the cognitive, social and interpersonal skills that complement technical skills to effective usage of all available resources. These resources can be crew members, ground personnels (e.g. ATCs; dispatchers, maintenance personnels etc.), company managers, aircraft hardware, automation systems, Safety Operation Procedures (SOPs), and training (Flin et al., 2002, 2003). CRM training that is implemented by airline companies aims to increase skills such as communication, team management, leadership, decision-making skills, workload management, stress management, and situation awareness.

The need for CRM emerged during the 1970s after the series aircraft accidents occurred due to human errors such as the Tenerife disaster. Accident investigations revealed that aircrafts became more reliable with the technical advancements of the aircraft design while people became less reliable (Helmreich & Foushee, 2010, pp. 6). The investigation of crashes at those times showed the major human factors causing accidents such as lack of interpersonal communication and cooperation, leadership and decision making (Flin et al., 2002). Addressing the major problem raised an awareness of taking precautions on the problem. Aviation authorities gathered in a workshop called “Resource Management on the Flight Deck” held by National Aeronautics and Space Administration (NASA) on 1979 to discuss possible countermeasures of human errors, and the term “Cockpit Resource Management” has emerged (CRM; Cooper, et. al., 1980; Helmreich, et. al., 1999). United Airlines in the U.S. and KLM in Europe pioneered the first CRM training programs (Flin, et. al., 2002). Following its initial implementation, CRM rapidly became a widely adopted training approach aimed at fostering team effectiveness to minimize errors and reduce accident rates.

Although the main goal of CRM has remained consistent over time, its scope has evolved and expanded in response to operational needs. Initially, in the early stages of the aviation industry, technical failures were identified as the primary cause of aviation accidents. Consequently, motor and technical skills were regarded as critical factors in reducing accident rates (Helmreich et al., 1999). Pilot training programs were thus designed with the objective of developing the "perfect pilot" (Ion, 2011). However, the landscape of aviation began to shift significantly after the 1950s with advancements in aircraft technology, including innovations in design and the introduction of turbojet engines. These developments drastically reduced the prevalence of technical failures as a contributing factor to aviation accidents (Helmreich et al., 1999). Despite the significant reduction in technical failures and a corresponding decrease in overall accident rates, the anticipated elimination of aviation accidents did not materialize. Detailed investigations into the causes of accidents revealed that the unsafe acts of pilots had emerged as a direct factor. In response, the concept of CRM was introduced as a proactive measure to address this issue, marking a pivotal shift in focus from purely technical competence to the broader management of human factors in aviation safety.

1.2.1. Generations of CRM

1.2.1.1. The First Generation of CRM.

CRM training was first introduced by United Airlines in 1981 and subsequently by KLM in 1984, following a pivotal NASA workshop in 1979. These early implementations were designed to enhance the management skills of crew members (Helmreich et al., 1999; İnan, 2018; Kanki et al., 2010). Initially termed "Cockpit Resource Management," the training primarily targeted cockpit crews and sought to address individual behavioral styles and rectify ineffective practices within the cockpit. The focus was on fostering assertiveness among junior first officers and mitigating authoritarian tendencies among captains. The early CRM training programs were structured as seminars that integrated psychological assessments with managerial principles such as leadership development. However, these initial efforts lacked a precise definition of what constituted effective behavior. For instance, while the objective was to promote a more assertive communication style among junior officers and reduce authoritarianism in captains, the specific criteria for measuring and implementing such behavioral changes were not clearly articulated (Helmreich et al., 1999; İnan, 2018; Kanki et al., 2010).

Recognizing the limitations of a one-time training approach, many organizations began incorporating CRM into their recurring training schedules, often using non-aviation scenarios and exercises as primary components. Some programs also implemented Line Operations Flight Training (LOFT), which provided realistic, full-mission simulations that allowed crews to practice communication, management, and leadership skills in real time (Helmreich et al., 1999; İnan, 2018; Kanki et al., 2010). Despite these developments, some pilots resisted the training, claiming it attempted to alter their personalities (Helmreich et al., 1999; İnan, 2018; Kanki et al., 2010).

1.2.1.2. The Second Generation of CRM.

After the first implementation of CRM, NASA held another workshop in 1986. At this time, airline companies around the world that initiated the training published reports about their programs. Both the workshop and the reports emphasized that CRM training could not be separated from the pilot training to provide ultimate gain. Implementing embedded training programs that covered both regular training and CRM training was also recommended (Helmreich et al., 1999; İnan, 2018; Kanki et al., 2010).

At the same time, a new generation of CRM training that expanded its’ scope had emerged. The new generation emphasized the group dynamics in the cockpit shifting the focus from individual behaviors to group behaviors. The new training was also delivered to seminars, but these seminars were more team-oriented, covering topics such as team building, effective briefing strategies, managing stress, situation awareness, effective decision-making strategies and breaking the error change to prevent disastrous results. Being more group oriented also evolved the term “cockpit resource management” into the “crew resource management” to stress the importance of group (Helmreich et al., 1999; İnan, 2018; Kanki et al., 2010).

1.2.1.3. The Third Generation of CRM.

This generation of CRM brought several changes in the CRM training programs. The characteristics of aviation systems such as organizational climate began to be integrated into the CRM training programs. In this generation, technical training was merged with the CRM training programs to promote effective usage of technical skills. Automation usage and recognition of human factors were also included in the scope of CRM training programs.

At the same time, CRM training programs were extended to the other personnel such as flight attendants, dispatchers, and maintenance personnel; and became a joint training program. However, with all these developments, the ultimate focus of the CRM, which was the reduction of human error was diluted unintentionally (Helmreich et al., 1999; İnan, 2018; Kanki et al., 2010).

1.2.1.4. The Fourth Generation of CRM.

This generation came with the major change introduced by the Federal Aviation Administration (FAA). The FAA introduced the Advanced Qualification Program (AQP) in the early 1990s. AOP was a voluntary program that required organizations to develop innovative training programs specific to organizations. In the scope of AOP, organizations had to assess their training needs to develop training addressing CRM skills as well as technical skills. It also required formal certification and evaluation of the crew by using line-oriented evaluation (LOE) in the simulation.

This integration of CRM into technical skills required organizations to specify normal and abnormal behaviors to ensure proceduralized decisions and actions. It also aimed to provide baseline of operational behaviors (Helmreich et al., 1999; İnan, 2018; Kanki et al., 2010).

1.2.1.5. The Fifth Generation of CRM.

Since CRM training was first implemented, although it was not effectively communicated, its primary focus has been on preventing errors by utilizing all available resources. However, James Reason's influential work on human error in 1990 marked a new phase for CRM training by introducing the concept that human error is inevitable. Building on Reason's insights, Helmreich, Merritt, and Wilhelm (1999) argued that if errors are indeed inevitable, CRM should function as an error management tool with three defense layers: avoiding errors, trapping errors promptly, and mitigating their consequences which is called the error troika.

Helmreich and colleagues' (1999) approach brought the concept of 'error acceptance' into aviation safety practices. Accepting errors does not imply accepting violations—deliberate deviations from rules and regulations (Reason, 1990, pp. 206). Instead, it acknowledges human vulnerability to mistakes and emphasizes proactive measures to prevent these from leading to accidents and incidents. Thus, the fifth generation of CRM training is viewed as an error management strategy for human error (Helmreich et al., 1999; İnan, 2018; Kanki et al., 2010). Today, the fifth generation of CRM training programs continue to be delivered by integrating human factors and threat and error management (TEM). To increase the effectiveness of these programs, competency based training (aiming to teach operators reflecting skills into behaviors) approach is emphasized and started to be merged with CRM trainings (Başdemir, 2020, pp. 9).

When we look at the five generations of CRM, it is possible to tell that as it has evolved over the years, its focus has shifted from individual managerial skills to a broader framework that prioritizes error management and safety through teamwork. This progression has also led to the development of key CRM components, including communication, leadership, situational awareness, decision-making, and teamwork, each of which plays a vital role in achieving CRM's overarching goals. Initially, CRM training centered on modifying individual behaviors, but as the understanding of human error has deepened, these core components were integrated to provide a more comprehensive approach. Each element works synergistically to create a resilient crew environment, allowing teams to anticipate and mitigate errors more effectively, ultimately enhancing operational safety across the aviation industry. The current, holistic CRM model reflects this evolution, underscoring that safety depends not only on individual competencies but on the coordination of these critical skills within the team. Therefore, the comprehensive CRM training program should include basic CRM components such as situational awareness, communication, team management, leadership, workload and fatigue management, stress management, and decision making (Çetingüç, 2016, pp. 410-420; Kanki et al., 2010).

1.2.2. Components of CRM

CRM is related to using all available resources. These resources can be people, environment, automation or any other flight related parts. Flights are operated in a changing environment. This change can occur within the pilot, within the aircraft, and the environment around the aircraft. Pilots should constantly monitor and be aware of these changes and also consider the probability of changes in the near future. Thus, *the situation awareness* (SA) level of pilots should be maximum to attain flight safety (Çetingüç, 2016, pp. 410). The SA has three levels namely perception, comprehension and future predictions. The pilots need to perceive the changes in the actively monitored surroundings, comprehend what the changes mean, and predict the possible problems related to the changes. For example, when a warning light is activated, pilots should perceive that it is activated and which system it was related to. In the second level, pilots should comprehend what the warning light means and how it should be treated. In this level, pilots apply the related procedures to fix the problem. In the third level, pilots apply take the precautions after the problem is fixed or controlled to achieve safe landing (Başdemir, 2020, pp. 54-55). Loss of SA can lead to interruption in communication and failures in decision making processes. CRM training programs aim to teach pilots how to attain and maintain SA.

Communication is one of the key elements of CRM. Pilots constantly communicate with each other, cabin crew, ATCs and technical personnel during the flight operations. Pilots should communicate about their knowledge, changes in environment, changes in systems and changes in their cognitive and physical state during the flight. Communication not only conveys information but also helps to establish effective teams, establish predictable behavior pattern, maintain attention and sustain SA (Başdemir, 2020, pp. 53-55; Çetingüç, 2016, pp. 413; Kanki et al., 2010, pp. 122). Any disruption in communication can lead to problems in decision making and team management. Effective communication is addressed by CRM training programs. Pilots are taught active listening, assertiveness and effective briefing methods for effective CRM.

Pilots are performing in a team although they are actively flying the aircraft. Thus, *team management* is an important part of CRM. This team consists of ground personnels, dispatchers, ATCs, technicians, and cabin crew. All the parts of the team should operate in coordination to achieve flight safety (Başdemir, 2020, pp.110; Çetingüç, 2016, pp. 420). For example, pilot-in-command (PC, could be captain pilot or First Officer [F/O]) flies the aircraft and the pilot-monitoring (PM) monitors the automation systems. In an emergency, parts of the team should know the responsibilities. Captain pilot takes control and F/O controls the appropriate flight manuals or PC continues to control the aircraft and PM does the flight manual controls. Cabin crew should make appropriate announcements to inform passengers. PM should know to communicate with ATCs about the emergency and communicate with technicians when needed. All of these processes should be in coordination to achieve appropriate decisions to solve the emergency situation and land safely. To achieve flight safety, every part of the team should know their responsibilities and act accordingly. Safety Operation Procedures (SOPs) help the team, especially pilots, to operate the flight safely. Thus, well-prepared SOPs are important for team management. This shows the importance of organizations' commitment to CRM (Tullo, 2010, pp. 67-74). Organizations should ensure that teams can achieve flight safety by following the SOPs. The way to provide this is to establish a positive safety culture. Pilots operating in organizations with a positive safety culture can know that upper management commits safety issues, establish and apply the rules and regulations to increase safety, and protect them when needed. This does not mean that violations are disregarded. On the contrary, this means that errors are inevitable but when they occur, SOPs are helping the team to prevent disastrous consequences, management analyze their root causes and take the appropriate precautions to prevent reoccurring. Thus, positive organizational culture is important for effective team management in CRM (Tullo, 2010, pp. 68-74). CRM training programs deliver all the rules and regulations, SOPs and required skills for team management.

Leadership is another important part of CRM and being a team. Managing the team effectively is the responsibility of the leader who is the captain pilot of the crew. Captain pilots should ensure that the SOPs are followed, communication and coordination between crew members are established, and teams are performing their duties effectively (Çetingüç, 2016, pp. 422; Ginnett, 2010, pp. 94). In a team in which members barely know each other, leaders play a crucial role for team formation and work management. Effective leaders should show the authority that is needed and also be democratic to hear others' voices in the team. In addition, effective leaders should discuss the task duties, team and individual boundaries, and related norms and regulations for effective team performance. In the flight operations, captain pilots have the responsibility to be the leader of the crew members (Ginnett, 2010, pp. 94-100). Thus, CRM training programs address the importance of leadership and the characteristics of effective leaders. CRM gave importance to team management for effective team performance. Having a leader may seem to underestimate the team's performance. However, having a leader is important to escalade the team's performance rather than underestimating its performance (Ginnett, 2010, pp. 94).

Being a team and having a leader does not override the importance of individual performance, which is one of the main focuses of CRM. On the contrary, being a team and having a leader is important for preventing individual errors, trapping them and mitigating their consequences when needed. *Work management* is an important part of the CRM for effective team performance as well as effective individual performance. Managing the work of the crew based on their job description, thus, is the responsibility of the leader. Leaders can be responsible for teamwork management, but individuals also are responsible for managing their own work. CRM training programs address effective teamwork management and individual work management from planning to action because ineffective teamwork management and individual work management can lead to stress and fatigue for crew members. Fatigue management is also a part of work management as it directly impacts flight safety and operational effectiveness. CRM frameworks often integrate strategies to mitigate fatigue among aviation personnel, recognizing that fatigue can impair cognitive functioning, situational awareness, and decision-making abilities. Effective fatigue management involves scheduling practices that minimize sleep deprivation and provide adequate rest opportunities, as well as promoting self-awareness among crew members regarding their fatigue levels and limitations (Caldwell et al., 2009). CRM training emphasizes tools and techniques to recognize signs of fatigue and encourages open communication within the team to address potential issues before they affect performance. This proactive approach to managing fatigue aligns with safety goals, as studies show that fatigued crew members are more prone to errors, miscommunication, and compromised safety (Bendak & Rashid, 2020; Morris et al., 2018). Hence, work and fatigue management are indispensable elements within CRM, contributing to enhanced safety outcomes and the well-being of crew members.

Effective work management is also important for *stress management*, which is a vital component for CRM. In aviation, stress is a major factor that can compromise safety due to its impact on cognitive functions, judgment, and communication—three core elements in flight operations. CRM integrates stress management as a fundamental component to help aviation crews maintain high levels of performance under pressure. In CRM training, stress management involves recognizing stressors that may arise in-flight, such as time pressure, equipment issues, or unforeseen weather conditions. By identifying these stressors early, crew members can actively engage in stress-reducing techniques that are part of CRM protocols (Salas et al., 2001, 2006). CRM's approach to stress management encompasses both psychological and interpersonal techniques. For example, breathing exercises and mindfulness practices are encouraged to help crew members manage immediate physiological responses to stress. Additionally, CRM emphasizes effective communication as a tool to alleviate stress. By fostering open communication, CRM training helps crew members feel comfortable discussing their stress levels and asking for support, which can reduce the feeling of isolation that exacerbates stress (Çetingüç, 2016, pp.180-194; Helmreich et al., 1999). In practical terms, CRM-trained teams use specific strategies such as workload distribution and prioritization, where tasks are delegated according to the strengths of each crew member during stressful situations. This not only prevents overloading of a single individual but also increases the team's overall situational awareness and adaptability (O'Hare, 2003). Moreover, stress management within CRM is proactive rather than reactive. This means that instead of waiting until stress becomes overwhelming, CRM encourages crews to maintain a baseline level of mental readiness and resilience. This proactive management aligns with the safety culture in aviation, where anticipating and preparing for challenging situations is a priority. By incorporating stress management into CRM, the aviation industry aims to create a resilient crew environment that can withstand both expected and unexpected challenges, ultimately flight safety (Prince et. al., 2017). Stress is an inevitable part of the flight operations due to the threats and errors inherent in the flight operations. Since high levels of stress can impair cognitive functioning and judgments, it can also impair decision making processes which are vital for flight operations.

Decision-making is a core component of Crew Resource Management (CRM) because it underpins the ability of flight crews to respond effectively in dynamic and high-pressure situations. In the CRM context, decision-making involves assessing situational data, evaluating options, and selecting a course of action that aligns with safety and operational priorities (Orasanu & Fischer, 1997). This structured approach helps reduce cognitive load during time-sensitive situations and minimizes reliance on intuitive responses, which can be error-prone in stressful environments. A crucial aspect of decision-making within CRM is the concept of shared decision-making, where input from all crew members is encouraged to ensure a comprehensive understanding of the situation. This collaborative approach prevents the pitfalls of single-point decision-making and reduces the risk of error by leveraging the collective expertise and perspectives of the crew (Helmreich et al., 1999). Decision making concepts have changed through the years from naturalistic decision making to aeronautical decision making in which decision making seemed like risk management in TEM. This shift emphasizes the importance of risk perception and risk assessment as essential components of effective decision-making. It also aims to detect the human errors and correct them which is in line with TEM framework (Helmreich, 2002). Through structured and collaborative decision-making, CRM aims to enhance flight safety by enabling crews to make sound decisions even under high-stress conditions.

The ultimate goal of CRM is preventing unsafe acts, correcting them and mitigating the consequences if unsafe acts occur. All skills that pilots achieve during CRM training programs help them to succeed components of CRM effectively. Through the evolution of CRM, the focus has been shifted from individual unsafe acts to team performance. Hence, the importance of unsafe acts has been placed back to team performance with the fifth-generation CRM. Since the ultimate goal of CRM was to reduce unsafe acts and it became mandatory for pilots carrying passengers in 2001 by the FAA (Çetingüç, 2016), measuring the effectiveness of the CRM training programs became an issue. To measure the effectiveness of CRM training programs several tools were developed. The following section will present the measurements of CRM and the evaluation of its effectiveness in terms of unsafe acts.

1.2.3. Measures of CRM and Its Effectiveness on Unsafe Acts

Various methods have been utilized to evaluate the effectiveness of CRM training programs. Given that the primary goal of CRM training is to reduce accidents, accident rates are often considered as an indicator of effectiveness. However, researchers generally refrain from relying on accident rates due to the infrequent occurrence of accidents in commercial aviation (Flin et al., 2002; O’Connor et al., 2008). Since accidents are rare events, focusing solely on accident rates may fail to capture critical behavioral insights related to unsafe actions that do not result in accidents.

Given the low incidence of aviation accidents, researchers have explored alternative methods to evaluate the effectiveness of CRM training. These methods include analyzing participants' responses to the training, assessing attitudes, measuring learning outcomes, and observing crew behavior. Among these approaches, reaction measures—gauging aircrew perceptions of the training's impact—are the most frequently employed (Mearns et al., 2001; O’Connor et al., 2008). Attitude measures represent another valuable method for assessing CRM, as attitudes are well-established predictors of behavior (Ajzen, 1991). By comparing safety attitudes before and after CRM training, researchers can gain insights into the program’s impact (Mearns et al., 2001; O’Connor et al., 2008; Shuffler et al., 2010). One widely used self-report tool in this context is the Cockpit Management Attitude Questionnaire (CMAQ), which evaluates the influence of CRM training on aircrew attitudes (Gregorich et al., 1990). Similarly, the Flight Management Attitudes Questionnaire (FMAQ; Merritt et al., 1996) was developed to specifically measure pilots' attitudes toward CRM.

Knowledge assessments, often conducted pre- and post-training, allow for the comparison of knowledge gains (Flin et al., 2002; O’Connor et al., 2008; Shuffler et al., 2010). For crew behavior, evaluations are typically performed in simulated flight scenarios such as LOFT exercises and in line operation evaluations (LOE), where experienced observers (such as trainers or examiner pilots) assess the safety-related behaviors of pilots, observing how CRM skills translate into practice. Behavioral marker systems, such as Line/LOS checklists (Helmreich et al., 1997) and the European NOTECHS system (Flin et al., 2003; O’Connor et al., 2002; van Avermaete, 1998) have been developed to standardize these assessments all of which need special training to implement.

Numerous studies have been conducted to evaluate the effectiveness of CRM training programs by assessing learned CRM behaviors and their application in on-the-job behavior assessments. Research on learned CRM behaviors has demonstrated that leadership behaviors acquired during CRM training are positively associated with accurate decision-making in emergency scenarios, as observed in simulator studies (Bienefeld & Gudela, 2011). Pilots exhibiting stronger leadership behaviors were more likely to make correct and appropriate decisions in simulated emergency situations. Additionally, learned coordination behaviors were found to correlate positively with the ability to prioritize critical information and actions during emergencies. Pilot groups with high coordination behaviors demonstrated greater accuracy in ranking the importance of information provided to them and in identifying effective actions. These groups also exhibited higher rates of correct decision-making in emergency scenarios (Kay et al., 2014). These findings suggest that CRM training programs are effective in equipping pilots with critical CRM behaviors, which are essential for managing complex and high-stakes situations effectively.

While studies examining the translation of CRM skills into on-the-job performance remain limited, one seminal contribution comes from Thomas (2004). Thomas investigated the relationship between CRM skills and threat and error management performance by observing crew behaviors during routine line operations across 323 flight sectors (individual airport-to-airport operations). The observations were conducted by 25 senior aircrew observers who underwent a two-day training program to enhance interrater reliability. During these observations, the non-technical skills of pilots, as well as threats (e.g., environmental factors) and errors (e.g., crew-related factors) encountered during line operations, were documented. Observers also assessed whether the identified threats and errors were effectively managed. The findings revealed that higher levels of cooperation, assertiveness, situational awareness, vigilance, and contingency planning were positively associated with the effective management of errors. Conversely, higher levels of workload management were linked to a reduced number of managed errors. Thomas hypothesized that elevated workload might enhance aircrew focus on immediate tasks, potentially leading to decreased situational awareness. When workload was effectively managed, it could inadvertently contribute to attention distractions among crew members, thereby influencing error management outcomes.

In another study, Serin (2016) measured self-reported safety operation behavior and unsafe acts of the pilots. The results showed no association between the safety operation behaviors which were the behavioral reflections of CRM and the number of unsafe acts reported by pilots.

These studies highlight the potential importance of CRM in enabling crew members to effectively manage threats and errors during flight operations, thereby enhancing flight safety. However, contradictory findings from previous research indicate that the relationship between CRM and unsafe acts by commercial airline pilots requires further investigation. Moreover, acquiring CRM skills does not guarantee their translation into behavior; pilots must possess the competence to apply these skills in practice. Therefore, assessing CRM competencies, which encompass both skills and behaviors, is crucial for obtaining clearer insights.

Additionally, inconsistencies between studies underline the need for further research in this area. Implementing CRM assessments often requires specialized training, making their application challenging for researchers. While user-friendly and accessible tools, such as CMAQ and FMAQ, are available to use, they primarily measure attitudes rather than actual behaviors or skills. Thus, there is a need for a measurement tool that evaluates CRM applications in a more user-friendly and practical manner. Given the importance of CRM in preventing unsafe acts, understanding pilots’ unsafe acts as direct causes of accidents and incidents remains critical.

Existing CRM measurements generally focus on CRM skills and behaviors. As previously mentioned, CRM training programs today are designed to be competency-based and aim to enhance pilots' CRM competencies. Therefore, observing and improving CRM competencies through simulators or LOE has become a part of CRM training programs (Başdemir, 2020; Çetingüç, 2016). However, since having knowledge of CRM or possessing these skills does not guarantee that they will turn into behavior, organizations combine classroom training with simulator training and LOE to ensure transference of knowledge and skills into behaviors. For this reason, it is also important that the newly developed CRM measurement is both user-friendly and focused on pilots' competencies.

Developing a measurement tool for CRM competencies can also help researchers to examine the relationship between CRM competencies and other contributors of unsafe acts such as fatigue levels, personality traits and safety climate as well as the relationship between CRM competencies and unsafe acts. Although the ultimate goal of CRM is to prevent unsafe acts, it can also help pilots to mitigate the effects of other contributors such as fatigue, pernicious personality traits and safety climate on the unsafe acts. For instance, workload and stress management components of CRM can be a countermeasure for in-flight fatigue by effectively organizing the in-flight task load to provide bunk sleep or cockpit nap for fatigued pilots. Effective stress management competencies can also help pilots to reduce stress-induced fatigue and might reduce fatigue related unsafe acts. Similarly, CRM competencies can help pilots make decisions and utilize all resources effectively, regardless of their personality traits. For instance, pilots with anxious personality traits may exhibit more rational behavior by adhering to SOPs and considering the suggestions of other pilots. All these examples might provide propositions regarding the relationship between CRM competencies and contributors of unsafe acts at the individual level. These suggestions will also be discussed in detail based on the literature in the following sections.

At the organizational level, CRM training designed to enhance CRM competencies can be considered a reflection of an organization's safety climate. A positive safety climate is characterized by a strong commitment to safety, open and effective communication, prioritization of safety over productivity, the encouragement of reporting safety concerns without fear of reprisal, and the allocation of sufficient resources to support safe operations (Zohar, 2010). These attributes align closely with the foundational principles of CRM. Organizations have a critical responsibility to promote flight safety by establishing and enforcing rules, regulations, and procedures, as well as implementing proactive measures, such as revising protocols in response to emerging safety issues. This organizational commitment is evident in the practical application of CRM principles by crew members to sustain and improve flight safety. Consequently, it can be argued that pilots' CRM competencies may function as an indirect indicator of their perceptions regarding the organization's safety climate, a relationship that needs further exploration.

1.3. Organizational Safety Climate

Safety climate defined as "a summary of molar perceptions that employee share about their work environment" (Zohar, 1980). Although culture and climate commonly have been used interchangeably, they are somewhat addresses the different constructs (Mearns et al., 1998). Whereas culture defined as "the set of shared, taken for granted implicit assumptions that groups hold, and that determines the way how group perceive, think about and reacts to various environments", climate represents a manifestation and measurable aspect of the culture (Schein, 1990). Safety climate represents workers' attitudes, beliefs and perceptions about the safety and risk in the organizations at a particular place and time (Zohar, 1980). Since it is a perception of workers regarding the safety culture in the organizations, it can change depending on the situation of the environment or conditions of the organizations (Wiegmann et al., 2004). Because attitudes, perceptions and beliefs are important predictors of behaviors (Glendon & Litherland, 2001), safety climate can be a good predictor for behaviors. The following section will present the existing literature on the relationship between safety climate and unsafe acts.

Studies examining the relationship between organizational safety climate and unsafe acts mainly come from the traffic context. For example, Zohar and collegues (2014) reported that perceived negative safety climate was associated with more dangerous behaviors, mainly hard-brake, among truck drivers. Swedler and collegues (2015) reported supportive results to Zohar and colleagues. They reported that positive safety climate was associated with more dangerous behaviors such as distracted driving resulting in hard brakes. They also reported that the positive safety climate was related to the fewer crashes among truck drivers. Additionally, negative safety climate was related to higher number of self-reported errors and violations among professional drivers (Öz et al., 2010, 2013). Similar results were reported by Sullman and colleques (2017). They reported that the positive safety climate was associated with a smaller number of self-reported errors, lapses and violations among truck drivers. They also reported that the positive safety climate was related to fewer active crashes. Drivers carrying petroleum products also revealed similar results showing that perceived positive safety climate was associated with less errors and violations (Şimşekoğlu & Nordfjærn, 2015). Studies conducted with bus drivers revealed matching results showing that positive safety climate was associated with a smaller number of errors and violations of the bus drivers (Chen et al., 2019; Wills et al., 2006).

1.3.1. Organizational Safety Climate in Aviation

In the aviation context, safety climate research is mainly conducted to examine the relationship between safety climate and safety behaviors such as safety compliance, safety participation and safety courtesy. Studies showed that positive safety climate was associated with high levels of safety behaviors measured as safety compliance, safety participation (Maneechaeye & Potipiroon, 2022a; Xu et al., 2022), and safety courtesy among airline pilots (Maneechaeye & Potipiroon, 2022a). Similarly, positive safety climate was associated with higher levels of safety behaviors among Indonesian civil pilots (Fernandes et al., 2018) and Taiwanese pilots (Lin, 2012). In these studies, measured safety behaviors consisted of intention to obey the rules and regulations, using safety procedures, intentions to ensure highest levels of safety, intentions to share information with the team, intensions to inform the team about safety rules, regulations and procedures, and intensions to take actions to stop violations of team members. This means that the safety behaviors of pilots are associated with the management of unsafe acts as well. Thus, one can speculate that the positive perceptions of pilots on organizational safety climate are important to manage the unsafe acts of the pilots.

A positive organizational safety climate can be characterized by a strong commitment to safety, open and effective communication, the prioritization of safety over productivity, a willingness to report safety concerns without fear of reprisal and the availability of resources to support safe operations (Zohar, 2010), all of which rely on the hearth of CRM. Organizations have the responsibility to promote flight safety by developing and applying rules, regulations and procedures, and to take actions like revising existing procedures in case of safety issues. This responsibility exerts itself in the applications of CRM by crew members to ensure flight safety. Thinking that safety climate is the shared values, attitudes, perceptions and beliefs of the workers in the organizations (Zohar, 1980), CRM training programs are the crucial tools to create shared values, attitudes, perceptions and beliefs regarding the prioritization of safety, and to encourage cooperative approach to error management (Gao et al., 2013). When the CRM training programs successfully create shared values, attitudes, perceptions and beliefs regarding the prioritization of safety, this can promote the effective application of CRM in the flight operation.

Literature clearly shows the link between safety climate and unsafe acts as well as the link between effective CRM and unsafe acts. Thus, it can be speculated that effective CRM can help flight crew to manage errors before accidents and incidents occur. Also, a positive organizational safety climate can help organizations to reinforce the link between effective CRM and managing errors by promoting a shared understanding of the importance of safety and encourage a cooperative approach to error management (Gao et al., 2013).

A positive organizational safety climate is also important for managing fatigue-related risks in flight operations. Aircrews' flight and duty times are determined by aviation authorities such as FAA and EASA. For example, FAA determined that the minimum rest period before the duty is 10 hours and minimum rest period after the duty is 10 hours for non-augmented crew and 12 hours for augmented crews. Similarly, EASA determined the minimum rest period before the flight duty as 12 hours. They also regulates the maximum flight and duty times in a week, in a month and in a year (Caldwell, 2005, 2012; Caldwell et al., 2009; Gawron, 2016). However, the rest time regulated by FAA and EASA starts when the aircraft approaches the parking position and the engines shut down (Gawron, 2016). Considering that airports are generally located outside of the cities, pilots need to travel to the hotel or their homes before they rest. Thus, they have limited time to obtain sufficient sleep and meet their personal needs. As a result, it is highly unlikely to obtain a minimum 8 hours of sleep (Caldwell, 2012; Caldwell et al., 2009), which is the minimum sleep requirement for an adult (Wehr et al., 1993). A positive organizational safety climate can help the organizations to recognize the rest requirements of the pilots, analyze the fatigue-related risks inherent in the operations, and develop appropriate systems to reduce the fatigue related symptoms of the pilots by effectively planning the duty and rest period of pilots and training pilots on the countermeasures of the fatigue. Thus, it can be speculated that organizational safety climate can mediate the link between CRM competencies and unsafe acts by mitigating the symptoms of fatigue.

1.4. Fatigue

Fatigue, which is defined as a physiological state of reduced physical and mental performance capability resulting from sleep loss, extended wakefulness, circadian phase, and/or workload, which can impair a person's alertness and ability to adequately perform safety-related operational duties (ICAO, 2012) is an unavoidable aspect of flight operations due to their 24/7 nature. Aircrews are particularly susceptible to fatigue as they frequently experience multiple flight sectors, rapidly changing time zones, variable flight schedules, and limitations on both the duration and quality of sleep (Avers & Johnson, 2011).

While fatigue is a common symptom experienced in daily life, it poses a significant risk in high-risks operations like aviation, where it is recognized as a critical factor contributing to accidents and incidents (Caldwell, 2005). Aviation accident and incident reports indicate that fatigue has been a contributing factor in approximately 20% of aviation accidents and incidents (Åkerstedt, 2000; Petrie et al., 2004). Furthermore, it has been estimated that 4–8% of aviation accidents and incidents are directly attributable to fatigue (Caldwell, 2005).

Realization of significant contribution to accidents and incidents had raised the question of the prevalence of fatigue among pilots. Jackson and Earl (2006) reported that 75% of 162 pilots flying short-haul flights (flights less than 6 hours) showed severe fatigue on a chronic fatigue scale. Eighty-one percent of those pilots also reported that they felt more fatigued than they experienced 2 years ago. In addition, 80% of them reported impairments in judgments while flying due to fatigue. Reis and collegues (2013, 2016) also analyzed the prevalence of fatigue among commercial airline pilots. They reported striking results that showed approximately 91% of 453 airline pilots experienced severe fatigue. They also reported that the severity of fatigue was positively related to the flown hours. Additionally, a questionnaire conducted with 500 commercial airline pilots showed that 56% of the pilots fell asleep in the cockpit and 1 out of 3 captain pilots reported that they found F/O also fell asleep when they woke up. Among these pilots, 86% of them were reported decrease in their performance in the last 6 months (Steptoe & Bostock, 2011). Due to its high prevalence among pilots, the consequences of fatigue can be catastrophic in the aviation industry. Understanding its consequences and the effects on pilot behaviors can be vital to prevent adverse effects and enhance flight safety.

1.4.1. Consequences of Fatigue

Consequences of fatigue can be evaluated in a wide spectrum. Several studies have shown the consequences of fatigue regarding human performance. Some studies reported that fatigue is related to deterioration in psychomotor abilities and attention (Killgore et al., 2009; Tucker et al., 2010). Deterioration in visual performance due to the decrease in attention and visual perception was also shown as consequence of fatigue (Quant, 1992). Visual neglects in central and peripheral stimuli combined with decreased sensitivity to peripheral environment changes were also found to be the consequences of fatigue (Rogé et al., 2003). In addition, Jackson and collegues (2011) reported deficiencies in divided attention when participants were asked to respond visual and auditory stimuli. Participants committed significantly more omission and commission errors when they were sleep deprived.

Additionally, impairments in cognitive abilities have been observed by fatigue researchers. For example, fatigue due to excessive wakefulness resulted in poor working memory performance for auditory (Tyagi et al., 2009) and visual stimuli (Smith et al., 2002). Moreover, deficiencies in problem solving abilities (Linde & Bergströme, 1992), reasoning and processing abilities (Neri et al., 1992), and processing speed (Zuckerman et al., 2007) were reported consequences of fatigue due to sleep deprivation. Pilots are expected to monitor the automation systems and environmental changes consistently. They gather information from the aircraft systems, environment and other personnel. They are expected to perceive the information, process it and decide appropriate action. Also, they are expected to modify the actions or systems when necessary to ensure safe flight operations. When there is a deterioration in visual perception, processing and reasoning abilities, and problem-solving abilities, the unsafe acts of the pilots can be inevitable. For example, impairments in attention and visual performance might make pilots vulnerable to perceptual errors. Similarly, impairments in psychomotor abilities might be related to committing more skill-based errors.

Deterioration in reasoning and problem-solving abilities can also be directly related to the decision errors. Indeed, research conducted with a larger pilot sample in a different flight operation supported these ideas. Yen and collegues (2009) conducted research with 1893 pilots operating oceanic, regional or short-haul flights. They reported that pilots reported significant increase in headaches, eye irritation, shortening of the visual field, backaches, yawning, loss of interest and motivation, depressive state, irritability, drowsiness, aggressiveness, neck pain, difficulty in evaluating time, impatience, and decrease in verbal communication as the symptoms of physical fatigue after the flight. They also reported significant increase in desire to get rid of duties, lack of anticipation, lack of well-known actions and reflexes, difficulty in decision making, slow actions and movements, tendency to delay decision making, slow understanding, bad coordination of actions and movements, and difficulties in oral and written expressions as the symptoms of mental fatigue after the flight. As a result, they showed a significant increase in errors and little mistakes such as calculation or interpretation. Besides, pilots can be vulnerable to the feeling of reaching their destination as soon as possible when they are fatigued. Thus, they might commit more violations. Thinking of these possibilities, fatigue can become a vital factor in error management.

Although fatigue has predominantly been studied in the context of sleep deprivation, some researchers have highlighted its multidimensional nature (Arnedt et al., 2001; Avers & Johnson, 2011). Fatigue is considered a complex state that encompasses psychological, physiological, and emotional components. Physiological symptoms of fatigue have been linked to a range of indicators such as reduced reaction time, heavy eyelids, headaches, frequent yawning, lack of energy, and bodily aches. Mental fatigue, on the other hand, is characterized by difficulties in concentration, attentional lapses, challenges in thinking and decision-making, and communication problems. Furthermore, emotional fatigue has been associated with irritability towards friends, colleagues, and family, heightened emotional sensitivity, and a lack of motivation (Avers & Johnson, 2011). Despite the recognition of fatigue's multidimensional nature, there is limited research exploring the relationship between multidimensional fatigue and unsafe acts committed by pilots.

Regardless of its dimensions, fatigue is a significant yet often overlooked issue in the aviation industry (MacDonald, 2012) and should be recognized as a critical contributor to adverse events. Effective countermeasures must be implemented to prevent its harmful consequences. Several strategies have been adopted by airlines to address the risks associated with fatigue at both the individual and organizational levels. At the individual level, countermeasures such as cockpit napping, bunk sleep, activity breaks, and increased cockpit lighting, particularly during nighttime operations, have been proposed to alleviate fatigue during flight (Caldwell et al., 2009; Olaganathan et al., 2021; Petrie et al., 2004). These interventions aim to mitigate the symptoms of fatigue among pilots. At the organizational level, civil aviation authorities like the FAA and EASA enforce stringent regulations concerning duty and rest times, as well as scheduling practices. Additionally, these authorities have recommended that airline companies implement Fatigue Risk Management Systems (FRMS) to monitor and manage fatigue-related risks on an ongoing basis (Caldwell et al., 2009; Olaganathan et al., 2021).

To effectively address fatigue-related symptoms, beyond regulations, pilots must be aware of these symptoms in themselves and their colleagues in the cockpit. They should also engage in assertive communication regarding these symptoms, both with one another and with management, to mitigate the risk of adverse events associated with fatigue. For instance, when a pilot experiences fatigue and requires in-flight rest, they should communicate this to their fellow pilot, allowing for adjustments in workload to create time for cockpit napping or bunk sleep. This is where effective CRM serves as a crucial countermeasure to fatigue. Furthermore, when one pilot reports fatigue, the other pilot can increase monitoring of both the fatigued pilot and the automation system, as well as the changing environment. This enhances attention and situational awareness when necessary. To achieve this, effective CRM practices must be ensured and maintained.

Although little has known about the exact relationship between CRM and fatigue, fatigue management combined with workload management is an important part of effective CRM (Çetingüç, 2016, pp. 410). Effective CRM can play a vital role in reducing and managing unsafe acts resulting from fatigue in flight operations. By applying effective CRM, managing workload, encouraging teamwork and communication and cooperation in the cockpit can decrease fatigue-related symptoms.

The reduction of fatigue-related symptoms is closely linked to a positive organizational safety climate, which is exemplified through effective CRM practices. Pilots are expected to report being "unfit to fly" prior to initiating flight operations if they experience fatigue. In organizations with a positive safety climate, pilots are more likely to feel empowered to disclose their unfitness without fear of sanctions or repercussions. Such a climate fosters trust and promotes open communication regarding fatigue-related issues. However, research has shown that many pilots are reluctant to report fatigue, even though they acknowledge that fatigue has contributed directly to errors during flight operations (Jackson & Earl, 2006; Reis et al., 2013). This reluctance to report can amplify the effects of fatigue, especially when combined with in-flight fatigue, leading to severe or catastrophic consequences. Addressing this hesitation is vital for mitigating the risks associated with fatigue in aviation, highlighting the importance of cultivating a positive safety climate within organizations.

Apart from the fatigue at the individual level and organizational safety climate at the organizational level stated above, one surprising factor has emerged in the recent aviation accident investigation as a contributor factor which is the pernicious personality traits (Ma et al., 2023). Ma and colleagues reported that pernicious personality traits were the causal factors of 22% of the general aviation accidents. This result can be considered surprising for aviation, since airlines incorporate personality assessments as a part of their pilot recruitment processes. Consequently, pilots tend to exhibit similarities in personality traits and differ from the general population in certain characteristics. The findings of Ma and colleagues, which identified pernicious personality traits as factors contributing to aviation accidents, underscore the importance of investigating the relationship between personality traits and pilots' unsafe behaviors.

1.5. Personality

Personality research has, over the years, focused on exploring distinctive patterns of behavior within specific contexts and situations. Despite extensive study, researchers have not reached a consensus on a precise definition of personality (Pervin, 2002). However, various scholars have proposed a shared understanding of the concept. It is commonly acknowledged that personality contributes to the stable and unique patterns of thoughts, emotions, and behaviors exhibited by an individual (Pervin, 2002). Broadly, personality can be defined as the complex set of psychological attributes that influence an individual's characteristic behavioral patterns across different situations and over time (Gerrig, 2013).

Different psychologists have developed different theories and taxonomies regarding personality such as psychodynamic theories, humanistic theories, social-learning and cognitive theories and trait personality theories (Gerrig, 2013). Among these theories, the most influential and commonly used taxonomy is the Big Five or Five Factor Model of the personality (Sleep et al., 2021). Five Factor Model (FFM) of personality proposed five aspects of personality that individuals vary on (McCrae, 2010; McCrae & Costa, 2008; McCrae & John, 1992). However, FFM did not categorize individuals into certain types, indeed, it identifies the tendencies of individuals to behave in a particular way (McCrae, 2010; McCrae & Costa, 2008).

FFM has proposed that individuals differed on five traits namely extraversion, agreeableness, neuroticism, conscientiousness, and openness to experience which are stable across cultures (McCrae, 2010; McCrae & Costa, 2008; McCrae & John, 1992; Rolland, 2002). *Extraversion* reflects individuals' relationship with their social environment. Individuals who score high on extraversion dimension are seen as social, talkative, cheerful, enthusiastic, warm, excitement-seeking, fun-loving, loving, enterprising and energetic (McCrae & Costa, 2008; McCrae & John, 1992; Pervin, 2002; Rolland, 2002). Besides, extravert individuals are more likely to be leaders in the groups (McCrae & Costa, 2008). Whereas extraversion is mainly related to the individuals themselves, *agreeableness* is related to the relationship styles formed with other individuals (Rolland, 2002). Agreeableness consists of sympathy, thrust, cooperation and altruism (McCrae & John, 1992). Individuals who score high on this dimension are gentle to others, well-mannered, reliable, helpful and forgiving (McCrae & Costa, 2008; McCrae & John, 1992; Rolland, 2002). Contrary to extraversion and agreeableness, *neuroticism* reflects intense emotional instability (Rolland, 2002). Main features of neuroticism are characterized by anxiety, depression, anger, and hostility. Individuals who score high on neuroticism struggle with negative emotions, irrational thoughts, difficulty in communication and forming health relationships with others, and difficulty in managing stressful situations (McCrae & Costa, 2008; McCrae & John, 1992; Pervin, 2002; Rolland, 2002). *Conscientiousness*, on the other hand, is related to the self-discipline and self-control (Rolland, 2002). Individuals with high levels of conscientiousness strive for success, pursuing perfectionism in their work and have a high level of self-discipline to achieve their goals. At the same time, they think carefully and plan to act. Individuals high on conscientiousness are described as reliable, organized, hard-working, determined and ambitious (McCrae & Costa, 2008; McCrae & John, 1992; Pervin, 2002; Rolland, 2002). Lastly, *openness to experience* is characterized by freedom, intellectual creativity, curiosity, and behavioral flexibility. Individuals who score high on this dimension are enjoy from creativity and diversity in experiences and open to new and original ideas (McCrae & Costa, 2008; McCrae & John, 1992; Pervin, 2002; Rolland, 2002).

While McCrae and Costa (1997, 2008) argued that the five basic dimensions of personality are consistent across cultures, the interpretation of these dimensions may differ depending on the cultural context. A comprehensive study on the universality of the Five-Factor Model (FFM) has shown that the core dimensions are largely stable across 50 cultures, though certain dimensions are influenced by culturally specific interpretations (McCrae & Terracciano, 2005). Notably, an additional dimension, named *negative valance*, has been identified within the Turkish cultural context (Gençöz & Öncül, 2012). This negative valance factor encompasses self-attributions such as being ill-mannered, pretentious, greedy, hidebound, backstabbing, and rude.

Through the years, the dimensions of FFM have been used to predict behaviors of individuals in different contexts such as traffic and aviation (e.g. Bing et al., 2007; Ebrahim et al., 2022; Mallia et al., 2015; Sümer, 2003; Sümer & Özkan, 2002; Winter et al., 2021; Wu & Lebreton, 2011). Numerous studies have been dedicated to examining the relationship between personality traits and unsafe acts in the traffic context with different samples. Different researchers adopted different approaches to study this relationship. Some of them focused on the symptoms of the FFM dimensions such as anger, hostility, and sensation-seeking, and some of them focused on the dimensions as whole. Researches showed that driver anger and hostility, symptoms of neuroticism, were positively associated with violations, errors and lapses (Dahlen & White, 2006; King & Parker, 2008; Lucidi et al., 2019; Tanglai et al., 2022). Similarly, emotional stability which is also a symptom of neuroticism was negatively associated with risky driving and unsafe acts of the drivers (Dahlen & White, 2006). Besides, negative affectivity and hostility was found to be related to the violations and lapses (Beanland et al., 2014). The bus driver sample in Italy also yielded similar results. It was reported that bus drivers with hostile tendencies reported more violations and errors whereas bus drivers with high anxiety reported more lapses (Mallia et al., 2015). Among Turkish and Greek drivers, driver aggression was positively associated with unsafe acts of the drivers (Sümer, 2003) as well as the sensation-seeking tendencies which is the commonly studied openness-to-experience symptom of personality (Constantinou et al., 2011; Sümer, 2003).

Research focusing on the dimensions as a whole also showed the association between FFM factors and unsafe acts in different samples. For example, neuroticism was positively associated with aberrant driving behaviors such as exceeding speed limit, abnormal stay, driving overtime, and hard deceleration and acceleration among Taiwanese truck drivers. Also, agreeableness, conscientiousness and openness-to-experience was positively associated with driving overtime (Wei et al., 2021). Similarly, a large-sample study comparing drivers from China, Japan, and Vietnam showed that agreeableness was negatively associated with errors, lapses and violations (Hussain et al., 2020). However, other dimensions showed different results in different countries. For example, conscientiousness yielded negative correlations with slips, errors and violations among Japanese and Vietnamese drivers, yet it showed positive associations among Chinese drivers. Also, neuroticism was negatively associated with slips and violations among Chinese drivers yet positively associated with Japanese drivers (Hussain et al., 2020). Among the Australian and Italian drivers, neuroticism, extraversion and openness-to-experience were positively associated with aberrant driver behaviors whereas agreeableness and conscientiousness were negatively associated with them (Tinella et al., 2022).

In addition, studies on FFM factors conducted with Turkish drivers reported that conscientiousness, extraversion and agreeableness were negatively associated with errors, lapses and ordinary violations of drivers whereas neuroticism and negative valance was positively associated with errors, lapses and violations (Fındık et al., 2024). Similarly, extraversion, conscientiousness, agreeableness and openness-to-experience were found to be positively associated with errors while they were negatively associated with violations. Neuroticism and negative valance were negatively associated with errors and positively associated with violations (Yılmaz Demirok, 2023) implying that drivers with high levels of neuroticism and negative valance reported to commit less errors and more violations than drivers with low levels of neuroticism and negative valance.

Although the results from the example studies stated above showed the associations between personality traits and unsafe acts of drivers, the power of the associations showed smaller coefficients. Therefore, it can be inferred that personality traits can be the indirect predictors of unsafe acts rather than the direct prediction. Personality research in the aviation context had mainly different focuses. Thus, the following section will present the personality research findings in the literature.

1.5.1. Personality Research in Aviation

Personality research within the aviation context has primarily focused on identifying the personality profiles of pilots to ensure the selection of individuals best suited for the profession. Studies on fighter pilots have indicated that they tend to exhibit high levels of extraversion and emotional stability. Neuroticism, in contrast, has been negatively associated with pilot performance due to the inherently stressful nature of flight operations (Boyd et al., 2005; Callister et al., 1999; Chappelle et al., 2010; Furnham, 1992). Callister and colleagues (1999) further argued that individuals displaying high levels of anxiety, hostility, and impulsivity were unsuitable for piloting aircraft, particularly fighter jets. Moreover, military fighter pilots were reported to score higher on extraversion compared to the general population. However, more recent findings challenge these earlier conclusions. For example, Carretta and colleagues (2016) found that fighter pilots scored lower on extraversion and neuroticism but higher on thrill-seeking and adventure-seeking tendencies compared to the general population. Similarly, Glicksohn and Naor-Ziv (2016) reported analogous findings, and a study of Chinese fighter pilots demonstrated lower neuroticism and higher extraversion among this cohort (Chang et al., 2018).

Furthermore, Carretta et al. (2016) noted that military pilots exhibited higher levels of conscientiousness and lower levels of agreeableness relative to the general population. It has been suggested, however, that the personality traits conducive to success in military aviation may not align with the demands of commercial aviation (Musson et al., 2004). Fighter pilots typically operate solo, and their personality profiles are tailored for single-pilot flight operations. Yet, when transitioning to multicrew cockpit environments as captains, traits beneficial in solo operations might become detrimental in a collaborative setting (Musson et al., 2004). Therefore, it is critical to analyze pilots' personality traits within the appropriate operational context to ensure alignment with the specific demands of their roles.

In the context of commercial aviation, recent research examining actively flying airline pilots revealed distinct personality profiles compared to the general population. Pilots scored significantly lower on neuroticism, extraversion, and openness to experience while scoring significantly higher on agreeableness and conscientiousness (Mesarosova et al., 2019). Although Mesarosova and colleagues identified unique personality traits for a sample of UK airline pilots, their findings differed from previous studies in certain dimensions. For instance, Fitzgibbons et al. (2004) reported that commercial pilots in the United States scored lower on neuroticism and openness to experience and higher on conscientiousness, consistent with Mesarosova et al. However, U.S. pilots exhibited higher extraversion and lower agreeableness compared to the UK sample. A comprehensive review by Chaparro et al. (2020) synthesized findings from various studies in different aviation contexts. The review indicated that commercial airline pilots generally scored lower on neuroticism and higher on conscientiousness compared to the general population. Regarding extraversion, 75% of the reviewed studies found higher scores among pilots, while 25% reported lower scores. For agreeableness, half of the studies indicated lower scores for commercial pilots, while the other half reported higher scores. Similarly, for openness to experience, 50% of the studies found lower scores among pilots, while the remaining studies observed scores comparable to the general population. These findings highlight variability in personality profiles across different studies and contexts.

Although the influential research on personality profiles among pilots, there has been no consensus regarding the distinct personality profiles among pilots except for neuroticism and conscientiousness. Also, little was known regarding the relationship between personality traits and unsafe acts in the aviation context. Considering the results from driving context, personality traits might be used to predict unsafe acts of the pilots. Yet, this prediction might not be direct since the predictor power of the personality traits was low for unsafe acts in the driving context. Besides, variability in personality traits among drivers is probably higher than among pilot sample because personality assessments are the important for pilot selection processes (Martinussen & Hunter, 2018). This means that actively flying pilots share some level of personality traits such as low levels of neuroticism, high levels of extraversion, and high levels of conscientiousness (Martinussen & Hunter, 2018). As a result, the variability of scores in personality traits will be lower than the driver samples although there might be variability at a certain level. Since this could be an issue, the predictive power of personality traits on unsafe acts might be lower than the driver samples. For this reason, personality traits of pilots might not be the direct predictors of errors and violations committed during flight operations, but they might indirectly predict unsafe acts by moderating the relationship between CRM and unsafe acts.

Effective CRM plays a crucial role in mitigating unsafe acts, and personality traits related to interpersonal relationships may significantly influence CRM effectiveness. For instance, a study by Davis et al. (2005) demonstrated that agreeableness was negatively associated with the assertiveness and communication dimensions of CRM skills, indicating that pilots with higher levels of agreeableness and conscientiousness exhibited lower assertiveness and communication abilities. Furthermore, the study reported a positive association between openness to experience and situation awareness, suggesting that pilots scoring higher on openness demonstrated better situational awareness. It is important to note, however, that the reported associations were characterized by small effect sizes, highlighting the limited direct predictive power of personality traits on CRM competencies (Davis et al., 2005).

Consequently, rather than serving as direct predictors of CRM competencies or unsafe acts, personality traits may be more effectively utilized as moderating variables in the relationship between CRM competencies and unsafe acts. This approach could provide a more detailed understanding of the relationship between personality and CRM performance.

Apart from the CRM, fatigue and personality at the individual level stated above, aviation accident investigation analyses have shown that safety climate was a contributor factor for pilots' unsafe acts (Lenné et al., 2008; Ma et al., 2023; Shappell et al., 2007; Wiegmann & Shappell, 2001). Although the contribution reported in these studies were small, a positive safety climate might play an important role in CRM training programs to increase the safety participation of pilots and prevent fatigue symptoms by planning flight operations. CRM training programs might help organizations to create shared perceptions on safety prioritization and increase safety behaviors in flight operations implying the positive safety climate in the organizations. Similarly, a positive safety climate might help organizations to appropriately plan flight operation schedules to prevent pilots' fatigue before-flight and encourage them applying effective CRM to prevent in-flight fatigue. Therefore, although the individual contribution of safety climate in aviation accident analyses was small, a positive safety climate might help organizations to mitigate the result of other contributors to prevent unsafe acts. Consequently, examining the possible relationship between safety climate and unsafe acts as well as other contributors of unsafe acts such as CRM competencies and fatigue symptoms can be important to reveal the role of safety climate in unsafe acts occurrence.

1.6. The Aim of the Present Study

In light of existing literature, the present study focuses on gaining a deeper understanding of the relationship between Crew Resource Management (CRM) and unsafe acts among commercial airline pilots. Study 1 aims to revise the APilotBI-R through behavioral interviews and develop a self-report CRM competency scale to assess the CRM skills of commercial pilots. The main study, on the other hand, seeks to identify the predictors of unsafe acts, explore the mediating roles of organizational safety climate and fatigue symptoms, and examine how personality traits moderate the relationship between CRM competencies and unsafe acts.

CHAPTER 2

STUDY 1: REVISION OF AIRLINE PILOT BEHAVIOR INVENTORY AND DEVELOPMENT OF THE CRM COMPETENCY SCALE

2.1. Introduction

The unsafe acts of pilots are the direct causes of aviation accidents (Shappell & Wiegmann, 2000; Wiegmann & Shappell, 2001). Extensive analyses of aviation accidents have been conducted to examine the prevalence of unsafe acts contributing to these incidents. Findings indicate that approximately 57% of accidents were attributed to skill-based errors, 37% to decision errors, 7% to perceptual errors, and 23% to routine violations (Kelly & Efthymiou, 2019; Lenné et al., 2008; Ma et al., 2023; Shappell et al., 2007; Wiegmann & Shappell, 2001). While accident investigation analyses have offered valuable insights into the frequency of unsafe acts contributing to accidents, accurately measuring pilots' unsafe acts poses significant challenges for researchers. The frequency of these acts can be assessed through various methodologies, each with its own set of advantages and limitations.

Various methods are employed to measure pilots' unsafe acts, each with distinct advantages and limitations. Accident investigation analyses provide insights into the types and frequency of unsafe acts contributing to aviation accidents. However, their scope is limited by the rarity of accidents and the multifaceted contributors involved in such incidents (Martinussen & Hunter, 2018). Natural observations allow for capturing a wider range of unsafe acts that may not result in accidents. These observations are commonly used by organizations to evaluate pilots' performance but are often confidential and limited to authorized personnel. Observer reliability and the potential influence of observation on pilot behavior also pose challenges, requiring rigorous observer training, which can be costly. Alternatively, video recordings may improve reliability but introduce additional resource demands (Mavin & Roth, 2014; Caponecchia et al., 2014).

Flight simulators offer another method, enabling controlled assessments of unsafe acts through tailored scenarios. However, high-fidelity simulators, typically accessible only to airline companies due to their expense, limit widespread use. While low-fidelity simulators are an option, they raise concerns about reliability and generalizability (Martinussen & Hunter, 2018). Self-report measures, such as the Airline Pilot Behavior Inventory (APilotBI), present a low-cost and scalable method for assessing unsafe acts. This tool, developed by Serin (2016) based on theoretical frameworks and subject matter expertise, includes 46 examples of unsafe acts. However, theoretical development necessitates further revision through pilot interviews. While self-reports are vulnerable to socially desirable responding, ensuring anonymity can mitigate this issue (Lajunen & Summala, 2003; Yılmaz et al., 2022). Therefore, revising APilotBI is one of the aims of study 1.

Assessing the frequency of unsafe acts is critical not only for preventing their recurrence but also for understanding the underlying contributors in commercial aviation. To address this issue, airline companies have implemented Crew Resource Management (CRM) training programs designed to equip pilots with the skills to effectively utilize all available resources. CRM plays a central role in managing errors and ensuring flight safety within the airline industry. The recognition of human factors as significant contributors to aviation accidents has elevated the importance of CRM over the years. Consequently, airlines have increasingly developed and implemented CRM training programs aimed at enhancing crew members' non-technical skills, including communication, collaboration, team performance, situational awareness, decision-making, workload and fatigue management, and stress management. Following 2001, aviation authorities mandated CRM training programs for pilots involved in passenger-carrying operations (Çetingüç, 2016).

After the first initiation, the effectiveness of the CRM training programs became into question since effective CRM applications in the cockpit came from the effective learning and turning learning into behaviors. Different researchers developed different measures of CRM focusing different aspect of it such as attitudes and behaviors (Flin & Martin, 2001; Helmreich, et. al., 1990; Helmreich & Wilhelm, 1991; O’Connor et al., 2002). To assess attitudes, Cockpit Management Attitudes Questionnaire was commonly used (Gregorich et al., 1990). Attitude studies mainly showed positive attitudes toward CRM (Bennett, 2019; Boedigheimer, 2010; Brown

& Rantz, 2010; Helmreich, et. al.,1990; Helmreich & Wilhelm, 1991). Contrary to attitudes studies, behavior studies lacked quantity and consensus. A study conducted by Thomas (2004) reported that higher levels of cooperation, assertiveness, situation awareness, vigilance and contingency planning was associated with higher numbers of errors managed. However, Serin (2016) did not found significant association between unsafe acts and CRM behaviors.

To evaluate CRM behaviors, behavioral marker systems such as the Line/LOS Checklists (Helmreich et al., 1997) and the NONTECHS behavioral marker system (Flin et al., 2003) have been developed. These markers are designed primarily for organizational use, requiring trained observers to assess pilots' behaviors during line operations. While these tools offer a comprehensive approach to assessing CRM behaviors, their reliance on specialized training and direct cockpit observations makes them challenging for researchers without authorization to access the cockpit. This limitation highlights the need for accessible and easy-to-use CRM measurement tools for research purposes. Moreover, CRM training programs aim to enhance pilots' CRM skills and foster the application of these skills in operational contexts. Translating acquired skills into practical behaviors requires pilots to feel competent in applying these skills (MacLeod, 2021). Contemporary CRM training programs incorporate competency-based training approaches to facilitate the integration of learned skills into professional behaviors (Başdemir, 2020; MacLeod, 2021). Consequently, an effective CRM measurement tool should encompass both skills and behaviors, providing a comprehensive assessment of pilots' competencies.

In the light of the existing literature, study 1 aims to explore the CRM competencies of commercial airline pilots in Türkiye and develop a self-report easy-to-use CRM competency measure.

2.2. Method

2.2.1. Participants

Twelve male commercial airline pilots participated in the semi-structured interviews. The age range of the participants was between 30 and 54 (*M*= 40.333, *SD*= 8.326). Five of them were First Officers (F/O) and seven of them were Captain Pilots (CP). Four of them were also working as CRM instructors in their companies. The mean of the total flight hours in the commercial airlines was 6425 hours (*SD*= 3616.911).

2.2.2. Procedure

Ethical permission was obtained from Middle East Technical University Ethics Committee (see Appendix A) for the interview study. Semi-structured interviews were conducted with 12 commercial airline pilots with different experience levels. All interviews were conducted online via Zoom or Microsoft Teams.

At the beginning of the interviews, all participants were given information about the aim of the interviews and asked to give verbal consent about their voluntary participation in the interviews (see Appendix B for Inform Consent). All participants were informed that video recordings would be obtained during the interview for the analysis process. Participants were assured that all the personal information would be blurred in the videos to ensure anonymity.

2.2.3. Instruments

The interview form consisted of some demographic questions and questions related to the CRM competencies and pilots' unsafe acts in different situations (see Appendix C). Demographic questions contained age, gender, their current position in their job and the total flight hours in the commercial airlines.

Behavior questions were focused on errors and violations that pilots can commit during the different phases of flight operations such as preparation, take-off, cruise, landing and parking. Errors were defined as the failure of a behavior to achieve the desired result. This may be due to memory or attention problems, or the behavior performed to achieve the desired result is not appropriate for the desired result. Violations were defined as knowingly and intentionally not applying rules or procedures or applying them differently. Participants were asked to exemplify errors and violations that they might commit as many as possible. The example questions for errors and violations were "When you think about the behaviors a pilot exhibits during flight to gain and maintain control of the aircraft, what errors can a pilot commit in this process?" and "When you think about what needs to be done when coming into parking position after the flight and parking it, what violations can a pilot commit during this process? The questions were flourished during the interviews based on the behavior classification of human factors analysis and classification system namely skill-based errors, decision errors, perceptual errors and violations (Shappell & Wiegmann, 1997; Wiegmann & Shappell, 2001).

CRM competency questions were focused on different situations that pilot could face during the flight. Normal flight conditions, stressful situations, emergency situations and fatigued situations that could affect the safety of the flight. To separate stressful conditions and emergency situations, stressful situations were defined as the situations when there was a problem during the flight that did not require immediate action. Emergency situations, on the other hand, were defined as problematic situations that required immediate action during the flight. The questions were flourished during the interviews to capture core competency elements proposed by European Union Aviation Safety Agency (EASA, 2023). Participants were asked to exemplify the competencies that are needed to ensure flight safety in normal conditions, stressful conditions, emergency conditions and when they were fatigued. For example, they were asked “Which CRM competencies do you use in an emergency?”, “Which CRM competencies do you use in the stressful situations?” and “Which CRM competencies do you use during the decision-making process in the flight?”. Besides, all questions in the interview form were clarified to capture core competencies proposed by EASA. Example clarification questions were “which competencies do you need during manual flight?”, “which competencies do you need communication with the crew, air traffic control (ATC) or other crews?” and “which competencies do you need to achieve situation awareness?”. Participants were also encouraged to comment on competencies that they need or use during the flight other than the ones asked for.

2.3. Results

Each recording was transcribed verbatim to prepare the recording for content analysis. Transcription was performed separately by the researcher.

2.3.2. Revision of APilotBI Items

In the transcription process, each unsafe act mentioned by participants was meticulously documented, with every error and violation recorded item by item in a Word document. These unsafe acts were formatted using infinitive verb forms and first-person pronouns for consistency. Additionally, items from the original APilotBI were incorporated into the list, resulting in a preliminary item pool of 138 unsafe act items. To refine the item pool, items were reviewed by the author, identifying and marking duplicates. For each set of duplicates, only one representative item was retained. Following this initial evaluation, the item pool was reduced to 72 unique items. Of these, 40 items were found to be identical to those in the original APilotBI.

A second evaluation was conducted by a subject matter expert, who was a captain pilot and a CRM instructor. This review focused on ensuring that the items adhered to aviation-specific terminology and were consistent with safety regulations. After this expert evaluation, the final item pool was refined to 68 items, ensuring relevance and precision for further use.

Finally, the items were reviewed by six subject matter experts, all of whom were actively flying pilots. Each expert was provided with definitions of the specified error types and violations and was asked to assign each item to the most relevant dimension (refer to Appendix D for the Expert Evaluation Form). The evaluations revealed that 57 out of the 68 items were consistently assigned to the same dimensions, demonstrating an 83% agreement among the experts. Of the remaining items, five were assigned to the same dimensions by at least three experts, suggesting partial consensus. However, no consensus was reached for six items, leading to their exclusion from the inventory. As a result, the final version of the APilotBI-R comprised 62 items under four theoretical dimensions of *skill-based errors, decision errors, perceptual errors, and violations.*

2.3.1. Developing the item pool of CRM-CS

In the process of transcription, each competency mentioned by the participants was recorded item by item in a Word document. Once transcription was completed, all competencies stated by the participants were compiled into a preliminary item pool. These competencies were rephrased using first-person pronouns and written in the infinitive form to ensure consistency. The initial pool comprised 165 items. the item pool, then, was reviewed by the author for identifying and highlighting duplicate competencies. For each duplicate, only one instance was retained, resulting in 98 competencies after the first round of evaluation.

Next, a subject matter expert, a captain pilot and CRM instructor, conducted a second evaluation. This review focused on theoretical alignment and the appropriateness of the competencies within the framework of the European Union Aviation Safety Agency (EASA) core competency framework. Following this evaluation, 82 competencies were retained. Subsequently, the remaining items were sent to six subject matter experts, all of whom were actively flying airline pilots. The experts were provided with definitions of each dimension in the EASA core competency framework and asked to assign each item to its most relevant dimension (see Appendix E for the Expert Evaluation Form). The results showed that 75 items were consistently assigned to the same dimensions, indicating a 91% agreement rate among the experts.

For the remaining seven items, at least three experts assigned them to the same dimensions, but the lack of consensus among the other three experts suggested potential issues with wording. To address this, the seven items were rephrased for clarity. After re-wording, the subject matter experts confirmed the clarity of these items. Consequently, all seven reworded items were retained on the scale. The final version of the Crew Resource Management Competency Scale (CRM-CS) consisted of 82 items under seven theoretical dimensions of *application of knowledge, procedures and regulations, communication and coordination, flight management under automation and manual control, leadership and teamwork, situation awareness and decision making, and workload management*.

2.4. Discussion

In Study 1, the 62 items of APilotBI-R were grouped into 4 theoretical and thematical dimensions: *skill-based errors*, *decision errors*, *perceptual errors, and violations.* Skill-based errors consisted of behaviors related to the prioritizing of attention, omission or commission of some items in the checklists, and rotely application of highly practiced habitual behaviors. Decision errors were related to the application of inappropriate plans and procedures. Perceptual errors were related to the misunderstanding of the changes and information presented in the environment and other crew members. Violations, on the contrary, were related to wishful incompliance with procedures and regulations.

The 82 items of CRM-CS were grouped into 7 theoretic and thematic dimensions: *application of knowledge, procedures and regulations, communication and coordination, flight management under automation and manual control, leadership and teamwork, situation awareness and decision making, and workload management*. Application of knowledge, procedures and regulations were related to the competencies for applying and following existing knowledge, procedures and regulations. Communication dimension was related to the competencies for interpersonal communication and coordination. Flight management under automation and manual control was related to the competencies for managing and monitoring the deviations from the flight plan under automation and manual control. The leadership and teamwork dimension were related to the competencies required for interpersonal relationships between crew members. Situation awareness and decision-making dimension was related to the competencies required for perception, comprehension and management of environmental changes and usage of that knowledge in decision making processes. Lastly, workload management was related to the competencies required for maintaining effective work capacity by prioritizing and distributing the available work.

Study 1 was a qualitative study aiming to provide bases for revision of APilotBI-R and development of CRM-CS. This qualitative characteristic of Study 1 strengthens the basis of the questionnaires and improves the comprehensiveness of the questionnaires. The interviewees in Study 1 were actively flying pilots with different experience levels and position titles. This provided obtaining a variety of competencies and behaviors during the interviews. Also, some of the interviewees were CRM instructors, which strengthens the variety of obtained information. Semi-structured interviews provided flexibility to obtain much information. When clarification was needed, the questions were paraphrased and re-asked to the interviewees. For behavior questions, interviewees were hesitant to provide classified information such as SOPs which could be important to understand the standard operation functions. However, they provided comprehensive behavioral examples which could strengthen the content of APilotBI-R.

Additionally, a measure focusing on CRM competencies of commercial airline pilots was developed. In line with this aim, semi-structured interviews were conducted with 12 actively flying commercial airline pilots, which were transcripted and analyzed in content to extract example CRM competencies. The final version of the questionnaire included 82 items measuring CRM competencies (see Appendix I for final items). Study 1 also aimed to revise APilotBI-R which measures unsafe acts of commercial airline pilots. In line with this aim, behavior questions were included in the semi-structured interviews. The final version of APilotBI-R included 62 behavioral items (see Appendix J for final items).

To summarize, Study 1 provided valuable information to develop CRM-CS and revise APilotBI-R. The qualitative approach in Study 1 enriched the content of

CRM-CS and APilotBI-R. The attempt to develop CRM-CS and revise APilotBI-R is believed to provide valuable information in literature. Future research will address the theoretical and empirical predictors and outcomes of relationships by using CRM-CS and APilotBI-R. It is believed that theoretical and empirical information obtained from the usage of CRM-CS and APilotBI-R would positively contribute to flight safety and aviation psychology literature. The following section will present the factor structures of the newly developed CRM-CS and revised version of APilotBI-R, psychometric properties of the questionnaires, and the relationships with other safety critical variables.

CHAPTER 3

MAIN STUDY: EXAMINING THE RELATIONSHIP BETWEEN CRM COMPETENCIES, ORGANIZATIONAL SAFETY CLIMATE, INDIVIDUAL VARIABLES AND UNSAFE ACTS OF THE PILOTS

3.1. Introduction

Aviation accident analyses have revealed that skill-based errors were found to be the leading causes of these accidents followed by decision errors, violations and perceptual errors. These analyses have also shown the contributor factors of unsafe acts such as CRM failures, fatigue, pernicious personality traits and safety climate. Realization of unsafe acts as direct causes of accidents, airline companies developed CRM training programs to prevent unsafe acts and mitigate the consequences of contributor factors (Gregorich et al., 1990; Helmreich et al., 1999; Helmreich & Foushee, 2010).

CRM plays a pivotal role in preventing, trapping, and mitigating unsafe acts. CRM training programs are designed to equip crew members with the skills necessary for the effective application of CRM principles to manage unsafe acts before they culminate in adverse events (Helmreich & Foushee, 2010). Consequently, effective CRM serves as a critical countermeasure to mitigate unsafe acts, particularly those occurring within the cockpit. Despite its importance, the literature offers limited research on the relationship between CRM and the unsafe acts of commercial airline pilots.

In examining this relationship, Thomas (2004) found that crew vigilance, situational awareness, information sharing regarding plans and changes, and decision-making skills were negatively correlated with the number of errors committed during flights. Furthermore, these CRM skills were positively associated with the ability to trap errors before adverse outcomes occurred. This suggests that CRM skills such as situational awareness, vigilance, communication, coordination, and decision-making are critical for preventing and mitigating unsafe acts during flight operations.

However, Serin (2016) reported conflicting findings, indicating that safety operation behaviors, behavioral manifestations of CRM, were not significantly associated with self-reported unsafe acts. These divergent results highlight the need for further research to explore the relationship between CRM and unsafe acts among commercial airline pilots. Moreover, they suggest that additional factors may influence this relationship, needing a more detailed examination into the relationship between CRM and pilots' unsafe acts.

A critical factor that might influence committing unsafe acts is aircrew fatigue which is a crucial problem for current flight operations (Caldwell, 2012; Olaganathan et al., 2021; Steptoe & Bostock, 2011). Flights are 7/24 non-stop operations around the world. Aircrew spend several hours in the cockpit, operate in the night, change time zones frequently, and get limited sleep in time and quality. Thus, this makes aircrew vulnerable to fatigue. Studies showed that majority of the pilots experienced severe fatigue symptoms and decrease in job performance due to fatigue (Caldwell, 2012; Jackson & Earl, 2006; Reis et al., 2013, 2016; Steptoe & Bostock, 2011). Thus, it can be speculated that pilots might be vulnerable to committing unsafe acts due to the important consequences of fatigue.

Numerous studies have shown the consequences of fatigue on human performance. Fatigue has shown to be related to deterioration in psychomotor abilities and divided attention (Killgore et al., 2009; Tucker et al., 2010), decrease in attention and visual perceptions (Quant, 1992), and insensitivity to environmental changes (Rogé et al., 2003). Also, decrements in working memory performance (Tyagi et al., 2009), problem solving abilities (Linde & Bergströme, 1992), and processing speed and abilities (Neri et al., 1992; Zuckerman et al., 2007) were well-stated in the literature. When there is a deterioration in visual perception, processing and reasoning abilities, and problem-solving abilities, the unsafe acts of the pilots can be inevitable. For example, impairments in attention and visual performance might make pilots vulnerable to perceptual errors. Similarly, impairments in psychomotor abilities might be related to committing more frequent skill-based errors. Deterioration in reasoning and problem-solving abilities can also be directly related to the decision errors.

Consequences of fatigue were also shown among pilots. Yen and colleagues (2009) studied 1,893 pilots flying oceanic, regional, or short-haul routes. Their findings revealed that pilots experienced notable physical fatigue symptoms after flights, including headaches, eye irritation, reduced visual field, back pain, yawning, loss of interest and motivation, depressive moods, irritability, drowsiness, aggressiveness, neck pain, difficulty perceiving time, impatience, and reduced verbal communication. Mental fatigue symptoms were also reported, such as a heightened desire to avoid duties, diminished anticipation, impaired reflexes, slower decision-making and movements, delayed understanding, poor coordination, and challenges in oral and written communication. These issues often led to more errors and minor mistakes, such as miscalculations or misinterpretations. Additionally, fatigued pilots showed a greater inclination toward "get-there-itis," prioritizing arrival over safety, which increased the likelihood of rule violations. Considering these factors, fatigue emerges as a critical element in managing errors effectively.

Airline companies have introduced various strategies to manage pilot fatigue, including cockpit napping, using bunk beds for sleep, scheduling activity breaks, and increasing cockpit lighting during night flights (Caldwell et al., 2009; Olaganathan et al., 2021; Petrie et al., 2004). However, for these measures to be effective, pilots must be able to recognize signs of fatigue in themselves and their colleagues. They should also communicate these concerns openly and assertively, both within the cockpit and with management. This is where effective CRM becomes essential. For instance, when a pilot declares fatigue another other one can increase monitoring of the fatigued pilot, automation systems, and the changing environment, enhancing attention and situational awareness. Effective CRM ensures harmonious adaptations to sustain flight safety. Consequently, effective CRM practices are crucial to mitigating the effects of fatigue in the cockpit, which in turn can improve effective management of unsafe acts.

The last factor that might be important for committing unsafe acts is the personality traits of the pilots. Several studies have shown the association between personality traits and unsafe acts. Driver anger and hostility (Beanland et al., 2014; Dahlen & White, 2006; King & Parker, 2008; Sümer, 2003; Tanglai et al., 2022), emotional stability (Dahlen & White, 2006), and negative affectivity (Beanland et al., 2014) were associated with unsafe acts of drivers. Additionally, anxiety levels (Mallia et al., 2015) and sensation-seeking tendencies (Sümer, 2003; Sümer & Özkan, 2002) were found to be correlated with unsafe acts of drivers. Besides, agreeableness, conscientiousness and openness-to-experience, i.e. dimensions of FFM, were associated with aberrant driver behavior (Hussain et al., 2020; Tinella et al., 2022; Wei et al., 2021) and unsafe acts of drivers (Hussain et al., 2020). However, it is important to note that the associations between personality traits and unsafe acts of drivers reported above were relatively small.

In the aviation context, the role of personality traits differs from that in driving, as personality assessments are a key component of the pilot recruitment process (Martinussen & Hunter, 2018). Pilots were reported to have lower levels of neuroticism and higher levels of conscientiousness than the general population (Chaparro et al., 2020; Fitzgibbons et al., 2004; Mesarosova et al., 2019). However, no consensus was reached on other dimensions of FFM. Also, little was known regarding the relationship between personality traits and the unsafe acts of pilots. Thus, there is a need for examination of the relationship between personality traits and unsafe acts in the aviation context.

Considering the weak associations between personality traits and unsafe acts of drivers, the associations between personality traits and unsafe acts of pilots might be weaker due to the personality assessments during recruitment process. This might create a restricted range in the variability of personality scores among pilot samples. For this reason, examining the direct relationship between personality and unsafe acts could be misleading. However, personality traits can be treated as moderators between CRM and unsafe acts. Especially personality traits related to interpersonal dynamics such as agreeableness, conscientiousness, neuroticism and extraversion can play a role in regulating CRM and unsafe acts. For instance, a study by Davis et al. (2005) found that agreeableness was negatively correlated with the assertiveness and communication aspects of CRM, indicating that pilots with higher agreeableness and conscientiousness exhibited lower assertiveness and communication skills. Conversely, openness-to-experience was positively associated with situational awareness, suggesting that pilots with higher openness demonstrated better situational awareness. However, these associations were relatively weak, reflecting the limited predictive power of personality traits as direct determinants of CRM competencies.

The last factor that might influence committing unsafe acts is organizational safety climate. A positive organizational safety climate is characterized by a strong commitment to safety, effective and open communication, prioritizing safety over productivity, encouraging the reporting of safety concerns without fear of retaliation, and providing resources to support safe operations (Zohar, 2010). Numerous studies have shown the relationship between positive safety climate and unsafe acts. A positive safety climate was associated with less dangerous driving (Zohar, 2010), less frequencies of self-reported errors and violations (Öz et al., 2010, 2013; Şimşekoğlu & Nordfjærn, 2015; Sullman et al., 2002) among professional drivers such as truck drivers, bus drivers and tanker drivers. Also, the positive safety climate was associated with high levels of safety participation, safety compliance and courtesy among pilot samples (Fernandes et al., 2018; Lin, 2012; Maneechaeye & Potipiroon, 2022b; Xu et al., 2022). Although studies among pilot samples address safety behaviors rather than special attention to unsafe acts, they reported promising results. However, considering the results from the professional driver samples, it is important to examine the relationship between organizational safety climate and unsafe acts.

A strong safety climate can also be important for an effective CRM. The elements of a strong organizational safety climate such as commitment to safety, effective and open communication, and prioritizing safety over productivity are deeply rooted in the principles of CRM. Organizations are responsible for promoting flight safety by implementing and enforcing rules, regulations, and procedures, as well as revising them when safety concerns arise. This responsibility is reflected in how crew members apply CRM to maintain safety during operations. Therefore, it can be speculated that positive evaluation on CRM can be related to the positive evaluations on organizational safety climate, which in turn can be associated with committing unsafe acts.

A strong safety climate in aviation organizations can also be important for mitigating the symptoms of fatigue. Although aircrews' flight, duty and rest times are determined by aviation authorities such as FAA and EASA, fatigue is still a crucial problem for committing unsafe acts (Caldwell, 2005, 2012; Caldwell et al., 2009; Gawron, 2016). Since the regulations on rest times specify the minimum required rest time, and commonly flight operation schedules are arranged based on these minimum requirements, pilots are highly likely to have less time to get sufficient sleep (Caldwell, 2012; Caldwell et al., 2009). Thus, a positive organizational safety climate enables organizations to identify pilots' rest needs, assess fatigue-related risks inherent in operations, and implement systems to minimize fatigue symptoms which in turn can mitigate the risk of committing unsafe acts and improve flight safety.

In the light of the existing literature, therefore, the present study mainly aims to examine the predictors of unsafe acts of commercial airline pilots and to explore possible mediator role of organizational safety climate and fatigue symptoms in the relationship between CRM competencies and unsafe acts. It is also aimed to explore the possible moderator role of personality traits in this relationship. In order to test these relationships, first the factor structures of the newly developed CRM-CS, and the revised APilotBI-R were determined.

3.2. Method

3.2.1. Participants

A hundred and seventy-six commercial airline pilots participated in the present study. Ten of them were female (5.7%) and a hundred and sixty-six of them (94.3%) were male pilots. The age range of the participants was between 25 and 62 (M =40.56, SD= 8.964). Among the participants, 91 of them (51.7%) were currently working as Captain Pilots (CP) and 85 of them (48.3%) were working as First Officers (F/O). The average of the total flight hours in commercial aviation was 6237.20 hours (SD=5353.676). The average hours flown in the last month was 71.93 (SD=19.332). Participants reported that they experienced an average of 0.19 incidents (SD=0.621) in the last year (see Table 1). The mean stress level of the participants in the normal flight conditions was 4.085 (SD= 1.935) over 11 (severely stressed).

3.2.2. Instruments

3.2.2.1. Demographic Information Form.

Demographic information form (see Appendix H) consisted of questions regarding participants' age, gender, current work position, total hours flown in commercial aviation, the hours flown in the last month, the number of incidents they experienced in the last three years, and the stress levels during the normal flight rated on 11-point Likert-type scale (0=not stressed at all, 10=severely stressed).

3.2.2.2. Airline Pilot Behavior Inventory-Revised.

The original 46-item Airline Pilot Behavior Inventory was revised in the present study (APilotBI-R). APilotBI-R consisted of 52 items measuring unsafe acts of commercial airline pilots (see Appendix I). The scale showed a 4-factor structure, named as *skill-based failures, decision failures, memory failures, and procedural incompliance*. Skill-based failures consisted of 27 items. Decision failures consisted of 10 items. Memory failures consisted of 7 items, and procedural incompliance consisted of 8 items. The Cronbach's alpha reliability coefficient of the factors was .90, .74, .70, and.70, respectively. The items of the inventory were rated on a 6-point Likert-type scale (1=Never, 6=Always).

3.2.2.3. CRM Competency Scale.

CRM Competency Scale (CRM-CS) was developed in the current study (see Appendix J). The scale consists of 49 competency items and three factors named *Flight Monitoring and Management* (FMM), *Fatigue and Work Management* (FWM), and *Crew Communication and Coordination* (CCC). FMM consisted of 21 items. FWM consisted of 13 items, and CCC consisted of 15 items. Internal reliability coefficients of the factors were .94, .87 and .91, respectively. The items were rated on a 5-point Likert-type scale (1= Poor, 5= Very Good).

Table 1. Demographic information

	Mean	*SD*	*Minimum*	*Maximum*	*%*	*N*
Age	40.56	8.964	25	62		
Total hours flown	6237.20	5353.676	127	24000		
Monthly hours flown	71.93	19.332	20	100		
Incident	0.19	0.621	0	4		
Stress	4.085	1.935	0	8		
Gender						
Male					166	94.3
Female					10	5.7
Position						
CP					91	51.7
F/O					85	48.3

3.2.2.4. Aviation Safety Climate Scale.

The Aviation Safety Climate Scale (ASCS) was developed by Evans, Glendon, and Creed (2007). The original ASCS comprised 18 items that assessed perceptions of the safety climate within a company (see Appendix K for the items). The original study proposed a three-factor structure, with the first factor labeled *Management Commitment and Safety Communication, Safety Training,* and *Equipment and Maintenance. The Management Commitment and Safety Communication* factor included 10 items. The Safety Training and Equipment and Maintenance factors each consisted of 4 items. Participants were asked to respond to each item using a 5-point Likert scale ranging from 1 "strongly disagree" to 5 "strongly agree." Cronbach's alpha coefficients for internal reliability were .95 for management commitment and safety communication, .89 for safety training and .87 for equipment maintenance in the present study.

3.2.2.5. Basic Personality Trait Inventory.

Basic Personality Trait Inventory (BPTI) was developed by Gençöz and Öncül (2012) to measure personality traits of Turkish people (see Appendix L). The scale consists of 45 adjectives that describe the person's characteristics. It revealed 6 personality traits, namely *extraversion, conscientiousness, agreeableness, neuroticism, openness to experience* and *negative valance*. The internal reliability coefficients of the factors were .83, .80, .86, .83, .73, and .68 in the present study, respectively. The items were rated on 5-point Likert-type scale ranging from 1 "this characteristic does not represent me at all" and 5 "this characteristic represents me very well."

3.2.2.6. Multidimensional Fatigue Symptom Inventory- Short Form.

The short form of the Multidimensional Fatigue Symptom Inventory (MFSI-SF) was originally developed to measure chronic fatigue symptoms of cancer patients (Stein et al., 2004). The inventory consists of 30 items measuring fatigue symptoms (see Appendix M). Since the inventory was developed to measure the multidimensional nature of fatigue, MSFI-SF was used to measure the fatigue symptoms of commercial airline pilots during the last month before participation. The inventory yielded 5 factors originally, named *general fatigue, physical fatigue, emotional fatigue, mental fatigue,* and *vigor*. Respondents were asked to rate their symptoms during the last month before participating in a 5-point Likert-type scale (0 = not at all; 4 = extremely). Cronbach's alpha coefficients for internal reliability were .90 for general fatigue, .88 for mental fatigue, .89 for physical fatigue, .89 for emotional fatigue, and .89 for vigor in the present study.

3.2.3. Procedure

Data collection was conducted through an online platform. The questionnaire package was uploaded on Qualtrics.com, and participants were recruited via personal messages on LinkedIn. They were provided with detailed information regarding the study's voluntary nature, objectives, and the procedures to be followed. Confidentiality and anonymity of their responses were also assured.

3.3. Results

A total of 185 commercial airline pilots participated in the study. However, 4 of them were excluded from the dataset since they did not complete the CRM-CS. The remaining 181 participants were subjected to the outlier analysis by calculating z-scores based on the total amount of time they had flown in commercial aviation and the amount of time they flown last month. Five of the remaining participants were also excluded from the dataset since they were outliers based on the analysis. Further analyses were conducted with the remaining 176 participants.

In the main study, explanatory factor analyses were conducted for revised version of APilotBI-R and the newly developed CRM-CS and. Confirmatory factor analysis was conducted for SOB, ASCS and MFSI-SF to ensure that their original factor structures were suitable for the data. BPTI, on the other hand, used in the original form since it was developed for measuring personality traits of Turkish people. You can find the explanatory factor analyses and confirmatory factor analyses results below. For further analyses, mean calculations were conducted for the factors of each scale.

3.3.1. *Factor Structure of APilotBI-R*

Principal axis factoring (PAF) analysis was conducted to explore the factor structure of the APilotBI-R. The Kaiser-Meyer-Olkin measure was .76, indicating that the sampling was adequate. In addition, Bartlett's test of sphericity was significant, indicating that the items were factorable (χ^2=5282.473, df = 1891, p< .001). The Eigenvalues of the 17 factors were greater than 1. However, the scree plot suggested a 4-factor structure. Since the 4-factor structure produced meaningful and interpretable solution, the final factor analysis was conducted by using 4-factor solution with oblique rotation. The Promax rotation method was used in the analysis because most of the factors had correlations higher than .50.

After the 4-factor solution for APilotBI-R, PAF analysis with Promax rotation was performed by fixing the number of factors to 4. Factor loading coefficients under .30 were suppressed to avoid cross-loadings and to achieve more compact patterns for factors. As a result, the 4-factor solution explained 30.180 % of the total variance. The contributions of the four factors to the explained variance were 19.165 %, 4.238 %, 3.713%, and 3.064%, respectively. A total of 53 items were loaded on one of the 4 factors (see Table 2). The remaining 9 items were excluded from the scale since they had smaller coefficients than .30. The pattern matrix showed 4 of the items were cross loaded across factors.

The first factor had the initial eigenvalue of 11.883 consisting of 28 items. This factor was mainly related to the poor technique of the pilots and inadvertent deviations from the rules and regulations. Example items for this factor were “Fixing on external factors and skipping routine monitoring”, “Climbing with wrong FPM” and “Forgetting one or more items when completing checklists”. Thus, this factor was named as *skill-based failures*. Skill-based failures initially consisted of 28 items, three of which were cross-loaded on other factors. Amon these three items, two of them had factor loadings on which the difference between them were exceeding .100. Thus, these two items remained in the factor. However, one of the items had a difference of less than .100 so it was excluded from the factor for further analysis. Skill-based failures consisted of the remaining 27 items.

The second factor had the initial eigenvalue of 2.627 consisting of 10 items. This factor is mainly related to the poor decisions made by pilots while controlling the flight. The example items for this factor were “Forcing the plane to land rather than diverting”, “Not using appropriate speed and thrust/N1 value during turbulence” and “Completing checklists rotely”. Therefore, this factor was called *decision failures*.

The third factor had the initial eigenvalue of 2.302 consisting of 7 items. This factor is mainly related to memory failures often associated with forgetting the intentions. Example items of the factor were “While parking, activating another application (e.g. nose wheel lock) instead of the parking brake”, “Forgetting to activate the "parking-brake" when parking the plane” and “Forgetting to gear-up after takeoff”. Therefore, this factor was named *memory failures*.

The last factor had the initial eigenvalue of 1.900 consisting of 8 items. This factor was mainly related to the wishful deviations from the procedures. Thus, the factor was named *procedural incompliance*. Example items for this factor were “Not feeling the need to give a departure briefing for the flight route before takeoff”, “Checking whether the NOTAMs/AIS/MET briefing documents are available on the aircraft" and “"Unfastening the shoulder straps before reaching 10,000 feet”.

3.3.2. Factor Structure of CRM-CS

Principal component analysis (PCA) was conducted to explore factor structure of the newly developed scale with 82 items. The Kaiser-Meyer-Olkin measure was .916, indicating that the sampling was adequate. In addition, Bartlett’s test of sphericity was significant, indicating that the items were factorable (χ^2=11319.047, *df*

Table 2. The Factor Structure of APilotBI-R

Items	Factors			
	SBF	DF	MF	PI
1)Uçak otomasyon altındayken. monitoring yapmamak	**.802**			
2)Dış etkenlere fix olup rutin monitoringi atlamak	**.732**			
3)Bazı SOP'ları uygulamayı unutmak	**.701**			
4)Yanlış FPM ile alçalmak	**.603**			
5)Buzlanma beklendiğinde "Engine Anti-iceing" veya "wing anti ice" sistemlerinin çalıştırılmadığını fark etmemek	**.601**			
6)Yanlış FPM ile tırmanmak	**.587**			
7)İniş sırasında. steril kokpit kurallarını atlamak	**.577**			
8)Yanlış taksi yolunu kullanmak	**.577**			
9)Checklistlerdeki maddelerin bazılarının (örneğin. flap ayarları) doğru ayarlarını okumak ancak ayarları set etmeyi unutmak	**.574**			
10)Türbülans sırasında ATC bilgilendirmesi yapmayı unutmak	**.566**			
11)Checklistleri tamamlarken. bir ya da birden çok maddeyi unutmak	**.544**			
12)Bir ya da birden fazla checklisti atlamak	**.540**			
13)Kalkış için piste gelirken dış ışıkların açık olmadığını fark etmemek	**.521**			
14)Kalkış sırasında. trafiğe odaklanıp motor enstrümanlarını ve hız göstergelerini kontrol etmeyi unutmak	**.494**			.358
15)Uçuş planını yanlış yorumlanmak	**.489**			
16)Hedef irtifaya 1000 feet kaldığında call-out yapılmadığını sonradan fark etmek	**.474**			
17)Hava Trafik Kontrolü'nden gelen değişiklik ya da izinleri yanlış anlamak	**.473**			
18)Tamamlanan bir checklistten sonra tamamlandığını sözlü olarak dile getirmemek ("complete" olarak belirtmemek)	**.470**			
19)Database'e fark etmeden yanlış uçuş ağırlığı girmek	**.456**		.317	
20) Görerek şartlarda yaklaşırken. uçağın kontrolünü geç ele almak	**.455**			
21)ATC izni olmadan sürat değişikliği yapmak	**.453**			
22)Kalkış sırasında. steril kokpit kurallarını atlamak	**.447**			
23)Yakıt alımı sırasında yolcu alımına başlamak	**.393**			
24)Dış etkenler müsaade etse de optimum irtifadan alçakta uçmak	**.384**			
25)Yanlış frekansa bağlanmak	**.383**			
26)Harici kontrolleri (extraneous inspection) tamamlamayı unutmak	**.333**			
27)Tasarruf amacıyla minimum yakıtla uçmak	**.327**			
28) Divert etmek gerekirken uçağı inişe zorlamak		**.660**		
29)Transition (TA) irtifası geçilince tüm ana ve yedek altimetreleri 29.92 inHg/1013.3 (hPa) olarak ayarlamak ancak çapraz kontrolünü atlamak		**.649**		
30)Türbülanstayken uygun sürat ve thrust/N1 değeri kullanmamak		**.635**		

Table 2. (continued)

31)İniş sırasında kuyruk rüzgârı limitlerini dikkate almayarak. uçağı inişe zorlamak		**.616**		
32)Fark etmeden. uçulacak rota için kalkış brifingi yapmamak		**.442**		
33)Checklistleri “ezbere” tamamlamak		**.386**		
34)Uçak stabil değilken yaklaşmaya devam etmek		**.372**		
35)Görüş limitleri. yaklaşma limitlerinden düşük olsa da yaklaşmaya devam etmek		**.356**		
36)Kalkıştan sonra. normal şartlarda. iniş takımlarını kapatmayı bir süre ertelemek		**.350**		
37)Kalkış sırasında. önden kalkan trafiğin türbülansını önemsememek		**.338**		
38)Park sırasında. park freni yerine başka bir uygulamayı (örneğin nose wheel lock) çalıştırmak			**.774**	
39)Uçağı park ederken “parking-brake”i aktive etmeyi unutmak			**.759**	
40)Kalkıştan sonra iniş takımlarını kapatmayı unutmak			**.673**	
41)İniş sırasında. iniş takımlarını aşağı almayı bir süreliğine unutmak			**.433**	
42)Uçuş öncesi koltuğu sabitlemeyi (ayarlamayı) unutmak			**.425**	
43)Fark etmeden yanlış flap açısı set etmek			**.384**	
44)ATC tarafından verilen irtifayı yanlış anlayarak yanlış irtifada uçmak			**.342**	
45)NOTAM’lar/ AIS/ MET brifing dokümanlarının uçaktan mevcut olup olmadığını kontrol etmek				**-.698**
46)Uçuş öncesi. uçulacak rota için kalkış brifingi yapmaya gerek duymamak				**.584**
47)Uçağın başına gelindiğinde gerekli teknik kontrolleri eksiksiz yerine getirmek			-.315	**-.566**
48)Omuz bağlarını 10.000 feete ulaşmadan çözmek				**.397**
49)Hedef irtifaya ulaşınca düz uçuş brifingi yapmamak				**.355**
50)Omuz bağlarını. 10.000 feet altına indikten sonra da bir süre takmamak				**.325**
51)Kalkış sırasında. yanlışlıkla uçağın burnunu dik bir açıyla kaldırarak. kuyruğun piste sürtmesine neden olmak				**.323**
52)Sistemlerde yapılan değişiklikleri sesli olarak dile getirmemek				**.322**
Eigenvalues	11.883	2.627	2.302	1.900
% of variance explained	19.165	4.238	3.713	3.064
Cronbach’s alpha	.90	.74	.70	.72

Note. SBF= Skill-based failures, DF= Decision failures, MF= Memory Failures, PI= Procedural Incompliance

= 3321, $p < .000$). The Eigenvalues of the 16 factors were greater than 1. However, the scree plot suggested a 3-factor structure. Since the 3-factor structure produced meaningful and interpretable solution, the final factor analysis was conducted by using 3-factor solution with oblique rotation. The oblique rotation method was used in the analysis because most of the factors had correlations higher than .50.

After the 3-factor solution for newly developed competency scale, PCA analysis with Direct Oblimin rotation was performed by fixing the number of factors to 3. Factor loading coefficients under .40 were suppressed to avoid cross-loadings and to achieve more compact patterns for factors. As a result, the 3-factor solution explained 45.582 % of the total variance. The contributions of the three factors to the explained variance were 40.065 %, 3.259 %, and 2.258%, respectively. A total of 49 items were loaded on one of the three factors (see Table 3). The remaining 33 items were excluded from the scale since they had smaller coefficients than .40. The pattern matrix showed no cross-loaded items across factors indicating a more compact factor pattern.

The first factor had the initial eigenvalue of 33.373 consisting of 21 items. This factor mainly consisted of monitoring and management competencies to ensure flight safety. Thus, the factor was named *flight monitoring and management*. The monitoring component was related to the competencies that are required for constant monitoring of the environment and automation systems. Example items for flight monitoring were “Keeping monitoring of the aircraft's altitude, speed and thrust values without skipping while flying manually” and “Being ahead of the aircraft”. Moreover, the management component of the factor was related to the competencies that required pilots for effective management of the changing environment, threats and errors. Example items for flight management were “Speaking out changes in automation systems in a timely manner” and “Being able to detect errors that may be made during the flight in a timely manner”.

The second factor had the initial eigenvalue of 3.205 consisting of 13 items. This factor had mainly two components, namely *fatigue and work management*. Fatigue management components were related to competencies that required pilots for eliminating fatigue related problems for themselves and for others. Example items for fatigue management were “Not hesitating to report “unfit” status when I am fatigued” and “Creating appropriate conditions to enable a crew member to rest when fatigue

Table 3. The Factor Structure of CRM-CS

Items	*FMM*	*FWM*	*CCC*
	Component		
1)Manuel uçarken. uçağın irtifa. hız ve thrust değerlerinin takibini atlamadan yapmak	.896		
2)Manuel uçuşta. uçuş planından sapmaları zamanında belirleyebilmek	.894		
3)Manuel uçuşta. uçuş planını optimum performans sağlayacak şekilde düzenleyebilmek	.775		
4)"Uçağın önünde olmak"	.729		
5)Uçuş sırasında emniyetini etkileyebilecek normal olmayan durumlarda. durumu doğru analiz edebilmek	.664		
6)Otomasyon sistemlerindeki değişiklikleri zamanında tespit edebilmek	.663		
7)Manuel uçuşta uçağı uygun yumuşaklıkta (smoothness) kullanabilmek	.636		
8)Uçuş emniyetini etkileyebilecek normal olmayan durumlarda sakinliğimi koruyabilmek	.608		
9) Otomasyon sistemlerindeki değişiklikleri zamanında dile getirebilmek	.601		
10)Uçuş emniyetini etkileyebilecek normal olmayan durumlarda kendi bilgime güvenerek şartlara en uygun kararı verebilmek	.575		
11)Uçuş öncesi. uçuşta oluşabilecek ve uçuş emniyetini olumsuz etkileyebilecek normal olmayan durumları doğru analiz edebilmek	.572		
12)Uçuş süresince yapılabilecek hataları zamanında tespit edebilmek	.553		
13)Overload olup muhakeme yeteneğini kaybetmemek	.548		
14)Normal şartlarda maksimum seviyede durumsal farkındalığa sahip olabilmek	.523		
15)Manuel uçuş sırasında dış etmenlerden gelen dikkat dağıtıcıları etkili bir şekilde yönetebilmek	.523		
16)Otomasyon seviyesi iş yükünü artırdığında manuel kontrole geçebilmek	.521		
17)Görev süresince yapılacak işlemlerin önceliğini belirleyebilmek	.497		
18)Uçuş emniyetini etkileyebilecek normal olmayan durumlara önceden hazırlıklı olabilmek	.491		
19)Uçuş sırasında sistemlerdeki değişikliği zamanında fark edebilmek	.489		
20)Normal uçuş şartlarında bile oluşabilecek olumsuz koşullar için tetikte olabilmek	.480		
21)Uçuş emniyetini etkileyebilecek normal olmayan durumlarda prosedürlere güvenerek şartlara en uygun kararı verebilmek	.435		
22)Ekip üyelerindeki yorgunluk durumunu tespit edebilmek		.626	

Table 3. (continued)

23)Yorgun olduğumda oluşabilecek hata yapma olasılığını engellemek amacıyla ekip üyelerinden beni daha fazla monitör etmelerini istemek		.588	
24)Yorgun olduğumda ekip üyelerine bunu deklare edebilmek		.578	
25)Ekip üyelerine davranışları ile ilgili etkili geribildirimler verebilmek		.574	
26)Yorgun olduğumda “unfit” durumunu rapor etmekten çekinmemek		.565	
27)Ekip içerisindeki çatışmaları etkili bir biçimde çözebilmek		.516	
28)Uçuş emniyetini etkileyebilecek normal olmayan durumlarda görev dağılımını stresi azaltacak şekilde düzenleyebilmek		.492	
29)Ekip üyelerindeki stres belirtilerini fark edebilmek		.481	
30)Ekip üyelerindeki yorgunluk durumunda. yorgun olan ekip üyesini normalden daha fazla monitör edebilmek		.458	
31)Ekip üyelerindeki yorgunluk durumunda. ekip üyesinin dikkatini dağıtmayacak ve işe odaklanmasını sağlayacak uyaranlar verebilmek		.444	
32)Değişken iş yükünü ekibe dengeli bir şekilde dağıtabilmek		.440	
33)Assertive olmak		.412	
34)Karar verme sürecinde ekibin fikirlerine önem vermek			.676
35)Kabin ekibini briefinglere dahil etmek			.670
36)Karar verme sürecinde ekibi. fikirlerini söylemeye teşvik edebilmek			.658
37)İletişimde ortak dili kullanmak			.614
38)Ekip içerisindeki koordinasyonu sağlayabilmek			.565
39)Ekip üyeleriyle iletişimde kullandığım üsluba dikkat etmek			.527
40)Ekip üyeleriyle bilgi iletişimini zamanında sağlayabilmek			.501
41)SOP’lara uygun davranmak			.501
42)Var olan operasyon talimatları hakkında bilgi sahibi olmak			.461
43)Uçuştan önce. uçuşa mental olarak hazırlanabilmek			.420
44)Ekip üyeleriyle doğru bilgi iletişimini sağlayabilmek			.414
45)Briefinglerde acil durum planlarını ekip üyeleriyle etkili bir şekilde paylaşabilmek			.411
46)Uçuş emniyetini etkileyebilecek normal olmayan durumlarda ekip arkadaşlarımın bilgisine güvenerek şartlara en uygun kararı verebilmek			.403
47)Kendi durumsal farkındalığımı ekip üyeleri ile paylaşabilmek			.401
48)Ekip ile açık iletişim halinde olabilmek			.401
Eigenvalues	33,373	3,205	2,420
% of variance explained	40,699	3,908	2,952
Cronbach’s alpha	.94	.87	.91

Note. FMM= Flight monitoring and management, FWM= Fatigue and work management, CCC= Crew communication and coordination occurs”. Work management component, on the other hand, related to competencies that required pilots for effective management of crews’ work and communicating about the work they had being performing. Example items for work management component were “Being able to give effective feedback to crew members about their behavior” and “Being able to distribute variable workload evenly across the crew members”. Therefore, this factor was named as “fatigue and work management”.

The last factor had an initial eigenvalue of 2.420 consisting of 15 items. This factor was mainly related to the competencies that were required for communicating with crew members, crews’ decision-making processes and timing of effective crew communication and coordination. Therefore, the factor was named *crew communication and coordination*. Example items for this factor were “Giving importance to the crew's opinions in the decision-making process”, “Being able to effectively share emergency plans with crew members in briefings”, and “Being to communicate accurate information with crew members”.

3.3.3. Bivariate Correlations between Study Variables

3.3.3.1. Bivariate Correlations between Demographics and Study Variables.

Age, total hours flown in commercial airlines, total hours flown in the last month before participation, the number of incidents experienced in the last year and stress level in a normal flight condition were used as a demographic variable. Factors of CRM-CS, APilotBI-R, MFSI-SF, and ASCS were used as study variables.

Pearson correlation analysis showed that age was significantly and positively correlated with flight monitoring and management (r= .21, p= .005), fatigue and work management (r= .25, p= .001), crew communication and coordination (r= .22, p= .003), vigor (r= .19, p= .010), conscientiousness (r= .20, p= .011) and openness-to-experience (r= .20, p= .011). This indicates that pilots evaluated their CRM competencies higher with age. Similarly, they reported feeling more vigorous with age. On the contrary, age was negatively associated with negative valance (r= -.210, p= .007) meaning that pilots evaluated themselves lower on negative valance with age. Besides, total hours flown in commercial aviation were significantly and positively associated with flight monitoring and management (r= .229, p= .002), fatigue and work management (r= .27, p< .001), and crew communication and coordination (r= .18, p= .016), and openness-to-experience (r= .227, p= .006) which indicated more experienced pilots reported higher CRM competency and openness-to-experience levels than less experienced pilots Surprisingly, none of the associations achieved significance with the flight hours in the last month before participation.

The number of incidents experienced in the last year was negatively related to the management commitment and safety communication (r= -.165, p= .038), safety training (r= -.193, p= .015), and equipment maintenance (r= -.203, p= .007). This showed that pilots experiencing less incidents in the last year reported more positive attitudes towards organizational safety climate. Experienced stress levels in normal flight conditions were negatively associated with flight monitoring and management (r= -.289, p< .001), fatigue and work management (r= -.181, p= .016), crew communication and coordination (r= -.257, p= .001) and vigor (r= -.230, p= .003) which indicated pilots who were more stressed in anormal flight conditions reported poorer CRM competencies than less stressed colleagues. Similarly, pilots experiencing more stress reported feeling less vigorous.

3.3.3.2. Bivariate Correlations between Study Variables.

Pearson correlation analysis was conducted to analyze relationships between study variables. All of the factors of CRM-CS were negatively associated with the factors of APilotBI-R. FMM was negatively associated with skill-based failures (r= -. 484, p<.001), decision failures (r= -.244, p= .001), memory failures (r= -.295, p<. 001), and procedural incompliance (r= -.251, p< .001). FWM was also negatively correlated with skill-based failures (r= -. 464, p< .001), decision failures (r= -.331, p=. 001), memory failures (r= -.223, p= .003), and procedural incompliance (r= -.262, p< .001). Similarly, CCC was negatively associated with skill-based failures (r= -.354, p<. 01), decision failures (r= -.238, p= .002), memory failures (r= -.294, p<. 001), and procedural incompliance (r= -.337, p<. 001). This indicated that pilots evaluating their CRM competencies as good levels reported less frequent unsafe acts than pilots evaluating their competencies poorer. In addition, FMM (r= .271, p< .001), FWM (r= .207, p= .009) and CCC (r= .283, p< .001) was positively associated with management commitment and safety communication factor of ASCS. FMM (r= .326, p< .001), FWM (r= .275, p< .001) and CCC (r= .319, p< .001) was also positively associated with safety training factor of ASCS. Moreover, FMM (r= .382, p< .001), FWM (r= .261, p= .009) and CCC (r= .423, p< .001) was positively associated with equipment maintenance factor of ASCS.

Similarly, all of the factors of CRM-CS were negatively correlated with fatigue factors except vigor. FMM was negatively associated with general fatigue (r= -.355, p<. 001), physical fatigue (r= -.356, p<. 001), emotional fatigue (r= -.339, p<. 001), mental fatigue (r= -.423, p<. 001), and positively associated with vigor (r= .430, p<. 001). FWM was negatively associated with general fatigue (r= -.332, p<. 001), physical fatigue (r= -.304, p<. 001), emotional fatigue (r= -.376, p<. 001), mental fatigue (r= -.377, p<. 001), and positively associated with vigor (r= .382, p<. 001). CCC was also negatively associated with general fatigue (r= -.306, p<. 001), physical fatigue (r= -.296, p<. 001), emotional fatigue (r= -.300, p<. 001), mental fatigue (r= -.313, p<. 001), and positively associated with vigor (r= .356, p<. 001). These results indicated that pilots reported good levels of CRM competencies reported less symptoms of chronic general, physical, mental physical, emotional fatigue and feeling more vigorous. Besides, all factors of CRM-CS were positively related to personality traits except neuroticism and negative valance. FMM was positively associated with extraversion (r= .328, p<. 001), conscientiousness (r= .361, p<. 001), agreeableness (r= .427, p<. 001), openness-to-experience (r= .554, p<. 001), and negatively associated with neuroticism (r= -.446, p<. 001), and negative valance (r= -.355, p<. 001). FWM was positively associated with extraversion (r= .296, p<. 001), conscientiousness (r= .348, p<. 001), agreeableness (r= .409, p<. 001), openness-to-experience (r= .448, p<. 001), and negatively associated with neuroticism (r= -.309, p<. 001), and negative valance (r= -.293, p<. 001). CCC was also positively associated with extraversion (r= .292, p<. 001), conscientiousness (r= .389, p<. 001), agreeableness (r= .498, p<. 001), openness-to-experience (r= .374, p<. 001), and negatively associated with neuroticism (r= -.355, p< .001), and negative valance (r= -.285, p< .001). It indicated that pilots with good levels of CRM competencies also scored high on extraversion, agreeableness, conscientiousness and openness-to-experience, and low on neuroticism and negative valance.

Skill-based failures were negatively associated with factors of ASCS which were management commitment and safety communication (r= -.261, p< .001), safety training (r= -.224, p= .004), and equipment maintenance (r= -.240, p= .002) which showed that pilots who reported committing skill-based failures more frequently evaluated their organization's safety climate more negatively. Similarly, pilots who reported committing skill-based failures more frequently reported feeling less vigorous in the last month before participation (*r*= -.396, *p*< .001). On the contrary, skill-based failures were positively associated with general fatigue (*r*= .443, *p*<. 001), physical fatigue (*r*=.428, *p*<. 001), emotional fatigue (*r*= .517, *p*<. 001), mental fatigue (*r*= .587, *p*<. 001), and negatively associated with vigor (*r*= -.396, *p*<. 001). This showed that pilots who reported committing skill-based failures more frequently also reported having more symptoms of general, physical, mental and emotional fatigue. Skill-based failures were also negatively correlated with extraversion (*r*= -.358, *p*< .001), conscientiousness (*r*= -.356, *p*< .001), agreeableness (*r*= -.305, *p*< .001), and openness-to-experience (*r*= -.503, *p*< .001); and positively correlated with neuroticism (*r*= .511, *p*<. 001) and negative valance (*r*= .332, *p*<. 001), implying that pilots who reported committing more skill-based failures also scored low on extraversion, conscientiousness, agreeableness, openness-to-experience and scored high on neuroticism and negative valance.

Decision failures were negatively correlated with the safety training factor of ASCS (*r*= -. 193, *p*=. 015), vigor (*r*= -. 187, *p*=. 015), conscientiousness (*r*= -.244, *p*=. 002) and positively correlated with neuroticism (*r*= .302, *p*<. 001) and negative valance (*r*= .249, *p*= .002) which showed that pilots reporting more frequent decision failures also reported more negative attitudes regarding their organization's safety training. Similarly, pilots reporting more frequent decision failures also reported feeling less vigorous, scored low on conscientiousness, and scored high on neuroticism and negative valance. Memory failures were negatively associated with management commitment and safety communication (*r*= -.171, *p*=. 031), and safety training (*r*= -.162, *p*=. 042) factors of ASCS, and openness-to-experience (*r*= -. 189, *p*=. 018); and positively associated with physical (*r*=. 231, *p*=. 003), mental (*r*= .306, *p*=. 001), emotional fatigue (*r*= .247, *p*<. 001), and neuroticism (*r*= .189, *p*=. 018). This revealed that pilots reporting more frequent memory failures also reported having negative attitudes of their organization's commitment and safety communication and safety training and also having high levels of openness-to-experience. On the contrary, they reported feeling more symptoms of physical, mental and emotional fatigue, and also higher levels of neuroticism. Procedural incompliance was negatively associated with management commitment and safety communication (*r*= -. 180, *p*=. 023), equipment maintenance (*r*= -. 193, *p*=. 015) factors of ASCS, extraversion (*r*= -. 160, *p*=. 046), and conscientiousness (*r*= -. 279, *p*<. 001); and positively correlated with general (*r*=

.214, *p*=. 005), physical (*r*= .257, *p*= .001), mental (*r*=.314, *p*<. 001), emotional fatigue (*r*= .328, *p*<. 001), neuroticism (*r*= .284, *p*<. 001) and negative valance (*r*= -. 167, *p*=. 037). This showed that pilots reporting more frequent procedural incompliance also reported more negative evaluations on their organization's management commitment and safety communication, equipment maintenance, and low levels of extraversion and conscientiousness. However, they reported feeling more symptoms of general, physical, mental and emotional fatigue, and also high levels of neuroticism and negative valance.

Factors of organizational safety climate showed negative association with fatigue factors, except vigor which showed positive association. Management commitment and safety communication was negatively correlated with general (*r*= -.306, *p*<. 001), mental (*r*= -.256, *p*=. 001), emotional fatigue (*r*= -.264, *p*=. 001), and positively associated with vigor (*r*= .216, *p*= .006). Safety training was also negatively associated with general (*r*= -.339, *p*<. 001), physical (*r*= -.192, *p*=. 015), mental (*r*= -.249, *p*=. 002), emotional fatigue (*r*= -.315, *p*<. 001), and positively associated with vigor (*r*= .215, *p*= .007). Similarly, equipment maintenance was negatively associated with general (*r*= -.316, *p*<. 001), physical (*r*= -.188, *p*=. 018), mental (*r*= -.263, *p*=. 001), emotional fatigue (*r*= -.297, *p*<. 001), and positively associated with vigor (*r*= .241, *p*= .002). These results revealed that pilots who evaluated their organization's safety climate more positively also reported lower levels of fatigue symptoms. Besides, pilots who evaluated their organization's safety climate more positively also reported feeling more vigorous (see Table 4). Moreover, management commitment and safety communication factors were positively correlated with conscientiousness (*r*= .184, *p*=. 022), agreeableness (*r*= .208, *p*= .009) and openness-to-experience (*r*= .185, *p*= .021), and negatively correlated with neuroticism (*r*= -.242, *p*=. 002), indicating that pilots with positive attitudes towards the organization's management commitment and safety communication reported higher levels of conscientiousness, agreeableness and openness-to experience, and lower levels of neuroticism. Additionally, safety training was positively correlated with extraversion (*r*= .199, *p*= .013), conscientiousness (*r*= .188, *p*= .019), agreeableness (*r*= .215, *p*= .007), and openness-to-experience (*r*= .256, *p*= .001) showing that pilots with positive attitudes towards the organization's safety training reported higher levels of extraversion, conscientiousness, agreeableness and openness-to experience. Equipment maintenance was positively related to extraversion (*r*= .221, *p*= .006), conscientiousness (*r*= .215, *p*= .007), agreeableness (*r*= .287, *p*< .001), and openness-to-experience (*r*= .278, *p*< .001) and negatively associated with neuroticism (*r*= -. 227, *p*=. 005) indicating that pilots with positive attitudes towards the organization's equipment maintenance reported higher levels of extraversion, conscientiousness, agreeableness and openness-to-experience, and lower levels of neuroticism.

Lastly, general fatigue was negatively associated with extraversion (*r*= -.330, *p*< .001), conscientiousness (*r*= -.321, *p*< .001), agreeableness (*r*= -.195, *p*= .015), and openness-to-experience (*r*= -.339, *p*< .001), and positively associated with neuroticism (*r*= .520, *p*<. 001) and negative valance (*r*= .342, *p*<. 001). Physical fatigue was also negatively correlated with extraversion (*r*= -.281, *p*< .001), conscientiousness (*r*= -.225, *p*= .005), agreeableness (*r*= -.169, *p*= .035), and openness-to-experience (*r*= -.289, *p*< .001), and positively associated with neuroticism (*r*= .503, *p*<. 001) and negative valance (*r*= .372, *p*<. 001). Similarly, emotional fatigue was negatively associated with extraversion (*r*= -.367, *p*< .001), conscientiousness (*r*= -.281, *p*< .001), agreeableness (*r*= -.228, *p*= .004), and openness-to-experience (*r*= -.348, *p*< .001), and positively associated with neuroticism (*r*= .625, *p*<. 001) and negative valance (*r*= .393, *p*<. 001). Moreover, mental fatigue was negatively associated with extraversion (*r*= -.442, *p*< .001), conscientiousness (*r*= -.280, *p*< .001), agreeableness (*r*= -.194, *p*= .015), and openness-to-experience (*r*= -.380, *p*< .001), and positively associated with neuroticism (*r*= .582, *p*<. 001) and negative valance (*r*= .397, *p*<. 001). However, vigor was positively associated with extraversion (*r*= .408, *p*< .001), conscientiousness (*r*= .321, *p*< .001), agreeableness (*r*= .412, *p*< .001), and openness-to-experience (*r*= .505, *p*< .001), and negatively associated with neuroticism (*r*= -.505, *p*<. 001) and negative valance (*r*= -.248, *p*<. 001). These results indicated that pilots experiencing more general, physical, mental and emotional fatigue symptoms scored low on extraversion, conscientiousness, agreeableness and openness-to-experience and high on neuroticism and negative valance. On the contrary, pilots feeling more vigorous scored high on extraversion, conscientiousness, agreeableness and openness-to-experience yet scored low on neuroticism and negative valance.

Table 4. Bivariate Correlations between Study Variables

		Correlations																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1.	Age	1																			
2.	TH	.80[b]	1																		
3.	MH	.16[a]	.22[b]	1																	
4.	Incid	.17[a]	.12	.05	1																
5.	Stress	-.14	-.09	-.02	.09	1															
6.	FMM	.20[b]	.22[b]	-.00	-.06	-.28[b]	1														
7.	FWM	.24[b]	.27[b]	-.03	.05	-.18[a]	.70[b]	1													
8.	CCC	.22[b]	.18[a]	.01	-.02	-.25[b]	.78[b]	.69[b]	1												
9.	SB	-.06	-.09	.01	.05	.15[a]	-.48[b]	-.46[b]	-.35[b]	1											
10.	Dec	.05	.05	.08	-.04	-.03	-.24[b]	-.33[b]	-.23[b]	.53[b]	1										
11.	Mem	.07	.06	-.06	.01	.01	-.29[b]	-.22[b]	-.29[b]	.39[b]	.35[b]	1									
12.	P. Inc	-.07	.01	.06	.01	.13	-.25[b]	-.26[b]	-.33[b]	.49[b]	.47[b]	.28[b]	1								
13.	Mc.Sc	-.10	-.12	-.12	-.16[a]	-.05	.27[b]	.20[b]	.28[b]	-.26[b]	-.14	-.17[a]	-.18[a]	1							
14.	ST	-.03	.00	-.02	-.19[a]	-.15	.32[b]	.27[b]	.31[b]	-.22[b]	-.19[a]	-.16[a]	-.14	.70[b]	1						
15.	EM	-.02	-.0	-.00	-.21[b]	-.15[a]	.38[b]	.26[b]	.42[b]	-.24[b]	-.13	-.12	-.19[a]	.73[b]	.78[b]	1					
16.	GF	-.08	-.07	.10	-.01	.22b	-.35[b]	-.33[b]	-.30[b]	.44[b]	.28[b]	.12	.21[b]	-.30[b]	-.33[b]	-.31[b]	1				
17.	PF	-.07	-.03	.04	-.06	.14	-.35[b]	-.30[b]	-.29[b]	.42[b]	.30[b]	.23[b]	.25[b]	-.16[a]	-.19[a]	-.18[a]	.82[b]	1			
18.	EF	-.06	-.04	.02	.03	.22[b]	-.33[b]	-.37[b]	-.30[b]	.51[b]	.40[b]	.24[b]	.32[b]	-.26[b]	-.31[b]	-.29[b]	.77[b]	.75[b]	1		
19.	MF	.00	.03	-.02	.06	.23[b]	-.42[b]	-.37[b]	-.31[b]	.58[b]	.40[b]	.30[b]	.31[b]	-.25[b]	-.24[b]	-.26[b]	.74[b]	.75[b]	.75[b]	1	
20.	Vigor	.19[b]	.12	-.05	.02	-.23[b]	.43[b]	.38[b]	.35[b]	-.39[b]	-.18[a]	-.11	-.15	.21[b]	.21[b]	.24[b]	-.61[b]	-.52[b]	-.57[b]	-.52[b]	1

Table 4. (continued)

	Correlations																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
21.E	.13	.04	.04	-.11	-.19^{a}	.32^{b}	.29^{b}	.29^{b}	-.35^{b}	-.13	-.09	-.16^{a}	.03	.19^{a}	.22^{b}	-.33^{b}	-.28^{b}	-.36^{b}	-.44^{b}	.40^{b}	1					
22.C	.20^{a}	.10	.03	.04	-.06	.36^{b}	.34^{b}	.38^{b}	-.35^{b}	-.24^{b}	-.08	-.27^{b}	.18^{a}	.18^{a}	.21^{b}	-.32^{b}	-.25^{b}	-.28^{b}	-.28^{b}	.32^{b}	,27^{b}	1				
23.A	.15	.06	.01	.03	-.06	.42^{b}	.40^{b}	.49^{b}	-.30^{b}	-.14	-.10	-.15	.20^{b}	.21^{b}	.28^{b}	-.19^{a}	-.16^{a}	-.22^{b}	-.19^{a}	.41^{b}	,39^{b}	,42^{b}	1			
24.N	-.09	-.04	.03	.05	.12	-.44^{b}	-.30^{b}	-.33^{b}	.50^{b}	.30^{b}	.18^{a}	.28^{b}	-.24^{b}	-.15	-.22^{b}	.52^{b}	.50^{b}	.62^{b}	.58^{b}	-.44^{b}	-,41^{b}	-,42^{b}	-,32^{b}	1		
25.O	.20^{a}	.22^{b}	.04	-.11	-.12	.55b	.44^{b}	.37^{b}	-.50^{b}	.12	-.18^{a}	-.14	.18^{a}	.25^{b}	.27^{b}	-.33^{b}	-.28^{b}	-.34^{b}	-.38^{b}	.50^{b}	,43^{b}	,51^{b}	.57^{b}	-,43^{b}	1.	
26.NV	-.21^{b}	-.13	-.10	-.03	.04	-.35b	-.29^{b}	-.28^{b}	.33^{b}	.24^{b}	-.05	.16^{a}	-.06	-.08	-.12	.34^{b}	.37^{b}	.39^{b}	.39^{b}	-.24^{b}	-,28^{b}	-,45^{b}	-.34^{b}	,55^{b}	-,39^{b}	1

Note. 1.Age= Age of the participants, 2. TH=Total flight hours, 3.MH= Average hours flown in the last month, 4. Incid= The number of Incidents in the last three years, 5. Stress= Stress levels in the normal flight conditions, 6. FMM=Flight monitoring and management, 7.FWM= Fatigue and work management, 8. CCC= Crew communication and cooperation, 9. SB= Skill-based failures, 10. Dec= Decision failures, 11. Mem= Memory failures, 12. P. Inc= Procedural Incompliance, 13. Mc.Sc= Management commitment and safety communication, 14. ST= Safety training, 15. EM= Equipment maintenance, 16. GF= General fatigue, 17. PF= Physical Fatigue, 18. EF= Emotional fatigue, 19. MF= Mental fatigue, 20= Vigor, 21. E= Extraversion, 22. C= Conscientiousness, 23. A=Agreeableness, 24. N=Neuroticism, 25. O= Openness-to-experience, 26. NV= Negative valance

3.3.4. The Predictors of Unsafe Acts of Commercial Airline Pilots

Four different hierarchical regression analysis were conducted to analyze the predictors of unsafe acts of commercial airline pilots. Factors of APilotBI-R, skill-based failures, decision failures, memory failures, and procedural incompliance, were entered into the model as predicted variables. In the first step of each analysis, control variables, i.e. age, total flight hours, hours flown in the last month and stress level in the normal flight operations, entered the model. In the second step of each analysis, personality traits, i.e. extraversion, conscientiousness, agreeableness, neuroticism, openness-to-experience and negative valance. In the third step, fatigue symptoms were added into the model, i.e., general fatigue, physical fatigue, emotional fatigue, mental fatigue and vigor, were included in the model. In the fourth step, factors of organizational safety climate, i.e. management commitment and safety communication, safety training and equipment maintenance, were included in the model. Lastly, factors of CRM-CS, i.e. flight monitoring and management, fatigue and work management, and crew communication and coordination entered the model.

3.3.4.1. Predictors of Skill-based Failures.

In the first hierarchical regression analysis, the predicted variable was the skill-based failures. After controlling the effects of control variables, personality traits improved the explained variance significantly (R^2= .341, $\Delta\ R^2$ = .312, F (10,165) = 8.537, p < .001). Neuroticism was positively associated with skill-based failures (B= .199, *SE= .054*, t= 3.667, p< .001, *95% CI* [.092, .306]) whereas openness-to-experience was negatively associated with it (B= -.268, *SE*= .073, t= -3.674, p< .001, *95% CI* [-.411, -.124]). This showed that pilots reported committing more skill-based failures when their neuroticism levels were higher. However, pilots reported committing less skill-based failures when their openness-to-experience levels were higher. However, pilots reported committing less skill-based failures when their openness-to-experience levels were higher. When fatigue symptoms were included in the model, they also improved the explained variance (R^2= .451, $\Delta\ R^2$ = .110, F (15, 160) = 8.772, p < .001). The results showed that mental fatigue was positively associated with skill-based failures (B= .258, *SE*= .066, t= 3.889, p< .001, *95% CI* [.127, .389]) meaning that pilots reported committing more skill-based failures when they evaluated their mental fatigue as high. When the organizational safety climate factors were added into the model, no significant additional variance was explained (*Δ*

F= 0.520, *p*= .669) although the whole model was significant (R^2= .457, *Δ* R^2 = .005, *F* (18,157) = 7.331, *p* < .001). This might indicate that safety climate might have the indirect predictor effect on skill-based failures rather than the direct effect. Lastly, the factors of CRM-CS significantly improved the explained variance (R^2= .497, *Δ* R^2 = .040, *F* (21,154) = 7.234, *p* < .001). Fatigue and work management (FWM; *B*= -.140, *SE*= .065, *t*= -2.150, *p*= .033, *95% CI* [-.267, -.011]) were negatively associated with skill-based failures showing that when pilots evaluated their FWM competencies as high, they reported committing skill-based failures less frequently (see Table 5).

3.3.4.2. Predictors of Decision Failures.

In the second hierarchical regression analysis, the predicted variable was the decision failures (see Table 6). After controlling the effects of control variables, the personality traits, they improved the explained variance significantly (R^2= .127, *Δ* R^2 = 114, *F* (10,165) = 2.411, *p*= .011). Neuroticism was positively associated with decision failures (*B*= .119, *SE*= .054, *t*= 2.202, *p*= .029, *95% CI* [.012, .225]). This showed that pilots reported committing more decision failures when their neuroticism levels were higher. No significant associations were found for other personality traits. When fatigue symptoms were included in the model, they also improved the explained variance (R^2= .267, *Δ* R^2 = .139, *F* (15,160) = 3.882, *p* < .001). Mental fatigue (*B*= .194, *SE*= .066, *t*= 2.924, *p*= .004, *95% CI* [.063, .325]) and emotional fatigue (*B*= .177, *SE*= .060, *t*= 2.968, *p*= .003, *95% CI* [.059, .294]) were positively associated with decision failures meaning that pilots reported committing more decision failures when they evaluated their mental and emotional fatigue symptoms as high. When the organizational safety climate factors were added into the model, no significant additional variance was explained (*Δ F*= 1.185, *p*= .317) although the whole model was significant (R^2= .283, *Δ* R^2 = .016, *F* (18,157) = 3.444, *p* < .001). This might indicate that safety climate might have the indirect predictor effect on decision failures rather than the direct effect. When the factors of CRM-CS were added into the model, they did no significant improvement in the explained variance (*Δ F*= 2.420, *p*= .068) although the model was significant (R^2= .315, *Δ* R^2 = .032, *F* (21,154) = 3.377, *p* < .001).

Table 5. The Predictors of Skill-based Failures

	R^2	ΔR^2	F	p	F_{change} p	B	SE	t	p	*Lower*	*Upper*
Controls	.029	.029	1.283	.279	.279						
Age						-,005	,005	-1,050	,295	-,015	,005
TH						.000	,000	,867	,387	,000	,000
MH						,000	,001	,109	,914	-,003	,003
Stress						,026	,014	1,864	,064	-,002	,053
Personality	.341	.312	8.537	.000	.000						
Extraversion						-,038	,049	-,791	,430	-,135	,058
Conscientiousness						-,037	,063	-,588	,557	-,162	,088
Agreeableness						,021	,073	,287	,774	-,124	,166
Neuroticism						,199	,054	3,667	,000	,092	,306
Openness						-,268	,073	-3,674	,000	-,411	-,124
NV						-,009	,079	-,119	,905	-,166	,147
Fatigue	.451	.110	8.772	.000	.000						
General						-,035	,058	-,612	,541	-,150	,079
Physical						-,025	,064	-,392	,696	-,152	,101
Emotional						,083	,060	1,390	,166	-,035	,200
Mental						,258	,066	3,889	,000	,127	,389
Vigor						,019	,039	,488	,626	-,058	,096
OSC	.457	.005	7.331	.000	.669						
MCSC						-,048	,040	-1,195	,234	-,126	,031
ST						,008	,057	,135	,893	-,106	,121
EM						,032	,058	,550	,583	-,082	,146
CRM	.497	.040	7.234	.000	.008						
FMM						-,145	,094	-1,541	,125	-,331	,041
FWM						-,140	,065	-2,150	,033	-,269	-,011
CCC						,101	,093	1,086	,279	-,083	,286

Note. TH= Total flight hours in commercial aviation, MH= Flight hours in the last month, Openness= Openness-to-experience, NV= Negative valance, OSC= Organizational safety climate, MCSC= Management commitment and safety communication, ST= Safety training, EM= Equipment maintenance, FMM= Flight monitoring and management, FWM= Fatigue and Work Management, CCC=Crew communication and coordination

3.3.4.3. Predictors of Memory Failures.

In the third hierarchical regression analysis, the predicted variable was memory failures. After controlling the effects of control variables, the personality traits improved the explained variance significantly (R^2= .116, Δ R^2 = .103, F (10,165) = 2.169, p = .022). Neuroticism was positively associated with memory failures (B= .120, SE= .043, t= 2.767, p= .006, *95% CI* [.034, .206]). This showed that pilots reported committing more memory failures when their neuroticism levels were higher. On the contrary, negative valance was negatively associated with memory failures (B= -.189, SE= .064, t= -2.969, p= .003, *95% CI* [-.314, -.063]) showing that pilots reported committing less memory failures when they evaluated their negative valance as high. When fatigue symptoms were included in the model, they improved the explained variance (R^2= .235, Δ R^2 = .119, F (15, 160) = 3.275, p < .001). The results showed that mental fatigue (B= .152, SE= .054, t= 2.802, p= .006, *95% CI* [.045, .259]) were

Table 6. The Predictors of Decision Failures

	R^2	ΔR^2	*F*	*p*	F_{change} *p*	*B*	*SE*	*t*	*p*	*Lower*	*Upper*
Control	,013	,013	,571	.279	,684						
Age						-,004	,004	-,822	,412	-,012	,005
TH						.000	,000	,867	,387	,000	,000
MH						,001	,001	,999	,319	-,001	,004
Stress						-,006	,012	-,481	,631	-,030	,018
Personality	,127	,114	2,411	.011	,002						
Extraversion						-,008	,048	-,174	,862	-,104	,087
Conscientiousness						-,101	,063	-1,593	,113	-,225	,024
Agreeableness						-,020	,073	-,278	,781	-,164	,124
Neuroticism						,119	,054	2,202	,029	,012	,225
Openness						,062	,073	,855	,394	-,081	,205
NV						,080	,079	1,009	,314	-,076	,236
Fatigue	,267	,139	3,882	.000	.000						
General						-,086	,058	-1,489	,138	-,201	,028
Physical						-,022	,064	-,336	,737	-,148	,105
Emotional						,177	,060	2,968	,003	,059	,294
Mental						,194	,066	2,924	,004	,063	,325
Vigor						,020	,039	,514	,608	-,057	,098
OSC	,283	,016	3,444	.000	,317						
MCSC						,025	,040	,630	,530	-,053	,103
ST						-,105	,057	-1,838	,068	-,218	,008
EM						,037	,057	,641	,523	-,077	,150
CRM	,315	,032	3,377	.000	,068						
FMM						-,034	,095	-,362	,718	-,222	,153
FWM						-,124	,066	-1,887	,061	-,254	,006
CCC						,008	,094	,090	,928	-,178	,195

Note. TH= Total flight hours in commercial aviation, MH= Flight hours in the last month, Openness= Openness-to-experience, NV= Negative valance, OSC= Organizational safety climate, MCSC= Management commitment and safety communication, ST= Safety training, EM= Equipment maintenance, FMM= Flight monitoring and management, FWM= Fatigue and Work Management, CCC=Crew communication and coordination

positively associated with memory failures, meaning that pilots reported committing more memory failures when they evaluated their mental fatigue symptoms as high. On the contrary, general fatigue symptoms were negatively associated with memory failures (*B*= -.131, *SE*= .047, *t*= -2.758, *p*= .006, *95% CI* [-.224, -.037]) indicating that when pilots felt higher general fatigue symptoms, they reported committing less memory failures. When the organizational safety climate factors were added into the model, no significant additional variance was explained (Δ *F*= 1.112, *p*= .346) although the whole model was significant (R^2= .251, ΔR^2 = .016, *F* (18,157) = 2.920, $p < .001$). This might indicate that safety climate might have the indirect predictor effect on memory failures rather than the direct effect. Lastly, the factors of CRM-CS significantly improved the explained variance (R^2= .311, ΔR^2 = .060, *F* (21,154) = 3.314, *p* = .001). The CCC was negatively associated with memory failures (*B*= -.168, *SE*= .076, *t*= -2.216, *p*= .028, *95% CI* [-.317, -.018]), meaning that pilots reported committing less memory failures when they evaluated their CCC competencies as high (see Table 7).

Table 7. The Predictors of Memory Failures

	R^2	ΔR^2	*F*	*p*	F_{change} *p*	*B*	*SE*	*t*	*p*	*Lower*	*Upper*
Control	,013	,013	,558	.279	,693						
Age						,002	,003	,576	,566	-,005	,009
TH						.000	,000	,186	,853	,000	,000
MH						-,001	,001	-1,046	,297	-,003	,001
Stress						,004	,010	,389	,698	-,015	,023
Personality Traits	,116	,103	2,169	.022	,005						
Extraversion						,015	,039	,388	,699	-,062	,092
Conscientiousness						-,008	,051	-,152	,880	-,108	,093
Agreeableness						-,018	,059	-,302	,763	-,134	,098
Neuroticism						,120	,043	2,767	,006	,034	,206
Openness						-,110	,058	-1,892	,060	-,226	,005
NV						-,189	,064	-2,969	,003	-,314	-,063
Fatigue	,235	,119	3,275	.000	.000						
General						-,131	,047	-2,758	,006	-,224	-,037
Physical						,095	,052	1,818	,071	-,008	,199
Emotional						,066	,049	1,356	,177	-,030	,162
Mental						,152	,054	2,802	,006	,045	,259
Vigor						,035	,032	1,100	,273	-,028	,098
OSC	,251	,016	2,920	.000	,346						
MCSC						-,026	,032	-,810	,419	-,090	,038
ST						-,054	,047	-1,163	,247	-,146	,038
EM						,046	,047	,988	,325	-,046	,139
CRM	,311	,060	3,314	.000	,005						
FMM						-,060	,076	-,781	,436	-,210	,091
FWM						,035	,053	,668	,505	-,069	,139
CCC						-,168	,076	-2,216	,028	-,317	-,018

Note. TH= Total flight hours in commercial aviation, MH= Flight hours in the last month, Openness= Openness-to-experience, NV= Negative valance, OSC= Organizational safety climate, MCSC= Management commitment and safety communication, ST= Safety training, EM= Equipment maintenance, FMM= Flight monitoring and management, FWM= Fatigue and Work Management, CCC=Crew communication and coordination

3.3.4.4. Predictors of Procedural Incompliance.

In the last hierarchical regression analysis, the predicted variable was procedural incompliance (see Table 8). After controlling the effects of control variables, the personality traits improved the explained variance significantly (R^2= .137, ΔR^2 = .094, *F* (10,165) = 2.614, *p* = .006). Neuroticism was positively associated with procedural incompliance (*B*= .162, *SE*= .073, *t*= 2.205, *p*= .029, *95% CI* [.017, .263]). This showed that pilots reported committing more procedural compliance when their neuroticism levels were higher. On the contrary, conscientiousness was negatively associated with procedural incompliance (*B*= -.201, *SE*= .086, *t*= -2.338, *p*= .021, *95% CI* [-.370, -.031]) showing that pilots reported committing less procedural incompliance when they evaluated their conscientiousness as high. When fatigue symptoms were included in the model, they improved the explained variance

(R^2= .213, ΔR^2 = .076, *F* (15, 160) = 2.883, *p* < .001). The results showed that emotional fatigue (*B*= .182, *SE*= .084, *t*= 2.162, *p*= .032, *95% CI* [.016, .349]) were positively associated with procedural incompliance, meaning that pilots reported committing more procedural incompliance when they evaluated their emotional fatigue symptoms as high. When the organizational safety climate factors were added into the model, no significant additional variance was explained (ΔF= 0.702, *p*= .552) although the whole model was significant (R^2= .223, ΔR^2 = .010, *F* (18, 157) = 2.506,

Table 8. The Predictors of Procedural Incompliance

	R^2	ΔR^2	*F*	*p*	F_{change} *p*	*B*	*SE*	*t*	*p*	*Lower*	*Upper*
Control	,042	,042	1,895	,114	,114						
Age						-,011	,006	-1,846	,067	-,022	,001
TH						.000	,000	1,607	,110	,000	,000
MH						,001	,002	,733	,465	-,002	,004
Stress						,027	,016	1,639	,103	-,005	,059
Personality	,137	,094	2,614	,006	,008						
Extraversion						-,011	,066	-,169	,866	-,141	,119
Conscientiousness						-,201	,086	-2,338	,021	-,370	-,031
Agreeableness						-,022	,099	-,221	,825	-,218	,174
Neuroticism						,162	,073	2,205	,029	,017	,307
Openness						,068	,099	,686	,494	-,127	,263
NV						-,054	,107	-,501	,617	-,266	,158
Fatigue	,213	,076	2,883	,000	.011						
General						-,156	,082	-1,896	,060	-,318	,007
Physical						,078	,091	,862	,390	-,101	,258
Emotional						,182	,084	2,162	,032	,016	,349
Mental						,155	,094	1,652	,100	-,030	,341
Vigor						,066	,056	1,188	,237	-,044	,176
OSC	,223	,010	2,506	,001	,552						
MCSC						-,021	,056	-,366	,715	-,132	,091
ST						,023	,081	,286	,775	-,137	,184
EM						-,066	,082	-,810	,419	-,227	,095
CRM	,255	,032	2,509	,001	,092						
FMM						,097	,136	,713	,477	-,171	,364
FWM						-,026	,094	-,278	,781	-,211	,159
CCC						-,270	,134	-2,007	,046	-,536	-,004

Note. TH= Total flight hours in commercial aviation, MH= Flight hours in the last month, Openness= Openness-to-experience, NV= Negative valance, OSC= Organizational safety climate, MCSC= Management commitment and safety communication, ST= Safety training, EM= Equipment maintenance, FMM= Flight monitoring and management, FWM= Fatigue and Work Management, CCC=Crew communication and coordination

p= .001). This might indicate that safety climate might have the indirect predictor effect on memory failures rather than the direct effect. Lastly, the factors of CRM-CS did not significant improvement the explained variance (ΔF= 2.185, *p*= .092) although the whole model was significant (R^2= .255, ΔR^2 = .032, *F* (21,154) = 2.509, *p* = .001). The summary of the hierarchical regression results was presented in Table 9.

3.3.5. The Relationship between CRM and Unsafe Acts: The Mediator Roles of Climate and Fatigue

Twelve serial mediation analysis was conducted to examine the mediator roles of organizational safety climate and fatigue symptoms by using Hayes Process Macro 4.0. Factors of APilotBI-R were entered into the model as predicted variables. Factors of the CRM-CS were entered into the model as predictor variables. Organizational

Table 9. The Summary of the Hierarchical Regression Results

	SB Failures	*Decision Failures*	*Memory Failures*	*Procedural Incompliance*
Control				
Age	NS	NS	NS	NS
TH	NS	NS	NS	NS
MH	NS	NS	NS	NS
Stress	NS	NS	NS	NS
Personality				
Extraversion	NS	NS	NS	NS
Conscientiousness	NS	NS	NS	Negative
Agreeableness	NS	NS	NS	NS
Neuroticism	Positive	Positive	Positive	Positive
Openness	Negative	NS	NS	NS
NV	NS	NS	Negative	NS
Fatigue				
General	NS	NS	Negative	NS
Physical	NS	NS	NS	NS
Emotional	NS	Positive	NS	Positive
Mental	Positive	Positive	Positive	NS
Vigor	NS	NS	NS	NS
OSC				
MCSC	NS	NS	NS	NS
ST	NS	NS	NS	NS
EM	NS	NS	NS	NS
CRM				
FMM	NS	NS	NS	NS
FWM	Negative	NS	NS	NS
CCC	NS	NS	Negative	NS

safety climate and fatigue symptoms as total scores were added into the model as mediators. The total score of organizational safety climate was computed as the mean score of the factor scores. The total score of fatigue symptoms was computed as the sum of general, physical, mental and emotional minus vigor scale. Age, total hours in commercial aviation, flight hours in the last month and stress levels in the normal flight conditions were entered as covariates. The serial mediation analysis showed significant results for predicting skill-based failures and decision failures.

3.3.5.1. Mediating Roles of Organizational Safety Climate and Fatigue Symptoms in the Relationship between FMM and Skill-based Failures.

In the first serial mediation analysis, the predicted variable was skill-based failures, and the predictor variable was FMM. The results showed that FMM explained 24% of the variance in skill-based failures (R^2= .241, F (5, 170) = 10.792, p < .001). It showed that FMM was negatively associated with skill-based failures (β= -.320, t= -6.888, p< .001). When the organizational safety climate and fatigue was entered into the model, the model explained 38% of the variance (R^2= .377, F (7, 168) = 14.511, p < .001). It showed that FMM was still negatively associated with skill-based failures (β= -.259, t= -4.378, p< .001). Besides, fatigue was positively associated with skill-based failures (β= .407, t= 5.837, p< .001) yet no significant association was found between organizational safety climate and skill-based failures (β= -.029, t= -0.427, p= .670). However, the indirect effect was significant (β = -.027, *SE*= .013, *95% CI* [-.056, -.006]) indicating that organizational safety climate and fatigue partially mediated the relationship between FMM and skill-based failures (see Figure 1). This means that when pilots evaluated their FMM competencies as high, they reported more positive attitudes toward the organizational safety climate and less fatigue symptoms, and reported committing less skill-based failures, in turn.

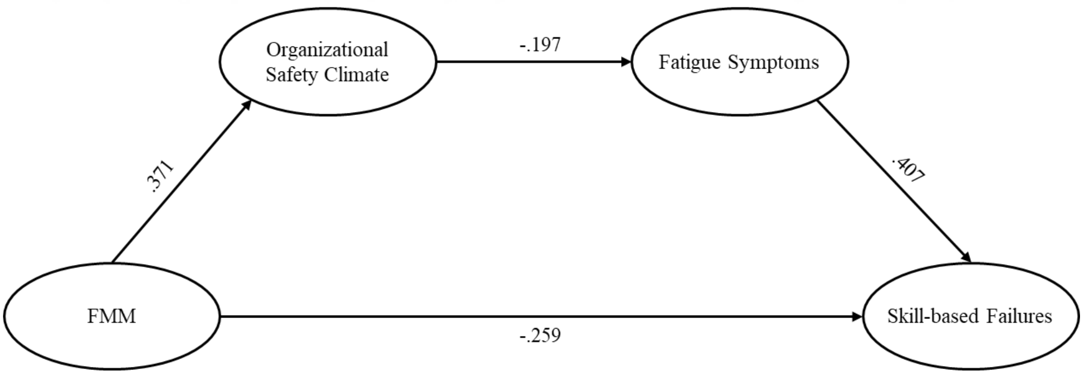

Figure 1. The Relationship between FMM and Skill-based Failures Mediated by Organizational Safety Climate and Fatigue

3.3.5.2. Mediating Roles of Organizational Safety Climate and Fatigue Symptoms in the Relationship between FWM and Skill-based Failures.

In the second serial mediation analysis, the predicted variable was skill-based failures, and the predictor variable was FWM. The results showed that FWM explained 24% of the variance in skill-based failures (R^2= .237, F (5, 170) = 10.548, p < .001). It showed that FWM was negatively associated with skill-based failures (β= -.483, t=

-6.801, $p < .001$). When the organizational safety climate and fatigue was entered into the model, the model explained 38% of the variance ($R^2 = .379$, F (7, 168) = 14.615, $p < .001$). It showed that FWM was still negatively associated with skill-based failures ($\beta = -.313$, $t = -4.435$, $p < .001$). Besides, fatigue was positively associated with skill-based failures ($\beta = .404$, $t = 5.796$, $p < .001$) yet no significant association was found between organizational safety climate and skill-based failures ($\beta = -.053$, $t = -0.890$, $p = .420$). However, the indirect effect was significant ($\beta = -.024$, $SE = .012$, *95% CI* [-.053, -.005]) indicating that organizational safety climate and fatigue partially mediated the relationship between FWM and skill-based failures (see Figure 2). This means that when pilots evaluated their FWM competencies as high, they reported more positive attitudes toward the organizational safety climate and less fatigue symptoms, and reported committing less skill-based failures, in turn.

3.3.5.3. Mediating Roles of Organizational Safety Climate and Fatigue Symptoms in the Relationship between CCC and Skill-based Failures.

In the third serial mediation analysis, the predicted variable was skill-based failures, and the predictor variable was CCC (see Figure 3). The results showed that CCC explained 13% of the variance in skill-based failures ($R^2 = .131$, F (5, 170) = 5.113, $p = .0002$). It showed that CCC was negatively associated with skill-based failures ($\beta = -.336$, $t = -4.457$, $p < .001$). When the organizational safety climate and fatigue was entered into the model, the model explained 33% of the variance ($R^2 = .327$, F (7, 168) = 12.651, $p < .001$). It showed that CCC was still negatively associated with skill-based failures ($\beta = -.169$, $t = -2.294$, $p = .023$). Besides, fatigue was positively associated with skill-based failures ($\beta = .467$, $t = 6.625$, $p < .001$) yet no significant association was found between organizational safety climate and skill-based failures ($\beta = -.055$, $t = -0.784$, $p = .434$). However, the indirect effect was significant ($\beta = -.037$, $SE = .017$, *95% CI* [-.075, -.010]) indicating that organizational safety climate and fatigue partially mediated the relationship between CCC and skill-based failures. This means that when pilots evaluated their CCC competencies as high, they reported more positive attitudes toward the organizational safety climate and less fatigue symptoms, and reported committing less skill-based failures, in turn.

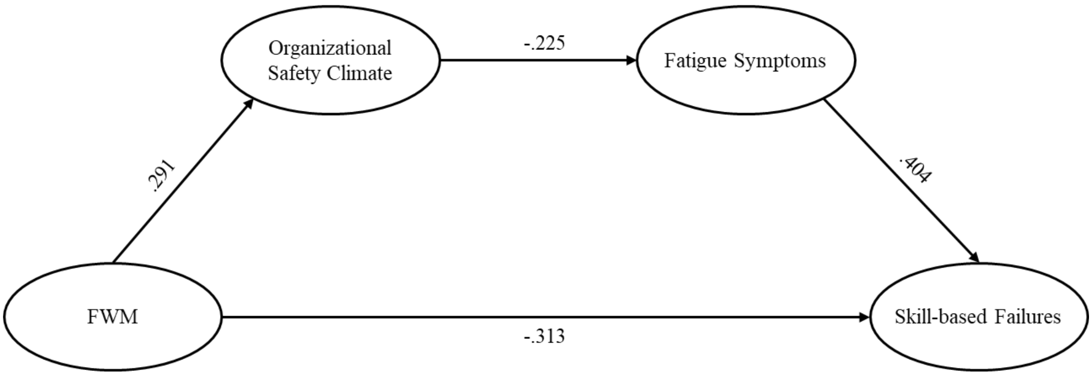

Figure 2. The Relationship between FWM and Skill-based Failures Mediated by Organizational Safety Climate and Fatigue

3.3.5.4. Mediating Roles of Organizational Safety Climate and Fatigue Symptoms in the Relationship between FMM and Decision Failures.

In the fourth serial mediation analysis, the predicted variable was decision failures, and the predictor variable was FMM. The results showed that FMM explained 9% of the variance in decision failures (R^2= .087, F (5, 170) = 3.227, p = .008). It showed that FMM was negatively associated with decision failures (β= -.290, t= -3.699, p= .0003). When the organizational safety climate and fatigue was entered into the model, the model explained 17% of the variance (R^2= .171, F (7, 168) = 4.934, p < .001). It showed that FMM showed no association with decision failures (β= -.152, t= -1.798, p= .074). Besides, fatigue was positively associated with decision failures

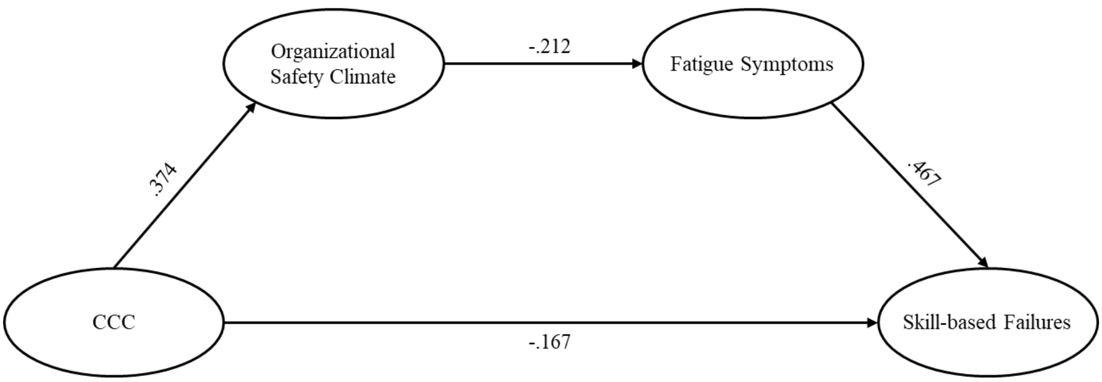

Figure 3. The Relationship between CCC and Skill-based Failures Mediated by Organizational Safety Climate and Fatigue

(β= .313, t= 3.931, p< .001) yet no significant association was found between organizational safety climate and decision failures (β= -.034, t= -0.445, p= .657). However, the indirect effect was significant (β = -.015, *SE*= .008, *95% CI* [-.034, -.002]) indicating that organizational safety climate and fatigue fully mediated the relationship between FMM and decision failures (see Figure 4). This means that when pilots evaluated their FMM competencies as high, they reported more positive attitudes toward the organizational safety climate and less fatigue symptoms, and reported committing less decision failures, in turn.

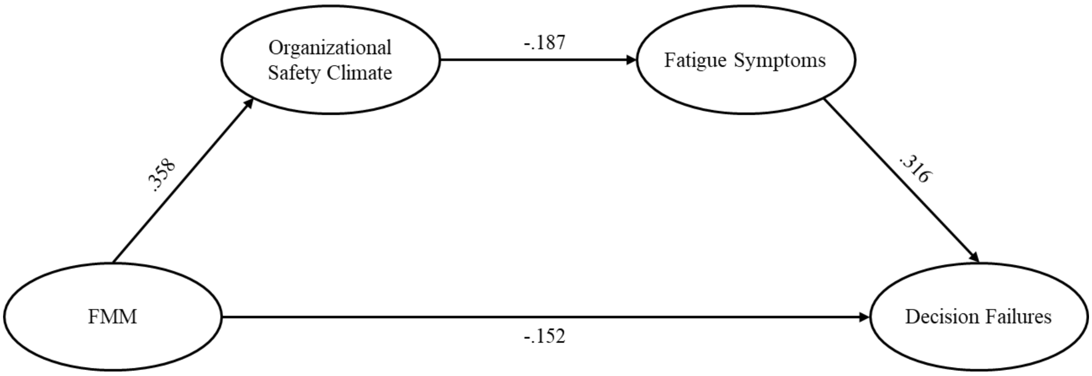

Figure 4. The Relationship between FMM and Decision Failures Mediated by Organizational Safety Climate and Fatigue

3.3.5.5. Mediating Roles of Organizational Safety Climate and Fatigue Symptoms in the Relationship between FWM and Decision Failures.

In the fifth serial mediation analysis, the predicted variable was decision failures, and the predictor variable was FWM. The results showed that FWM explained 14% of the variance in decision failures (R^2= .140, F (5, 170) = 5.552, p = .0001). It showed that FWM was negatively associated with decision failures (β= -.378, t= -5.015, p< .001). When the organizational safety climate and fatigue was entered into the model, the model explained 21% of the variance (R^2= .206, F (7, 168) = 6.230, p < .001). It showed that FWM showed a negative association with decision failures (β= -.263, t= -3.302, p= .001). Besides, fatigue was positively associated with decision failures (β= .2783, t= 3.531, p< .001) yet no significant association was found between organizational safety climate and decision failures (β= -.028, t= -0.374, p= .709). However, the indirect effect was significant (β = -.016, SE= .011, *95% CI* [-.044, -.002]) indicating that organizational safety climate and fatigue partially mediated the relationship between FWM and decision failures (see Figure 5). This means that when pilots evaluated their FWM competencies as high, they reported more positive attitudes toward the organizational safety climate and less fatigue symptoms, and reported committing less decision failures, in turn.

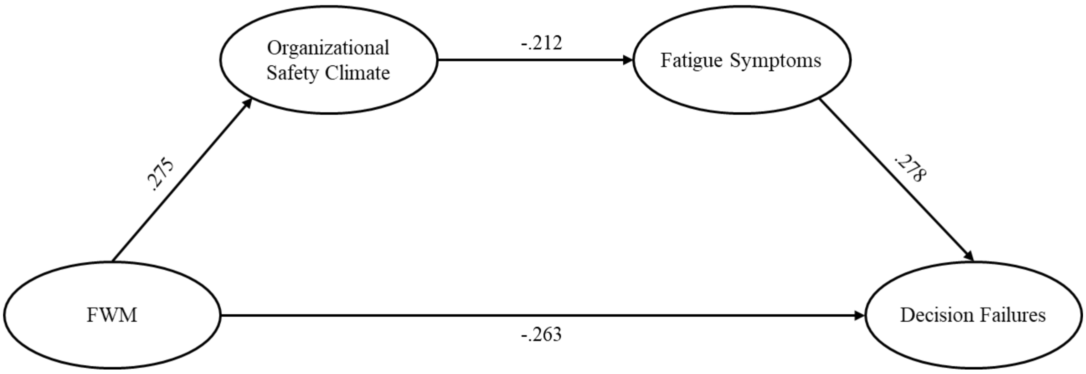

Figure 5. The Relationship between FWM and Decision Failures Mediated by Organizational Safety Climate and Fatigue

3.3.5.6. Mediating Roles of Organizational Safety Climate and Fatigue Symptoms in the Relationship between CCC and Decision Failures.

In the sixth serial mediation analysis, the predicted variable was decision failures, and the predictor variable was CCC. The results showed that CCC explained 8% of the variance in decision failures (R^2= .078, F (5, 170) = 2.867, p = .016). It showed that CCC was negatively associated with decision failures (β= -.268, t= -3.450, p< .001). When the organizational safety climate and fatigue was entered into the model, the model explained 17% of the variance (R^2= .172, F (7, 168) = 5.000, p < .001). It showed that CCC showed no association with decision failures (β= -.155, t= -1.904, p= .059). Besides, fatigue was positively associated with decision failures (β= .329, t=4.200, p< .001) yet no significant association was found between organizational safety climate and decision failures (β= -.026, t= -0.330, p= .742). However, the indirect effect was significant (β = -.026, *SE*= .014, *95% CI* [-.059, -.005]) indicating that organizational safety climate and fatigue fully mediated the relationship between CCC and decision failures (see Figure 6). This means that when pilots evaluated their CCC competencies as high, they reported more positive attitudes toward the organizational safety climate and less fatigue symptoms, and reported committing less decision failures, in turn.

3.3.6. The Relationship between CRM Competencies and Pilot Behavior: The Moderator Role of Personality Traits

A total of 72 moderation analyses were conducted to explore the moderator role of personality traits. In each moderation analysis, predicted variables were the factors of APilotBI-R and predictors were the factors of CRM-CS. In each analysis, moderator was the factors of BPTI, i.e. extraversion, conscientiousness, agreeableness,

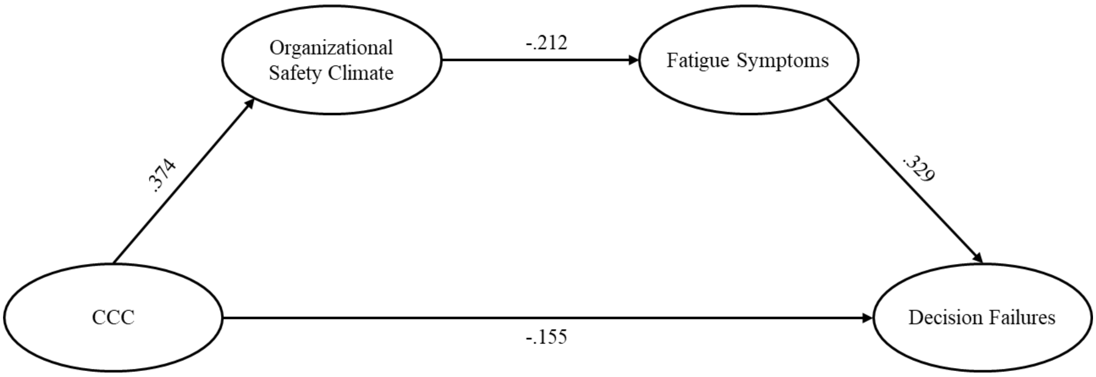

Figure 6. The Relationship between CCC and Decision Failures Mediated by Organizational Safety Climate and Fatigue

neuroticism, openness-to-experience, and negative valance. Only two moderation analysis achieved significance where procedural incompliance was the predicted variable, FMM and FWM were the predictors, and the neuroticism was the moderator variable.

3.3.6.1. Moderating Role of Neuroticism in the Relationship between FMM and Procedural Incompliance.

In the first moderation analysis where procedural incompliance was the predicted variable, and the neuroticism was the moderator variable, the predictor variable was the flight monitoring and management competencies. The model showed significant results (R^2= .142, F (7, 168) = 3.911, p < .001). Flight monitoring and management competencies were negatively associated with procedural incompliance failures (B= -.556, SE= .234, t= -2.372, p= .018) whereas neuroticism did not show significant direct prediction on procedural incompliance (B= -.778, SE= .501, t= -1.553, p= .122). However, the interaction effect reached significance (ΔR^2= .018, F (7, 168) = 3.478, p = .048). This showed that when pilots evaluated Flight monitoring and management competencies as high and their neuroticism level low (B = -.261, SE= .102, t= -2.565, p= .011, *95% CI* [-.462, -.060]), they reported lower procedural incompliance. This shows that pilots reported significantly lower frequency of procedural incompliance when they evaluated their FMM competencies high and neuroticism level low than when they evaluated their FMM competencies and neuroticism level low. However, there is no significant frequency change between low and high FMM competencies in procedural incompliance reporting when their neuroticism level was high (see Figure 7).

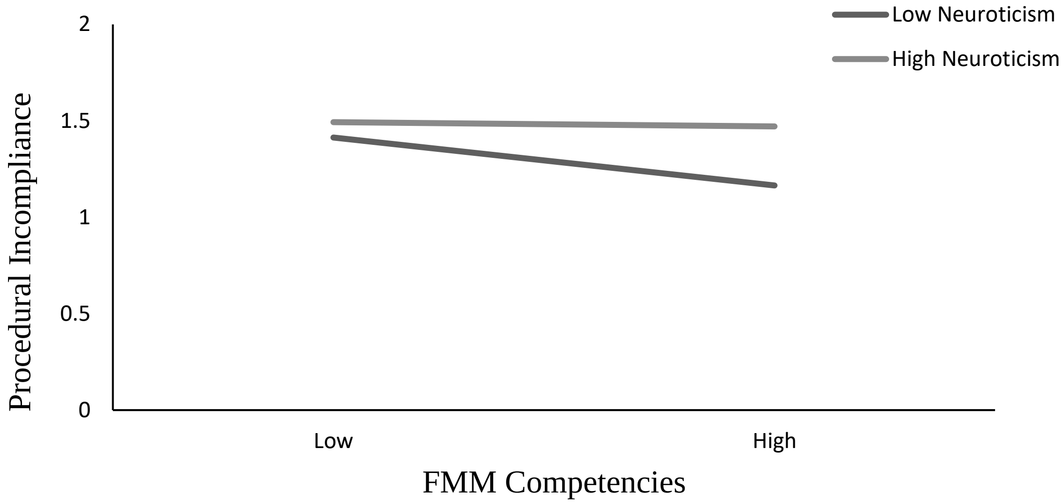

Figure 7. The Moderator Role of Neuroticism in the Relationship between FMM and Procedural Incompliance

3.3.6.2. Moderating Role of Neuroticism in the Relationship between FWM and Procedural Incompliance.

In the second moderation analysis where procedural incompliance was the predicted variable, and the neuroticism was the moderator variable, the predictor variable was fatigue and work management competencies. The model showed significant results (R^2= .186, F (7, 168) = 5.477, p < .001). Fatigue and work management competencies (B= -.750, SE= .199, t= -3.774, p< .001) and neuroticism (B= -1.060, SE= .397, t= -2.671, p= .008) were negatively associated with procedural incompliance failures. The interaction effect reached significance (ΔR^2= .046, F (7, 168) = 9.544, p = .002). This showed that when pilots evaluated their fatigue and work management competencies as high and neuroticism level low (B = -.337, SE= .084, t= -4.017, p< .001, *95% CI* [-.502, -.171]), they reported the lowest frequencies of procedural incompliance (see Figure 8). This shows that pilots reported significantly lower frequency of procedural incompliance when they evaluated their FWM competencies high and neuroticism level lower than when they evaluated their FWM competencies and neuroticism level low. However, there is no significant frequency change between low and high FWM competencies in procedural incompliance reporting when their neuroticism level was high.

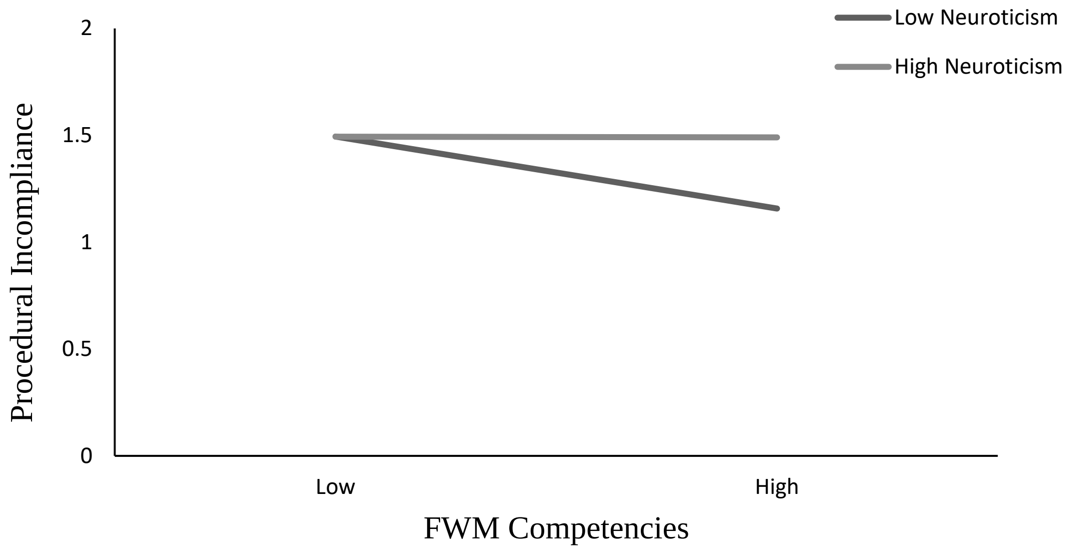

Figure 8. The Moderator Role of Neuroticism in the Relationship between FWM and Procedural Incompliance

3.4. Discussion

In the main study, the factor structures of the newly developed CRM-CS and the revised version of APilotBI were first examined. Once the factor structures were identified, the correlations between CRM-CS, demographic variables, and other safety-critical factors measured in the study were analyzed. Hierarchical regression analyses were then conducted to identify the predictors of unsafe acts among commercial airline pilots. Subsequently, mediation analyses were performed to explore the role of organizational safety climate and fatigue in the relationship between CRM competencies and unsafe acts. Finally, moderation analyses were carried out to investigate how personality traits moderate the link between CRM competencies and unsafe acts. The results showed significant critical relationships which could improve our understanding of the factors related to unsafe acts of pilots.

3.4.1. The Factor Structure of the APilotBI-R, and Its' Psychometric Properties

The 53-item revised APilotBI-R showed 4-factor structure; *skill-based failures, decision failures, decision failures and procedural incompliance*. The 4-factor structure supported the multidimensional nature of unsafe acts proposed by (Shappell et al., 2007; Shappell & Wiegmann, 2000; Wiegmann & Shappell, 2001). The factor structure of APilotBI-R showed distinct differentiation between factors although three out of 53 items had cross-loadings. Since the differences between loadings exceeded .100, they were able to differentiate the factors that were loaded higher.

The factors showed the different aspects of unsafe acts of commercial airline pilots. Accordingly, skill-based failures were related to failures in the application of technical knowledge and flight operation procedures. These behaviors consisted of highly practiced behaviors that were habitual in nature. Thus, highly practiced behaviors are likely to be performed with little and no conscious thoughts (Shappell et al., 2007; Shappell & Wiegmann, 2000; Wiegmann & Shappell, 2001). Breakdowns in visual perception, failing to prioritize attention, omission of some procedures or performing some procedures rotely result in committing skill-based failures in the flight operations. Thus, skill-based failures factor of APilotBI-R showed the characteristics of skill-based error division of unsafe acts (Shappell et al., 2007; Shappell & Wiegmann, 2000; Wiegmann & Shappell, 2001). There were two items that cross-loaded into other factors, yet the differences between loadings exceeded .100. Thus, they were retained in this factor. Overall, the skill-based failures factor emerged as a distinct factor that successfully discriminates the skill-based failures from other unsafe acts.

Decision failures in APilotBI-R were related to inappropriate decisions for the situations. These behaviors represented the application of improper procedures, misdiagnosing and wrong response to the situation and poor decisions. Thus, decision failures supported the decision error division proposed by Shappell and Wiegmann (2000). The decision failures factor of APilotBI-R emerged as a distinct factor with no cross-loaded items which implies that the items loaded on this factor successfully discriminate decision failures from other unsafe acts.

Memory failures in APilotBI-R were related to “forgetting something” and “not realizing that something is wrong”. These behaviors mainly represented the inexecution of knowledge due to not remembering. Memory failures were shown as a distinct factor that mainly emerged in the skill-based errors proposed by Shappell and Wiegmann (2000). Behaviors due to failures in memory are mainly categorized as skill-based errors in literature, yet they have emerged distinct behaviors than skill-based failures. Besides, there were no cross-loaded items which implies that the items loaded on this factor were successfully discriminate decision failures from other unsafe acts.

Procedural incompliance in APilotBI-R was related to deliberate deviations from the procedures. These behaviors represented inexecution of procedures and inappropriate maneuvers deliberately. This factor supported the routine violations in literature proposed by Shappell and Wiegmann (2000). Routine violations represent behaviors that are often tolerated by the authorities. They are mainly "bending the rules" due to rush or high practice such as not adhering to brief. Since they were tolerated by the authorities, they are vulnerable to being habitual. The procedural incompliance factor, as a result, showed the characteristics of routine violations. There was only one item that cross-loaded into another factor which had the difference of loadings over .100, yet it was retained in this factor.

The factors of APilotBI-R showed good psychometric properties in terms of reliability (i.e. internal reliability). Particularly, the factors of APilotBI-R displayed Cronbach's alpha coefficients .70 and above.

In conclusion, the revised version of APilotBI-R provided a stable and comprehensive measurement tool for unsafe acts of commercial airline pilots. It showed good reliability implying that APilotBI-R can be successful in measuring unsafe acts of commercial airline pilots. It also showed similar factor structure with the initial APilotBI (Serin, 2016). This can imply the revised version of APilotBI-R might capture more behavioral samples of unsafe acts committed during flight since it consisted of more items than the initial version.

3.4.3. The Factor Structure of the CRM-CS, and Its' Psychometric Properties

The present study showed the three-factor structure of CRM-CS with 49 items: *flight monitoring and management, fatigue and work management, and crew communication and cooperation*. The three-factor structure supported the multidimensional nature of CRM competencies proposed by the core competency framework of EASA (2023), Line/LOS checklist (Helmreich et al., 1997) and NOTECHS of O'Connor and colleagues (2002). The CRM-CS also showed district factor structure with no cross-loaded items between factors. This implies the practical distinction between factors among the competency perceptions of pilots.

The factors showed different aspects of CRM competencies among commercial airline pilots. Accordingly, flight monitoring and management competencies consisted of application of knowledge on procedures and regulations into the flight operations, and flight management competencies under manual control and automation. It also captured the competencies related to the situation awareness and decision-making process although they were distinct constructs in EASA framework, Line/LOS checklist and NOTECH framework. This is probably because flight monitoring and management competencies factor is comprehensive factor that requires application of knowledge, monitoring the flight plan and management of the deviations from the plan as well as being aware of the changes in the systems and in the environment, and making decisions accordingly to ensure flight safety. This can also show that these constructs are practically inseparable for commercial airline pilots. For example, application of appropriate knowledge requires awareness of systemic and environmental changes and making effective decisions to apply appropriate procedures to the situations. Besides, for effective management of flight, pilots need to assess the current situation and the deviations from the preliminary flight plan. As a result, flight monitoring and management competencies consist of application of knowledge, flight management competencies for both manual control and under automation, situation awareness and decision-making processes.

The fatigue and work management competencies factor was related to managing fatigue and workload of pilots for both them and crew members. It also captured the leadership competencies that was required for taking effective precautions and countermeasures to prevent fatigue symptoms and distractions due to workload such as detecting crew members fatigue symptoms, giving them stimuli like caffeine when needed. Although leadership was the distinct component of EASA framework (2023), Line/LOS checklist (Helmreich et al., 1997) and NOTECHS (Flin et al., 2003; O'Connor et al., 2002) framework, the fatigue and work management competencies factor comprised the leadership competencies. This can be because pilots are required to show leadership to manage crew members' fatigue and workload in order to keep them vigilant. For example, when they detect fatigue symptoms in crew members, they can take the initiative to mitigate the symptoms. They can give them stimulants such as caffeine, monitor their actions more carefully, and arrange their workload in order for crew members to take a cockpit nap or bulk sleep. As a result, they can use their leadership competencies to manage crew members' fatigue and workload. Since this can be the case, the pilots may not separate the practical implications of leadership, fatigue and work management. Thus, the factor may be expressed as a comprehensive factor that combines leadership competencies and fatigue and work management competencies.

The crew communication and coordination competencies factor was related to the open communication between crew members and effective coordination of crew in the flight operations. It also captured team decision-making processes to effective and appropriate decisions. Although decision-making was the distinct component of EASA framework (2023), Line/LOS checklist (Helmreich et al., 1997) and NOTECHS (Flin et al., 2003; O'Connor et al., 2002) framework, the crew communication and coordination competencies factor involved the items related to the team decision-making process such as giving importance to the ideas of crew members in decision-making processes, and encouraging crew members to speak their ideas during decision-making processes. This can be because pilots need open communication and coordination with other crew members for making effective and appropriate decisions in flight operations. Open and assertive communication and cooperative coordination between crew members is important for mitigating unsafe acts as well as effective team decision-making processes (Orasanu, 2010). For example, flight operations are mainly highly practiced and habitual in nature. Thus, it can be vulnerable to errors, especially unsafe acts. This vulnerability can be mitigated when more vigilant crew members speak up assertively and share critical information for appropriate decisions. Moreover, sharing critical information for appropriate decisions can encourage crew members to share information and be in coordination with other crew members. Therefore, this can be an interactive and interpersonal relationship that feed each other. As a result, pilots may perceive this process as inseparable, giving importance to open communication and coordination. Since this can be the situation, crew communication and coordination can emerge as a distinct factor consisting of team decision making processes.

The 3-factor structure was accepted based on the best fit for the data. Although theoretical evaluation of CRM-CS showed a 6-factor structure, the 3-factor structure was found to be more suitable for the data. There could be 2 main reasons for the differences between theoretical factor structure and data-based factor structure. The first reason might be that pilots' mental representations on some components are inseparable. For example, managing safe flight operations requires effective application of knowledge, effective situational awareness, and monitoring the flight plan and management of the deviations. This occurs spontaneously and sequentially for effective management of flight. Similar situations can be applied to fatigue and work management and also crew communication and cooperation. In fact, leadership competencies can be inseparable to effective management of fatigue symptoms and workload of crew members; effective communication and coordination can be inseparable from the effective decision-making process. As a result, mental representations of pilots can play a role in embedding some components into one factor. The second reason can be the sample size. Since the sample size was relatively low, the variability in the excluded items became low to construct separate factors. Thirty-three items were excluded from the CRM-CS due to lower loadings than .40. Thus, excluded items might result in losing some theoretical factors.

The CRM-CS showed the 3-factor structure that were distinct from each other and represent the multidimensional nature of CRM. It showed good psychometric properties in terms of reliability (i.e. internal consistency reliability). Particularly, the factors of CRM-CS displayed Cronbach's alpha coefficients .87 and above. It is believed that the CRM-CS will provide valuable contribution to measure CRM competencies of commercial airline pilots.

3.4.3. Empirical Discussion of The Relationships between Study Variables

3.4.3.1. Evaluation of the Predictors of Unsafe Acts of Commercial Airline Pilots.

Four hierarchical regression analysis was conducted to examine the predictors of unsafe acts of commercial airline pilots. In each regression analysis, the factors of APilotBI-R were treated as predicted variables. In the first step of each analysis, age, total flight hours in commercial airline, flight hours in the last month, and the stress levels in normal flight conditions were entered into the model as covariates. In the second step of each analysis, personality traits were entered into the model. In the third step of each analysis, fatigue symptoms were entered into the model. In the fourth step of each analysis, organizational safety climate was entered into the model. Lastly, factors of CRM-CS were included in the model.

3.4.3.1.1. Evaluation of Personality Traits as Predictors of Unsafe Acts

The results showed that neuroticism was positively associated with all factors of APilotBI-R, i.e. skill-based failures, decision failures, memory failures and procedural incompliance. The results provided support for the literature findings. In the literature, numerous studies showed the relationship between neuroticism and unsafe acts, especially among drivers. Drivers with high levels of neuroticism reported committing more errors and violations in the driving context (Beanland et al., 2014; Dahlen & White, 2006; Mallia et al., 2015; Sümer, 2003; Tanglai et al., 2022; Tinella et al., 2022; Wei et al., 2021; J. Xu et al., 2018). The results of the present study also showed pilots with high levels of neuroticism reported committing more skill-based failures, decision failures, memory failures, and procedural incompliance. It is not surprising that since neuroticism is characterized by aggression, impatience, being impetuous, anxiety and worry (Gençöz & Öncül, 2012; McCrae, 2010; McCrae & Costa, 2008; McCrae & John, 1992), pilots with high levels of neuroticism might fail to appropriately respond to the flight situations. A possible reason for this could be related to the reactions to stressful situations. People with high levels of neuroticism are likely to perceive the stress inherent in the situations more than people with low levels of neuroticism (Mohiyeddini et al., 2015; Schneider, 2004) which result in failures in cognitive processes and make them more vulnerable to errors (Mohiyeddini et al., 2015). The flight operations are inherently stressful events to certain degree since they are operated in constantly changing environment (Martinussen & Hunter, 2018). Therefore, pilots with high levels of neuroticism, characterized by anxiety, impatience, and worry, might perceive more inherent stress in flight situations resulting in cognitive failures and unsafe acts, eventually.

It is important to note that pilots recruitment processes consist of personality assessments (Çetingüç, 2016; Martinussen & Hunter, 2018). Numerous studies have also shown that pilots showed lower neuroticism levels than the general population (Carretta et al., 2016; Chang et al., 2018; Chaparro et al., 2020; Glicksohn & Naor-Ziv, 2016; Mesarosova et al., 2019). However, it seems that there is still a variability in neuroticism level among pilots. Therefore, this variability might exert itself in committing the frequency of unsafe acts.

On the contrary, openness-to-experience was negatively associated with skill-based failures. This result provides information contrary to results from driving context. Studies conducted in driving context showed that high levels of openness-to-experience was associated with committing violations among drivers (Hussain et al., 2020; Wei et al., 2021), on the contrary, skill-based failures in the present study represents basically errors. Openness-to-experience have characterized by self-confidence, self-assurance, bravery, and capability (Gençöz & Öncül, 2012; McCrae, 2010; McCrae & Costa, 2008; McCrae & John, 1992). When drivers have high levels of openness-to-experience, they might feel confident and assured about their driving skills and feel brave to execute their skills, they might be likely to execute their skills by violating the rules. On the other hand, when pilots feel confident and assured about their flying skills and feel brave to execute their skills, they might select the more appropriate behaviors for the situation and eventually commit less skill-based failures. Pilots are highly trained professionals for different flight situations. They take recurrent training to keep their knowledge fresh as well as fly several hours actively. This helps them always practice their knowledge and be prepared for the upcoming unexpected events. Therefore, when they feel confident and assured about their flying skills and feel brave to execute their skills, they might not hesitate to perform the suitable behaviors for the situations.

Similar to skill-based failures, negative valance was negatively associated with memory failures indicating that pilots with high levels of negative valance reported committing less memory failures than pilots with low levels of negative valance. This is surprising because negative valance is characterized by being ill-mannered, rude, pretentious, backstabbing, greedy and hidebound, and it is specific to Turkish culture (Gençöz & Öncül, 2012). Thus, the association between high negative valance and less memory failures were unexpected in the present study. Literature suggested that negative valance was positively associated with state anxiety, and emotional coping of stress (Gençöz & Öncül, 2012) showing that people with high levels of negative valance perceives the stress inherent in the situations more intense, feels more anxious in everyday situations, and use emotional coping strategies to deal with the stressful events. Since they feel more anxious in the stressful situations, using emotional coping strategies might help them to better emotional regulation, and reduce the stress and anxiety in stressful situations (Gilgoff et al., 2023). As a result, better emotional regulation allows them for clearer thinking by activating the executive center in the brain (Hossein et al., 2023) which is important to functioning better working memory for remembering the immediate past experiences (Funahashi, 2017). Therefore, pilots with high levels of negative valance might be better at using emotional coping strategies helping them to better regulate their emotions and better recalling of immediate past experiences which they highly practiced when actively flying.

Eventually, this might help them to better remember the standard procedures they practiced and less committing memory failures.

Conscientiousness, in addition, showed negative association with procedural incompliance which represents deviation from the procedures and regulations. This result supported the results of Tinella and colleagues (2022) reporting that high levels of conscientiousness was associated with lower violations among driver sample. Similar to drivers, pilots with high levels of conscientiousness reported committing less procedural incompliance implying that more conscientious pilots preferred to follow procedures and regulations more than low conscientious pilots. This might be because more conscientious pilots are more self-disciplined, prudent, hard-working, fussy and responsible individuals that might feel more responsible for flight safety and believe more following procedures and regulations ensures flight safety. As a result, more conscientious pilots might prefer to follow procedures and regulations more, committing less procedural incompliance.

Extraversion and agreeableness, however, showed no significant associations with any factors of APilotBI-R. Although high extraversion and low agreeableness was associated with committing more unsafe acts among driver sample (Hussain et al., 2020; Tinella et al., 2022), the present study found no significant associations of extraversion and agreeableness with unsafe acts of commercial airline pilots. This might be because extraversion and agreeableness are more related to interpersonal behaviors rather than unsafe acts. For example, being outgoing, talkative, warm, sincere, genial, tolerant, well-intentioned, and sensitive might be related to effective communication with other crew members, sharing critical information and being assertive in communicating with each other, being tolerant and responsive to other's fatigue and workload complaints, keeping them vigilant and focused during the flight operations. Therefore, extraversion and agreeableness might be related to effective CRM rather than unsafe acts. The correlations between extraversion and agreeableness might provide some support for this speculation. Extraversion and agreeableness were positively correlated with factors of CRM-CS implying extraversion and agreeableness might play a role in effective CRM. However, simple correlations might be insufficient to draw clear associations. Therefore, the role of extraversion and agreeableness on effective CRM needs further examination that might be focused on future studies.

In summary, the current study provided valuable information regarding personality traits predicting unsafe acts in commercial airlines. It stressed the predictive value of neuroticism and openness-to-experience on skill-based failures, neuroticism on decisional failures, neuroticism and negative valance on memory failures, and neuroticism and conscientiousness on procedural incompliance. The current study is also the first study examining the relationship between negative valance and unsafe acts. Therefore, it is believed that future studies might benefit from the result of the present study.

3.4.3.1.2. Evaluation of Fatigue Symptoms as Predictors of Unsafe acts

Fatigue symptoms were introduced into the model following the inclusion of personality traits. The results indicated that mental fatigue was positively associated with skill-based failures, decision failures, and memory failures, after accounting for the variance explained by control variables and personality traits. Specifically, pilots experiencing higher levels of mental fatigue reported a greater frequency of skill-based errors, decision-making failures, and memory failures. This finding is unsurprising when considering the known consequences of fatigue on cognitive functioning. Numerous studies have highlighted the detrimental effects of fatigue on cognitive abilities, including declines in psychomotor skills, visual performance, attention, working memory capacity, information processing speed and quality, and reasoning abilities (Jackson et al., 2011; Killgore et al., 2009; Linde & Bergström, 1992; Neri et al., 1992; Quant, 1992; Rogé et al., 2003; Smith et al., 2002; Tucker et al., 2010; Tyagi et al., 2009; Zuckerman et al., 2007). Given the high prevalence of fatigue among commercial airline pilots—due to long flight hours, multiple sectors flown, frequent time zone changes, and limited sleep quality and duration (Caldwell, 2012; Gawron, 2016; Jackson & Earl, 2006; Reis et al., 2013, 2016; Yen et al., 2009)—pilots are particularly vulnerable to mental fatigue, which increases the likelihood of committing errors. Flight operations demand that pilots continuously monitor aircraft systems and the changing environment, detect discrepancies within systems, and identify differences between systems and environmental conditions. Pilots are required to gather information constantly from systems, the environment, and fellow crew members regarding various situations, process this information, and act accordingly. Any disruption in this cognitive process due to the decline in cognitive abilities induced by fatigue can lead to inappropriate application of technical knowledge, poor decision-making, and lapses in operational procedures.

Similar to mental fatigue, emotional fatigue was positively associated with decision errors and procedural incompliance showing that pilots experiencing more emotional fatigue symptoms reported committing more decision failures and procedural incompliance. Emotional fatigue is characterized by chronic emotional exhaustion, depressive and distracted feelings. Literature have suggested that emotional exhaustion was associated with decrease in sustained attention (Linden et al., 2005; Orena et al., 2013; Österberg et al., 2009). Thus, a decrease in sustained attention might result in failures in detecting critical information for effective decision-making. Failures in effective decision-making, consequently, might result in committing more decision failures among pilots with higher emotional fatigue symptoms. Moreover, emotional exhaustion was negatively associated with safety motivation and safety compliance (Chen & Li, 2020; Liu et al., 2024). Therefore, emotional fatigue characterized by chronic emotional exhaustion might result in decreased safety motivation and compliance of commercial airline pilots. This decrease, in turn, make them vulnerable to committing procedural incompliance.

Surprisingly, general fatigue symptoms were found to be negatively associated with memory failures showing that pilots experiencing high general fatigue symptoms reported committing less memory failures. Generally, it is expected that individuals experiencing fatigue symptoms are likely to be vulnerable to committing memory failures since fatigue was associated with decreased cognitive functioning (Neri et al., 1992; Smith et al., 2002; Tyagi et al., 2009). However, commercial airline pilots showed a different tendency than stated in the literature. This could be because pilots might be more successful in detecting general fatigue symptoms such as feeling run down, worn out and fatigued. Thus, when they detect general fatigue symptoms, they might have a tendency to follow the checklists which help them to execute appropriate procedures. Consequently, they might commit less memory failures. It is important to note that there is a need for further examination in this relationship since there is little known in the literature about this relationship. Therefore, future studies might examine the possible mediators of this relationship to clarify this speculation.

In conclusion, the present study provided valuable information regarding the importance of mental fatigue and emotional fatigue on committing self-reported unsafe acts in commercial aviation. Besides, the negative relationship between general fatigue symptoms and memory failures provided surprising information which might be examined by further studies. It is also believed that stressing the predictive power of emotional fatigue, the antecedent of emotional exhaustion and burnout, on self-reported decision failures and procedural incompliance might provide information about the critical role of emotional well-being in flight safety and the need for effective interventions to mitigate fatigue-related risks.

3.4.3.1.3. Evaluation of Organizational Safety Climate as Predictors of Unsafe Acts

Organizational safety climate factors were included in the model after the control variables, personality factors and fatigue symptoms. After variance in unsafe acts explained by control variables, personality and fatigue symptoms were excluded, the factors of organizational safety climate did not significantly predict none of the factors of unsafe acts committed by commercial airline pilots. Literature have clearly stated that a positive safety climate was negatively associated with driver's errors and violations in driving context (Chu et al., 2019; Öz et al., 2010, 2013; Şimşekoğlu & Nordfjærn, 2015; Zhang et al., 2018). However, the results from the current study did not find any support for literature. A possible reason for insignificant associations between organizational safety climate and unsafe acts of commercial airline pilots is that a positive safety climate is related to the perception of crew members on the organization's prioritization of safety and providing available resources for increasing safety issues (Gao et al., 2013; Zohar, 2010). Indeed, aviation psychology literature suggested that a positive safety climate was positively associated with safety compliance and safety participation (Fernandes et al., 2018; Lin, 2012; Maneechaeye & Potipiroon, 2022a, 2022b; Xu et al., 2022).

Safety compliance and safety participation measured in these studies were related to the attitudes and intentions toward the applications of rules and procedures. Pilots with positive attitudes toward the organization's safety climate had also positive attitudes and intentions to comply with safety rules and regulations and participate the safety related issues such as incident reporting. It was suggested that safety trainings such as CRM training programs were important tools to improve safety compliance and safety participation attitudes and intentions (Reason, 1990; Shappell et al., 2007; Von Thaden et al., 2006).

Considering that a positive safety climate was characterized by shared values, perceptions and beliefs regarding the importance of safety, CRM training programs can help organizations to create these shared values, beliefs and perceptions among the commercial airline pilots. Therefore, effective CRM training programs might help pilots to improve their intentions and attitudes toward safety participation and compliance as well as teaching them how to use all available resources effectively. This might imply that the positive attitudes toward the organization's safety climate can exert itself in the application of effective CRM rather than the unsafe acts itself. Thus, when pilots have positive attitudes toward an organization's safety climate, they might be more likely to use all available resources to ensure flight safety. However, these positive attitudes might not directly predict the reduction in frequency of unsafe acts among commercial airline pilots. As a result, treating these attitudes as the possible mediator of the relationship between CRM and unsafe acts might provide valuable information rather than treating them as the direct predictors of unsafe acts.

In summary, the current study showed that organizational safety climate did not yield significant results for predicting self-reported unsafe acts of commercial airline pilots. However, this information can be used by future studies to examine possible underlying mechanisms in the relationship between organizational safety climate and unsafe acts in commercial aviation.

3.4.3.1.4. Evaluation of CRM Competencies as Predictors of Unsafe Acts

The factors of CRM-CS were included in the model after the control variables, personality factors, fatigue symptoms, and organizational safety climate. After variance in unsafe acts explained by control variables, personality, fatigue symptoms, and organizational safety climate were excluded, the factors of CRM-CS showed significant associations with skill-based failures and memory failures.

The results showed that fatigue and work management (FWM) was negatively associated with skill-based failures showing that pilots evaluating their FWM competencies as high reported committing less skill-based failures than pilots with low FWM competencies. This might show that feeling competent on managing fatigue symptoms and workload for themselves and for other crew members might help them to reduce the frequency of committing skill-based failures. Managing fatigue symptoms and workload in the flight operations requires awareness of their and other crews' current situations on fatigue and workload, and to act accordingly to eliminate the consequences of fatigue and workload. Literature clear stated the consequences of fatigue on cognitive performance (Killgore et al., 2009; Linde & Bergströme, 1992; Olaganathan et al., 2021; Quant, 1992; Roach et al., 2012; Tucker et al., 2010; Tyagi et al., 2009). Deterioration in cognitive performance, consequently, might have an impact on the application of technical knowledge onto the flight management, monitoring the automation systems and the changing environment, detection of changes and taking appropriate actions, all of which are related to skill-based failures. Being high on situational awareness and vigilant regarding their current situation of fatigue can help pilots for effective management of the consequences. Feeling competent on being aware of the current situation and managing them effectively can help them to mitigate its effects on unsafe acts, eventually. Considering that pilots high on situational awareness and vigilance were more successful in preventing ang mitigating the errors and violation in flight operations (Thomas, 2004), it might not be surprising that pilots high on situational awareness on fatigue symptoms of them might take precautions before the symptoms result in skill-based failures and committing less skill-based failures, consequently.

Similar speculation can be done to feel competent to manage workload. Workload is defined as the total amount of work done by the individual in a period of time (Morris et al., 2007). Completing a work in a period of time is highly depend on task demand and one’s energy level (Haga et al., 2002; Morris et al., 2007). Studies have suggested that high workload was associated with low levels of awareness, high level of fatigue (Haga et al., 2002), and high stress (Kumari & Aithal, 2020; MacDonald, 2003; Masi et al., 2023; O’Conor et al., 2020). Therefore, workload can result in decrements in decision-making skills, situation awareness, personal vigilance all of which can impair pilots’ behaviors (Masi et al., 2023). When pilots feel competent to effectively manage workload, they are more likely to manage the workload for both themselves and other crew members before decreasing awareness and increasing fatigue symptoms. This, in turn, can decrease the probability of committing skill-based failures.

The negative relationship between FWM and skill-based failures can also emphasize the countermeasure role of CRM competencies to mitigate fatigue symptoms. FWM competencies can play a crucial role in mitigating preliminary fatigue such as due to sleep deprivation, and in-flight fatigue such as due to long flight hours and workload. Considering that skill-based failures constituted majority of the direct causes of aircraft accidents (Lenné et al., 2008; Shappell et al., 2007; Wiegmann & Shappell, 2001), and the prevalence of fatigue among pilots (Caldwell, 2012; Morris et al., 2018; Reis et al., 2013), improving FWM competencies of pilots by addressing special importance on this factor in the CRM training programs might be important to reduce the leading cause of the aviation accidents.

In addition, the results showed that crew communication and cooperation (CCC) was negatively associated with memory failures, showing that pilots evaluating their CCC competencies as high reported committing less memory failures than pilots with low CCC competencies. Literature have clearly suggested that communication problems make significant contributions to aviation accidents improving the likelihood of committing errors (Alharasees et al., 2023; Brown & Rantz, 2010; Kanki, 2010; Mearns et al., 2001; Yıldız, 2024; Zieja et al., 2023). Although previous studies did not clear identification of which kind of failures had commonly occurred due to miscommunication, the current study provided an identification on the kind of failures occurred in communication failures.

CCC competencies provide pilots with an open and assertive communication and coordination environment during flight operations. This environment can help them to exchange critical information and coordinate the operation procedures in line with the SOPs. Effective communication and coordination can be characterized by assertiveness, asking questions and giving feedback when needed, supporting others and maintaining team focus (Mearns et al., 2001). CCC competencies, which is related to encouraging others to speak up, using appropriate jargons to prevent misunderstandings, trusting others' knowledge and skills, and providing open communication, can help pilots to create an effective communication and coordination environment. As a result, when one forgets a step in the procedure or critical information on aircraft management, for example, s/he can be assertively warned about the forgotten step or information. It is also possible that the other crew members intervene in the process and prevent memory failures from occurrence. Therefore, the negative relationship between CCC competencies and memory failures can imply that pilots with high levels of CCC can be more likely to succeed creating an open and assertive communication and coordination environment, which might prevent them commuting more memory failures, in turn.

On the contrary to these, none of the CRM-CS factors significantly predicted decision failures and procedural incompliance, after the explained variance by control variables, personality traits, fatigue symptoms and organizational safety climate. There might be some possible reasons for insignificant relationships between CRM-CS factors and decision failures and procedural incompliance. The first possible reason for this might be the high predictive power of personality traits and fatigue symptoms. These factors were included in the hierarchical regression analysis prior to CRM-CS factors. The results showed that both personality factors and fatigue symptoms were constituted with the majority of the explained variance in decision failures and procedural incompliance. This, consequently, might lower the predictive power of CRM-CS factors. The other possible reason for the insignificance might be the sample size. Generally, approximately 10 participants for require to test a regression analysis with 1 predictor (Wilson Van Voorhis & Morgan, 2007). In the current study, a total of 21 predictors were included in the model step by step. To meet the general rule, the sample size should have been 210 rather than 176. As a result, smaller sample size than the general rule might lower the chance of identifying existing relationships. Therefore, it can be recommended that future studies examine the relationship between CRM-CS factors, and decision failures and procedural incompliance by using larger sample size.

To sum up, the present study provided valuable information regarding the importance of FWM and CCC competencies on the frequency of committing self-reported skill-based failures and memory failures although it suffers from some limitations. Future studies might examine the CRM competencies and their relationships between unsafe acts by recruiting larger sample sizes.

3.4.3.1.5. Evaluation of the Mediating Roles of Organizational Safety Climate and Fatigue Symptoms in the Relationship between CRM Competencies and Unsafe Acts

Mediation analysis by using Hayes Macro 4.0 was conducted to examine the mediating roles of organizational safety climate and unsafe acts of commercial airline pilots. Twelve mediation analysis was conducted by using CRM-CS factors as predictors, factors of APilotBI-R as predicted variables, and the total scores of organizational safety climate and fatigue symptoms. Six of them yielded significant results in which skill-based failures and decision failures were the predicted variables.

The results showed that pilots with high levels of competencies in each factor of CRM-CS reported positive attitudes towards the organization's safety climate, lower fatigue symptoms, and also committing less skill-based failures and decision failures. Previous studies have suggested that a positive safety climate has associated with positive attitudes and intensions on safety compliance and safety participation (Gao et al., 2013; Maneechaeye & Potipiroon, 2022a, 2022b; O'Connor et al., 2011). Indeed, CRM training programs are crucial tools to improve attitudes and intensions on safety compliance and safety participation by creating shared values, beliefs, and perceptions on safety (Bennett, 2019; Brown & Rantz, 2010). Since CRM training programs aim to teach pilots CRM competencies, increased CRM competencies might result in positive evaluations of organization's safety climate. Both high levels of CRM competencies and positive evaluations of organization's safety climate emphasize the attitudes toward prioritization of safety which, in turn, might increase the likelihood of fatigue awareness and taking appropriate precautions to reduce fatigue symptoms. Eventually, reduction in fatigue symptoms might result in eliminating the decrease in cognitive abilities which is characterized by decrements in visual scan, attentional deficiencies, information processing speed and quality. Eliminating the decrease in cognitive abilities, as a result, helps pilots to apply relevant knowledge to manage effective and safe flights by preventing skill-based failures and decision failures.

The mediation analysis showed two important conclusions regarding committing skill-based failures and decision failures. The first conclusion is that all competency factors of CRM-CS play a role in committing skill-based failures and decision failures when combined with positive attitudes towards organization's safety climate and low levels of experienced fatigue symptoms. Although some of the CRM-CS factors did not yield significant associations with skill-based failures and decision failures in the hierarchical regression analysis, they yielded significant associations within the mediation analysis. This might imply that the predictive power CRM competencies on mitigating skill-based failures and decision failures can be elevated by pointing out other safety critical factors. Besides, organizational safety climate and fatigue symptoms were partially mediated the relationship between the all factors of CRM-CS and skill-based failures and decision failures. This indicates that CRM competencies have still some direct predictive powers on skill-based failures and decision failures. The insignificant results obtained from the hierarchical regression analysis could potentially be attributed to the small sample size.

The other important conclusion is that significant mediations were found for skill-based failures and decision failures which were the two leading direct causes of aviation accidents. Thus, the results of the current study might support the idea on the effectiveness of CRM training programs for reaching its ultimate goal. CRM training programs ultimately aims to reduce human errors during flight operations (Helmreich & Foushee, 2010; O'Connor et al., 2017; Salas et al., 1999, 2006). From the first initiation, they have evolved, revised and expanded their scopes, yet the ultimate goal stayed the same through the years. Reporting that CRM competencies were negatively associated with skill-based failures and decision failures might provide evidence that CRM training programs have yielded expected outcomes to reduce aviation accidents by reducing the leading causes of them.

In summary, the present study provides valuable information regarding the importance of CRM competencies combined with positive perceptions on organization's safety climate and low fatigue symptoms on decreasing the frequency of committing skill-based failures and decision failures. Since skill-based failures and decision failures were the leading causes of the aviation accidents, higher levels of CRM competencies combined with positive perceptions on organization's safety climate and low fatigue symptoms might be protective for aviation accidents.

3.4.3.1.6. Evaluation of the Moderating Role of Personality Traits in the Relationship between CRM Competencies and Unsafe Acts

Moderation analysis was conducted to examine the moderating role of personality traits on the relationship between CRM competencies and unsafe acts of commercial airline pilots. A total of 72 moderation analysis was conducted where factors of CRM-CS were the predictors, factors of APilotBI-R were the predicted variables and the factors of BPTI were the moderators. Two moderation analyses yielded significant results for procedural incompliance.

The results showed that the relationship between FMM and procedural incompliance was moderated by neuroticism as well as the relationship between FWM and procedural incompliance. The results indicated that pilots with high levels of FMM and FWM competencies committed fewer procedural violations when their neuroticism levels were low. This suggests that strong FMM and FWM competencies play a crucial role in reducing the frequency of procedural incompliance, particularly among pilots with lower levels of neuroticism. These results might be related to the concept of state anxiety. State anxiety can be defined as a transitory emotional state of feeling anxious, nervous and impatient whereas trait anxiety was related to stable anxiousness and nervousness across the situations (Spielberger et al., 1970). Being low on neuroticism characterized by state anxiety might play a constructive role for pilots rather than destructive, especially in stressful situations such as emergencies. Although flight operations are inherently stressful due to time pressure, constantly changing environment and high job demand, emergency situations might elevate the experienced stress. Pilots with low neuroticism and low state anxiety might be more likely to stay calm and control their anxiousness and nervousness in these situations. Because when pilots face stressful situations, their anxiety and nervousness level might increase (Dismukes et al., 2018), yet successful control of these emotions might help them to trust their FMM and FWM competencies and turn them into successful administrators of their actions without committing procedural incompliance. As a result, low neuroticism characterized by state anxiety might be constructive for committing procedural incompliance.

It is noteworthy to state that pilots have shown lower levels of neuroticism than the general population (Chang et al., 2018; Chaparro et al., 2020; Glicksohn & Naor-Ziv, 2016). However, there are still individual differences that create variability among commercial airline pilots. This variability combined with state anxiety characteristics can be protective for committing procedural incompliance. It is believed that the moderation results of the current study provide information regarding the constructive role of low neuroticism.

3.4.4. Critical Remarks

The sample of the current study consisted of actively flying commercial airline pilots from different organizations. The data was collected online and via snowball sampling, so it is not possible to talk about generalizability of the results. Future studies with bigger samples are suggested to validate the results of the present study. The questionnaire package included 6 different measurement tools focusing on the different variables. Therefore, pilots were required to answer a lot of questions that took on average 45 minutes to complete. Although they were informed that the questionnaires would continue to resume if they reached the link from the same IP address, most of the participants preferred to complete the questionnaire in one session. Thus, their attention level might be lowered during the answering. Besides, the questionnaires were based on self-reports which might be suffered from socially desirable responding (Yılmaz et al., 2022). Literature suggested that socially desirable responding in self-report measures might be lowered when the anonymity was ensured (Lajunen & Summala, 2003). It was clearly stated to the participants before participating that the questionnaire package did not include any questions regarding their personal and organizational identity and the answers would be stored with full anonymity. Still, participants might hesitate to reflect on their opinions. Future studies might employ more objective measures to examine the variables that might suffer from the socially desirable responding.

3.4.5. Practical Implications

The findings of the present study can provide significant implications for both the field of aviation psychology and the broader aviation industry. By introducing the CRM Competency Scale (CRM-CS) into the aviation psychology literature, this study provides an important tool for identifying pilots' CRM competencies and revealing areas requiring improvement. This might enable the design and implementation of targeted training programs aimed at enhancing these competencies. Furthermore, CRM-CS can offer a reliable method for assessing pilots' progress in CRM competencies following training interventions. For airline companies, CRM-CS can serve as an insightful metric for evaluating pilots' perceptions of the organization’s safety climate based on their CRM competencies. This information can guide the development of organizational strategies to create a more positive safety climate, ultimately enhancing overall flight safety. Additionally, aviation psychology researchers can employ CRM-CS to investigate the antecedents and consequences of CRM, shedding light on critical factors influencing and influenced by CRM practices. These insights are valuable for advancing both academic understanding and practical applications in aviation safety management.

Moreover, the revision of the APilotBI scale can hold considerable potential in identifying the frequency of unsafe acts exhibited by pilots during flight operations. By quantifying the occurrence of these acts, airline companies can develop targeted countermeasures to either prevent their manifestation or refine existing strategies, such as CRM training programs, to reduce their frequency. Measuring unsafe acts can serve as an important criterion when evaluating pilot performance. This not only allows for monitoring the development of individual pilots but also reflects the overall safety performance at the organizational level, enabling organizations to reshape the existing management strategies. Furthermore, identifying both the frequency and types of unsafe acts can be instrumental in investigating the underlying factors that contribute to specific unsafe acts, thereby facilitating a more comprehensive understanding of their origins and enabling more effective mitigation strategies. Additionally, it can be used in the evaluation of the effectiveness of CRM training, enhancing understanding of how specific competencies and attitudes influence safety outcomes. Ultimately, APilotBI-R can contribute to the broader goal of improving aviation safety through a deeper understanding of pilot performance and behaviors.

The present study provides valuable information on the predictors of pilots' unsafe acts regarding CRM competencies, fatigue symptoms, personality traits and organizational safety climate. Identifying the relationship between different CRM competencies and different types of unsafe behaviors is believed to contribute to reducing these acts, which can directly influence accident occurrence. Airline companies can use these results to identify the types of unsafe behaviors exhibited by their pilots and aim to enhance the CRM competencies associated with these behaviors. Moreover, the result of the relationship between personality traits and the types of unsafe acts might provide information on efficiency of personality assessments in the pilot recruitment processes. Although pilots are recruited based on certain characteristics in personality assessments, small variability still exists between pilots. This variability may exert itself in committing unsafe acts, especially committing incompliances in regulations and standard operation procedures.

The findings of the current study underscore the critical role of fatigue symptoms in the frequency of unsafe acts. While specific regulations establish minimum rest periods to ensure pilots have adequate time to recover from fatigue, these minimum thresholds are only designed to enable pilots to perform their duties safely. For instance, EASA mandates a minimum rest period of 12 hours before flight duty, beginning once the aircraft has reached its parking position and the engines are shut down. However, when considering commuting time and the need to satisfy personal requirements, this minimum rest duration may not be sufficient to allow for complete recovery from fatigue, which can accumulate over time. The results of this study might encourage organizations to reassess flight operation planning to address these considerations and mitigate fatigue-related unsafe acts.

Furthermore, the findings of this study provide valuable insights into how organizations can cultivate a more positive and proactive safety climate. Although there may not be a direct relationship between the organizational safety climate and pilots' unsafe acts, the results highlight the significant mediating role that safety climate, together with fatigue, plays in influencing the relationship between CRM competencies and unsafe acts. This suggests that fostering a positive and proactive safety climate within aviation organizations could serve as an effective strategy to reduce unsafe acts of pilots. Such a climate not only encourages open communication and collaboration among pilots but also promotes a shared commitment to safety, thereby contributing to the prevention of unsafe acts. Consequently, organizations that prioritize the development of a strong safety climate might be more likely to enhance flight safety, ensuring better operational outcomes and minimizing risks associated with human error and fatigue.

CHAPTER 4

CONCLUSION

The current study is believed to provide valuable contributions to aviation psychology literature. CRM has been placed vital importance to prevent and mitigate the pilot errors in the cockpit during flight operations (Helmreich & Foushee, 2010). CRM training programs have been developed and evolved through the years to increase non-technical skill of crew members to enable them effectively use all available resources (Helmreich et al., 1999; Helmreich & Foushee, 2010). Wide application of CRM training programs has raised a question on the effectiveness of these programs. Several measurement tools have been developed to measure CRM skills and behaviors of crew members such as Line/LOS checklists (Helmreich et al., 1997) and NOTECHS (Flin et al., 2003). The existing measurement tools require expert knowledge and training since they are based on observer ratings. The need for user-friendly and easy-to-use measure of CRM was provided in the present study. The Crew Resource Management Competency Scale was developed and evaluated in terms of psychometric properties. It was shown that CRM-CS was a reliable measure to examine CRM competencies of commercial airline pilots.

The initial Airline Pilot Behavior Inventory (Serin, 2016) was also revised and expanded to include more behavior examples of unsafe acts of commercial airline pilots. The APilotBI-R was also examined in terms of factor structure and psychometric properties. The current study showed that APilotBI-R was a reliable measure of unsafe acts of commercial airline pilots. This provides future research to examine the frequency of unsafe acts and the possible underlying mechanisms.

The predictors of unsafe acts in commercial aviation were also examined in the present study. Personality traits, fatigue symptoms, organizational safety climate and CRM competencies were analyzed to show the predictors of unsafe acts. It is believed that the current study brought valuable insight into the predictors of unsafe acts. The results of the analysis were clearly stated in the previous sections. Numerous studies took different approaches to examine the predictors of human error and pilot performance from accident analysis to experimental research (Lenné et al., 2008; Martinussen et al., 2022; Shappell et al., 2007; Thomas, 2004; Von Thaden et al., 2006). The present study employed self-reported measures to examine the predictors of unsafe acts. It expanded existing information regarding the preconditions for unsafe acts. These findings might help organizations to take proactive precautions to mitigate the consequences of unsafe acts and prevent aviation accidents.

The mediating roles of organizational safety climate and fatigue symptoms in the relationship between CRM competencies and unsafe acts of commercial airline pilots were also examined in this study. It clearly showed the high levels of CRM competencies combined with positive attitudes towards organization's safety climate and low levels of fatigue symptoms might be important for the frequency of committing skill-based failures and decision failures which have been found to be the leading causes of aviation accidents (Lenné et al., 2008; Ma et al., 2023; Shappell et al., 2007). These results stress the importance of possible mediating factors such as organizational safety climate and fatigue symptoms in the relationship between CRM competencies and unsafe acts. Future studies are suggested to focus on possible mediators in this relationship to explore the underlying mechanisms that elevate the predictor effect of CRM competencies.

The moderating role of personality traits in the relationship between CRM competencies and unsafe acts was also examined in this study. The results showed the moderating of neuroticism in the relationship between FMM and procedural incompliance, and also FWM and procedural incompliance. Previous studies mainly focused on the personality profiles of pilots in civil and military aviation (Chaparro et al., 2020; Fitzgibbons et al., 2004; Mesarosova et al., 2019). These findings pointed out the moderator role of neuroticism to elevate the negative relationship between FMM and procedural incompliance as well as the relationship between FWM and procedural incompliance. It is believed that these findings expand the understanding of the role of personality traits, specifically neuroticism, on voluntary unsafe acts namely procedural incompliance.

The current study advanced the understanding of CRM competencies and the predictors of unsafe acts. It also provides insight into the mediating roles of organizational safety climate and fatigue symptoms, and on the moderating role of personality traits in the relationship between CRM competencies and unsafe acts of commercial airline pilots. By developing a reliable and valid measure of CRM competencies and revising the initial APilotBI-R, it provides valuable self-report measurement tools for future research to examine the CRM competencies, unsafe acts and possible factors related to them.

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APPENDICES

A. APPROVAL OF THE METU HUMAN SUBJECTS ETHICS COMMITTEE FOR STUDY 1

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

DUMLUPINAR BULVARI 06800
ÇANKAYA ANKARA/TURKEY
T: +90 312 210 22 91
F: +90 312 210 79 59
ueam@metu.edu.tr
www.ueam.metu.edu.tr

Sayı: 28620816 /

20 Mayıs 2021

Konu : Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi : İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Doç.Dr. Bahar ÖZ

Danışmanlığını yaptığınız Gizem SERİN'in "Havayolu Pilotları için Ekip Kaynak Yönetimi ve Davranış Ölçeği Geliştirme" başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **179-ODTU-2021** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

[redacted]

Dr.Öğretim Üyesi Şerife SEVİNÇ
İAEK Başkan Vekili

B. INFORMED CONSENT FOR STUDY 1

Gönüllü Katılım Formu

Bu çalışma, ODTÜ Psikoloji Bölümü öğretim üyelerinden Doç. Dr. Bahar ÖZ danışmanlığında, ODTÜ Trafik ve Ulaşım Psikolojisi doktora öğrencisi ve TOBB ETÜ Psikoloji Bölümü Araştırma Görevlisi Uzm. Psk. Gizem SERİN tarafından yürütülmektedir. Çalışmanın amacı, havayolu pilotları için Ekip Kaynak Yönetimi (EKY) ve Pilot Davranış Ölçeği geliştirmektir. Bu kapsamda sizden istenen, pilotların EKY yetkinliklerini ve uçuş davranışlarını düşünerek size yöneltilen sorulara olabildiğince açık ve detaylı cevap vermenizdir. Verdiğiniz cevaplar, ölçek geliştirme sürecinde ölçek maddelerini oluşturmak amacıyla kullanılacaktır.

Bu çalışmaya katılmak tamamen gönüllük esasına dayamaktadır. Çalışma sürecinde yapılacak olan mülakatlarda hiçbir kişisel ya da kurum bilgisi istenmeyecektir. Mülakat boyunca verilen cevaplarda kayıplar olmaması ve cevapların sağlıklı bir şekilde toplanabilmesi amacıyla sadece ses kaydı yapılacaktır. Elde edilen ses kayıtları Mülakat süresince kendinizi rahatsız hissettiğiniz an mülakatı bırakabilirsiniz. Mülakat, yaklaşık olarak 30-45 dakika sürecektir.

Mülakat süresince verdiğiniz cevaplar geliştirilecek olan ölçek maddelerinin oluşturulabilmesi açısından oldukça önemlidir. Çalışma ile ilgili herhangi bir sorunuz olduğunda [redacted] adresinden ya da [redacted] numaralı telefondan Uzm. Psk. Gizem Serin'e ulaşabilirsiniz.

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum.

İsim Soyisim/Rumuz Tarih

İmza

C. INTERVIEW QUESTIONS

Demografik Bilgi Formu

1) Yaşınız:
2) Cinsiyet:
3) Çalıştığınız Pozisyonu:
4) Toplam uçuş süreniz:

CRM (EKY) Mülakat Soruları

1) Size göre CRM nedir?
2) Sizce normal uçuş şartları düşünüldüğünde, sergilemeniz gereken CRM yetkinlikleri nelerdir?
3) Sizce acil durumlarda, sergilemeniz gereken CRM yetkinlikleri nelerdir?
4) Sizce stres altında, sergilemeniz gereken CRM yetkinlikleri nelerdir?
5) Sizce kendinizde veya ekip içerisindeki yorgunluk durumunda, sergilemeniz gereken CRM yetkinlikleri nelerdir?
6) Sizce uçuş ekibinin CRM davranışları bir pilotun karar verme süreçlerini etkileyebilir mi? Evet ise Nasıl etkiler? Hayır ise neden?
7) Sizce normal uçuş şartları düşünüldüğünde, uçuş ekibinin sergilemesi gereken CRM yetkinlikleri nelerdir?
8) Sizce acil durumlarda, uçuş ekibinin sergilemesi gereken CRM yetkinlikleri nelerdir?
9) Sizce stres altında, uçuş ekibinin sergilemesi gereken CRM yetkinlikleri nelerdir?
10) Sizce kendinizde veya ekip içerisindeki yorgunluk durumunda, uçuş ekibinin yetkinlikleri gereken CRM davranışları nelerdir?
11) Uçuş koşulları düşünüldüğünde (normal şartlar ya da acil durumlar), sizce kurumunuzun (ekip planlama, dispatch, teknik, şirket yöneticileri vb.) sergilemesi gereken CRM yetkinlikleri nelerdir?

Pilot Davranışları Mülakat Soruları

HATA: Bir davranışın istenen sonuca ulaşamamasıdır. Bu durum hafıza veya dikkat sıkıntılarından ya da istenilen sonuca ulaşmak için yapılan davranışın istenilen sonuca uygun olmamasından kaynaklanabilir.

İHLAL: Hatalardan farklı olarak, bilerek ve isteyerek kuralların veya prosedürlerin uygulanmaması ya da farklı uygulanmasıdır.

1) Uçuş öncesi hazırlıkları düşündüğünüzde, bir pilot bu süreçte hangi hataları yapıyor olabilir?

2) Uçuş sırasında bir pilotun uçağın kontrolünü sağlamak ve devam ettirmek için sergiledikleri davranışları düşündüğünüzde, bir pilot bu süreçte hangi hataları yapıyor olabilir?
3) Uçuş sonrası uçağı park pozisyonuna getirirken ve park ederken yapılması gerekenleri düşündüğünüzde, bir pilot bu süreçte hangi hataları yapıyor olabilir?
4) Uçuş öncesi hazırlıkları düşündüğünüzde, bir pilot bu süreçte hangi ihlalleri yapıyor olabilir?
5) Uçuş sırasında bir pilotun uçağın kontrolünü sağlamak ve devam ettirmek için sergiledikleri davranışları düşündüğünüzde, bir pilot bu süreçte hangi ihlalleri yapıyor olabilir?
6) Uçuş sonrası uçağı park pozisyonuna getirirken ve park ederken yapılması gerekenleri düşündüğünüzde, bir pilot bu süreçte hangi ihlalleri yapıyor olabilir?
7) Normal uçuş şartları düşünüldüğünde bir pilotun kural ve prosedürler dışında verebileceği kararlar neler olabilir?
8) Uçuş sırasındaki acil durumlar düşünüldüğünde, bir pilotun kural ve prosedürler dışında verebileceği kararlar neler olabilir?

D. EXPERT EVALUATION FORM FOR AIRLINE PILOT BEHAVIOR INVENTORY

Pilot Davranışları Belirleme Çalışması Değerlendirme Formu

Aşağıda bir pilotun uçuş süresi boyunca farklı fazlarda sergileyebileceği bazı davranışlar ve bu davranışlara karşılık gelebilecek boyutlar sıralanmıştır. Sizden sıralanan davranışların her birinin davranış boyutlarının hangisini temsil ettiğini belirlemeniz istenmektedir. Aşağıda, her bir davranış boyutu ve tanımları verilmiştir. Lütfen, her bir tanımı ve Pilot Davranış Ölçeği maddelerini dikkatlice okuyarak size göre hangi boyutu temsil ettiğini maddenin yanında bulunan boş kutucuğa boyut numarasını yazarak belirtiniz. Lütfen sadece en uygun bulduğunuz boyutu belirleyerek sadece bir boyut numarası belirtiniz. Herhangi bir boyuta yerleştiremediğiniz maddeler için ilgili kutucuğu boş bırakınız.

1. **Decision errors**: Decision errors represent conscious, goal-intended behavior that proceeds as designed; yet the plan proves inadequate or inappropriate for the situation.
2. **Skill-based errors**: Skill-based behavior within the context of aviation is best described as "stick-and-rudder" and other basic flight skills that occur without significant conscious thought.
3. **Perceptual errors**: Perceptual errors occur when sensory input is either degraded or "unusual," as is the case with visual illusions and spatial disorientation or when aircrews simply misjudge the aircraft's altitude, attitude, or air speed
4. **Violations**: Violations represent a willful disregard for the rules and regulations that govern safe flight.

Pilot Davranış Ölçeği Madde-Boyut Eşleştirme Tablosu

	Boyut Numaraları
1) Uçağın başına gelindiğinde gerekli teknik kontrolleri eksiksiz yerine getirmek	
2) NOTAM'lar/ AIS/ MET brifing dokümanlarının uçaktan mevcut olup olmadığını kontrol etmek	
3) Fark etmeden yanlış flap açısı set etmek	
4) Kalkıştan sonra iniş takımlarını kapatmayı unutmak	
5) Uçuş öncesi koltuğu sabitlemeyi (ayarlamayı) unutmak	
6) Fark etmeden, uçulacak rota için kalkış brifingi yapmamak	
7) Uçuş öncesi, uçulacak rota için kalkış brifingi yapmaya gerek duymamak	
8) Kalkış için piste gelirken dış ışıkların açık olmadığını fark etmemek	
9) Taksi sırasında bütün izinleri tekrar kontrol etmeye gerek duymamak	
10) Normal şartlarda, taksi yaparken hız limitlerini aşmak	
11) Checklistleri tamamlarken, bir ya da birden çok maddeyi unutmak	
12) Kalkış sırasında, önden kalkan trafiğin türbülansını önemsememek	
13) Transition (TA) irtifası geçilince tüm ana ve yedek altimetreleri 29.92 inHg/1013.3 (hPa) olarak ayarlamak ancak çapraz kontrolünü atlamak	
14) Omuz bağlarını 10.000 feete ulaşmadan çözmek	
15) Hedef irtifaya 1000 feet kaldığında call-out yapılmadığını sonradan fark etmek	
16) Hedef irtifaya ulaşınca düz uçuş brifingi yapmamak	
17) Dış etkenler müsaade etse de optimum irtifadan alçakta uçmak	
18) İlgili hava alanlarının ATIS ve VOLMET'leri almamak	
19) Buzlanma beklendiğinde "Engine Anti-iceing" veya "wing anti ice" sistemlerinin çalıştırılmadığını fark etmemek	
20) Türbülans sırasında ATC bilgilendirmesi yapmayı unutmak	
21) Türbülanstayken uygun sürat ve thrust/N1 değeri kullanmamak	
22) Omuz bağlarını, 10.000 feet altına indikten sonra da bir süre takmamak	
23) Kalkıştan sonra, normal şartlarda, iniş takımlarını kapatmayı bir süre ertelemek	

24) İniş sırasında kuyruk rüzgârı limitlerini dikkate almayarak, uçağı inişe zorlamak	
25) Sistemlerde yapılan değişiklikleri sesli olarak dile getirmemek	
26) Kalkış sırasında, trafiğe odaklanıp motor enstrümanlarını ve hız göstergelerini kontrol etmeyi unutmak	
27) İniş sırasında, steril kokpit kurallarını atlamak	
28) Park sırasında, park freni yerine başka bir uygulamayı (örneğin nose wheel lock) çalıştırmak	
29) Yoğun kalkış trafiği nedeniyle, taksi yaparken acele etmek	
30) Checklistleri “ezbere” tamamlamak	
31) Checklistlerdeki maddelerin bazılarının (örneğin,flap settings) doğru ayarlarını okumak ancak ayarları set etmeyi unutmak	
32) ATC izni olmadan sürat değişikliği yapmak	
33) Uçuş bilgisayarına fark etmeden yanlış havaalanının bilgilerini girmek	
34) Görerek şartlarda yaklaşırken, uçağın kontrolünü geç ele almak	
35) İniş sırasında, iniş takımlarını aşağı almayı bir süreliğine unutmak	
36) Yanlış taksi yolunu kullanmak	
37) Bir ya da birden fazla checklisti atlamak	
38) Kalkış sırasında, yanlışlıkla uçağın burnunu dik bir açıyla kaldırarak, kuyruğun piste sürtmesine neden olmak	
39) Harici kontrolleri (extraneous inspection) tamamlamayı unutmak	
40) Yanlış frekansa bağlanmak	
41) Kalkış sırasında, steril kokpit kurallarını atlamak	
42) Aletli iniş sistemi (ILS) ile iniş yaparken, uçağın kontrolünü geç ele almak	
43) Tamamlanan bir checklistten sonra tamamlandığını sözlü olarak dile getirmemek (“complete” olarak belirtmemek)	
44) Yolcu almak için yanlış kapıya yanaşmak	
45) Hava Trafik Kontrolü’nden gelen değişiklik ya da izinleri yanlış anlamak	
46) Uçağı park ederken “parking-brake”i aktive etmeyi unutmak	
47) Dış etkenlere fix olup rutin monitoringi atlamak	
48) Uçak otomasyon altındayken, monitoring yapmama	
49) Görüş limitleri, yaklaşma limitlerinden düşük olsa da yaklaşmaya devam etmek	
50) Divert etmek gerekirken inişe zorlamak	

51) Yaklaşma sırasında sürat limitlerini aşmak	
52) Uçuş planını yanlış yorumlanmak	
53) Tasarruf amacıyla minimum yakıtla uçmak	
54) ATC tarafından verilen irtifayı yanlış anlayarak yanlış irtifada uçmak	
55) Zaman baskısı nedeniyle aceleci davranmak	
56) Uçak stabil değilken yaklaşmaya devam etmek	
57) Bazı SOP'leri uygulamayı unutmak	
58) Database'e fark etmeden yanlış uçuş ağırlığı girmek	
59) Yanlış FPM ile alçalmak	
60) Yanlış FPM ile tırmanmak	
61) Yakıt alımı sırasında yolcu alımına başlamak	
62) Checklistleri tamamlarken sadece önemli görülen maddelere odaklanmak	

E. EXPERT EVALUATION FORM FOR CRM COMPETENCY SCALE

CRM Yetkinlik Belirleme Çalışması Değerlendirme Formu

Aşağıda bir pilotun sahip olabileceği CRM yetkinlikleri ile ilgili bazı maddeler ve yetkinlik boyutları sıralanmıştır. Sizden sıralanan maddelerin her birinin yetkinlik boyutlarının hangisini temsil ettiğini belirlemeniz istenmektedir. Aşağıda, CRM yetkinlik boyutları ve tanımları verilmiştir. Lütfen, her bir tanımı ve olan CRM Yetkinlik Ölçeği maddelerini dikkatlice okuyarak her bir maddenin size göre hangi yetkinlik boyutunu temsil ettiğini maddenin yanında bulunan boş kutucuğa boyut numarasını yazarak belirtiniz. Lütfen sadece en uygun bulduğunuz boyutu belirleyerek sadece bir boyut numarası belirtiniz. Herhangi bir boyuta yerleştiremediğiniz maddeler için ilgili kutucuğu boş bırakınız.

CRM Yetkinlik Boyutları:

1. **Application of knowledge (KNO)**: Demonstrates knowledge and understanding of relevant information, operating instructions, aircraft systems and the operating environment
2. **Application of procedures and compliance with regulations (PRO)**: Identifies and applies appropriate procedures in accordance with published operating instructions and applicable regulations
3. **Communication (COM)**: Communicates through appropriate means in the operational environment, in both normal and non-normal situations
4. **Aeroplane flight path management — automation (FPA)**: Controls the flight path through automation
5. **Aeroplane flight path management — manual control (FPM):** Controls the flight path through manual control
6. **Leadership & teamwork (LTW):** Influences others to contribute to a shared purpose. Collaborates to accomplish the goals of the team
7. **Problem-solving — decision-making (PSD):** Identifies precursors, mitigates problems, and makes decisions

8. **Situation awareness and management of information (SAW**): Perceives, comprehends and manages information and anticipates its effect on the operation
9. **Workload management (WLM):** Maintains available workload capacity by prioritizing and distributing tasks using appropriate resources

CRM Yetkinlik Ölçeği Madde-Boyut Eşleştirme Tablosu:

Maddeler	Boyut Numaraları
1) Ekip içerisindeki koordinasyonu sağlayabilmek	
2) Ekibin karar verme mekanizmalarını karar verme süreçlerine dahil edebilmek	
3) Karar verme sürecinde ekibin fikirlerine önem vermek	
4) Karar verme sürecinde ekibi, fikirlerini söylemeye teşvik edebilmek	
5) Ekip ile açık iletişim halinde olabilmek	
6) Ekibin durumsal farkındalığını artırabilmek	
7) Assertive olmak	
8) SOP’lere uygun davranmak	
9) Değişken iş yükünü ekibin görevlerini tamamlaması yönünde etkili bir şekilde değerlendirebilmek	
10) Değişken iş yükünü ekibe dengeli bir şekilde dağıtabilmek	
11) Uçuş emniyetini etkileyebilecek normal olmayan durumlara önceden hazırlıklı olabilmek	
12) “Uçağın önünde olmak”	
13) Ekip üyelerindeki stres belirtilerini fark edebilmek	
14) Uçuştan önce, uçuşa mental olarak hazırlanabilmek	
15) Uçuş sırasında, uçuş emniyetini etkileyebilecek normal olmayan durumlarda sorunu değerlendirmek için zaman kazanabilmek	
16) Uçuş sırasında, uçuş emniyetini etkileyebilecek normal olmayan durumlarda panik yapmamak	
17) Overload olup muhakeme yeteneğini kaybetmemek	
18) Uçuş sırasında emniyetini etkileyebilecek normal olmayan durumlarda, durumu doğru analiz edebilmek	
19) Uçuş öncesi, uçuşta oluşabilecek ve uçuş emniyetini olumsuz etkileyebilecek normal olmayan durumları doğru analiz edebilmek	
20) Ekip üyelerindeki yorgunluk durumunu tespit edebilmek	
21) Stres altında konsantrasyonumun devamlılığını sağlayabilmek	

22) Uçuş emniyetini etkileyebilecek normal olmayan durumlarda görev dağılımını stresi azaltacak şekilde düzenleyebilmek	
23) Bir ekip üyesinde yorgunluk oluştuğunda dinlenebilmesini sağlayacak uygun koşullar oluşturabilmek	
24) Uçuş emniyetini etkileyebilecek normal olmayan durumlarda kendi bilgime güvenerek şartlara en uygun kararı verebilmek	
25) Uçuş emniyetini etkileyebilecek normal olmayan durumlarda ekip arkadaşlarımın bilgisine güvenerek şartlara en uygun kararı verebilmek	
26) Uçuş emniyetini etkileyebilecek normal olmayan durumlarda prosedürlere güvenerek şartlara en uygun kararı verebilmek	
27) Yorgun olduğumda "unfit" durumunu rapor etmekten çekinmemek	
28) Yorgun olduğumda ekip üyelerine bunu deklare edebilmek	
29) Yorgun olduğumda oluşabilecek hata yapma olasılığını engellemek amacıyla ekip üyelerinden beni daha fazla monitor etmelerini istemek	
30) Kabin ekibini briefinglere dahil etmek	
31) Tüm ekibin birbiriyle doğru ve açık bilgi paylaşımı sağlayabileceği bir iletişim ortamı oluşturabilmek	
32) Doğru prosedürleri doğru zamanda uygulayabilmek	
33) Ekip üyelerindeki yorgunluk durumunda, ekip üyesinin dikkatini dağıtmayacak ve işe odaklanmasını sağlayacak uyaranlar verebilmek	
34) Ekip üyeleriyle doğru bilgi iletişimini sağlayabilmek	
35) Uçuş emniyetini etkileyebilecek normal olmayan durumlarda sakinliğimi koruyabilmek	
36) Nerede, ne zaman ve kiminle iletişime geçeceğimi bilmek	
37) Ekip üyeleriyle iletişimde kullandığım üsluba dikkat etmek	
38) Ekip üyelerinin gerekli bilgileri doğru anladığından emin olmak	
39) Ekip içerisindeki çatışmaları etkili bir biçimde çözebilmek	
40) Ekip üyelerindeki yorgunluk durumunda, ekip üyesinin uyanık kalarak işe devamını sağlayacak şartlar oluşturabilmek	
41) Briefinglerde acil durum planlarını ekip üyeleriyle etkili bir şekilde paylaşabilmek	
42) Ekip üyeleriyle bilgi iletişimini zamanında sağlayabilmek	
43) Otomasyon sistemlerini uygun düzeyde kullanabilmek	
44) Uçuş sırasında sistemlerdeki değişikliği zamanında fark edebilmek	
45) Uçuş sırasında karar vermeden önce çevreden aldığım bilgileri doğru analiz edebilmek	

46) Uçuş sırasında maksimum seviyede monitoring yapabilmek	
47) Normal şartlarda maksimum seviyede durumsal farkındalığa sahip olabilmek	
48) Manuel uçuş sırasında dış etmenlerden gelen dikkat dağıtıcıları etkili bir şekilde yönetebilmek	
49) Uçuş süresince kendi bilişsel ve fiziksel durumumu monitor edebilmek	
50) Otomasyon seviyesini uçuşun fazına göre ayarlayabilmek	
51) Otomasyon seviyesi iş yükünü artırdığında manuel kontrole geçebilmek	
52) Manuel uçuşta, uçuş planını optimum performans sağlayacak şekilde düzenleyebilmek	
53) Uçuş süresince ekip arkadaşlarının bilişsel ve fiziksel durumunu monitor edebilmek	
54) Otomasyon sistemlerinin uçuş planına uygunluğunu kontrol edebilmek	
55) Manuel uçuşta uçağı uygun yumuşaklıkta (smoothness) kullanabilmek	
56) Manuel uçarken, uçağın irtifa, hız ve thrust değerlerinin takibini atlamadan yapmak	
57) Ekip üyelerine davranışları ile ilgili etkili geribildirimler verebilmek	
58) Manuel uçuşta, uçuş planından sapmaları zamanında belirleyebilmek	
59) Aldığım kararların ve yaptığım davranışların sorumluluğunu üstlenebilmek	
60) Otomasyon sistemlerini ve göstergelerini doğru anlayabilmek	
61) Uçuş süresince karşılaşabilecek tehditler için önceden önlem alabilmek	
62) Uçuş süresince yapılabilecek hataları zamanında tespit edebilmek	
63) Normal uçuş şartlarında bile oluşabilecek olumsuz koşullar için tetikte olabilmek	
64) Ekip üyelerindeki yorgunluk durumunda, yorgun olan ekip üyesini normalden daha fazla monitor edebilmek	
65) Duruma uygun karar verme stratejilerini kullanabilmek	
66) Otomasyon sistemlerini ve göstergelerini doğru anlatabilmek	
67) Otomasyon sistemlerindeki değişiklikleri zamanında tespit edebilmek	
68) Frekans iletişiminde kullandığım üsluba dikkat etmek	
69) Otomasyon sistemlerindeki değişiklikleri zamanında dile getirebilmek	
70) Kendi durumsal farkındalığımı ekip üyeleri ile paylaşabilmek	
71) Kurallara uygun davranmak	
72) İletişimde ortak dili kullanmak	

73) Var olan bilgimi beceriye dökebilmek	
74) Değişen çevre ile ilgili bilgi sahibi olmak	
75) Değişen sistemler ile ilgili bilgi sahibi olmak	
76) İşimi yaparken var olan bilgimi etkili bir şekilde kullanabilmek	
77) Var olan operasyon talimatları hakkında bilgi sahibi olmak	
78) Bir şeyler ters gittiğinde neyin ters gittiğini zamanında tespit edebilmek	
79) Görev süresince yapılacak işlemlerin önceliğini belirleyebilmek	
80) Gerektiğinde ekip arkadaşlarımın iş yükünü hafifletebilmek	
81) Gerektiğinde ekip arkadaşlarımdan yardım isteyebilmek	
82) Var olan operasyon talimatlarını uygulamak	

F. APPROVAL OF THE METU HUMAN SUBJECTS ETHICS COMMITTEE FOR MAIN STUDY

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

DUMLUPINAR BULVARI 06800
ÇANKAYA ANKARA/TURKEY
T: +90 312 210 22 91
F: +90 312 210 79 59
ueam@metu.edu.tr
www.ueam.metu.edu.tr

13 EYLÜL 2022

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Doç.Dr. Bahar ÖZ

Danışmanlığını yürüttüğünüz Gizem Serin ATIŞ'ın "**Kurum emniyet iklimi, ekip kaynak yönetimi ve bireysel faktörler arasındaki ilişkinin incelenmesi**" başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek gerekli onay **0475-ODTUİAEK-2022** protokol numarası ile onaylanmıştır.

Bilgilerinize saygılarımla sunarım.

[redacted]

Prof. Dr. Mine MISIRLISOY
Başkan

[redacted]

Doç. Dr. I.Semih AKÇOMAK
Üye

[redacted]

Dr. Öğretim Üyesi Müge GÜNDÜZ
Üye

[redacted]

Dr. Öğretim Üyesi Şerife SEVİNÇ
Üye

[redacted]

Dr. Öğretim Üyesi Murat Perit ÇAKIR
Üye

[redacted]

Dr. Öğretim Üyesi Süreyya ÖZCAN KABASAKAL
Üye

[redacted]

Dr. Öğretim Üyesi A. Emre TURGUT
Üye

G. INFORMED CONSENT FOR THE MAIN STUDY

Gönüllü Katılım Formu

Bu çalışma, Orta Doğu Teknik Üniversitesi Psikoloji Bölümü öğretim üyelerinden Doç. Dr. Bahar ÖZ danışmanlığında, Trafik ve Ulaşım Psikolojisi alanı doktora öğrencisi ve TOBB Ekonomi ve Teknoloji Üniversitesi Araştırma Görevlisi Uzm. Psk. Gizem SERİN ATIŞ tarafından doktora tez çalışması olarak yürütülmektedir. Çalışmanın amacı, ticari hava yollarında çalışan pilotlar için hem araştırma amacıyla kullanılabilecek bir Ekip Kaynak Yönetimi Yetkinlik Ölçeği oluşturmak hem de kurum emniyet kültürü, ekip kaynak yönetimi, bireysel değişkenler arasındaki ilişkinin incelenmesidir. Bu kapsamda sizden istenen, yönlendirilen sorulara soru yönergelerine uygun cevaplar vermenizdir.

Çalışma iki aşamadan oluşacaktır. İlk aşama yaklaşık 15 dakika sürecektir. İkinci aşama ise ilk aşamada cevapladığınız EKY Yetkinlikleri Ölçeği ile Pilot Davranışları Ölçeğini cevaplamanız istenecektir. İkinci aşama yaklaşık 10 dakika sürecektir. İkinci aşamaya katılmak isterseniz size sunulan kısma e-mail adresinizi ve rumuzunuzu girmeniz gerekmektedir. Lütfen, belirttiğiniz rumuzu daha sonra size gönderilen linkte belirmeniz için not ediniz.

Bu çalışmada, fiziksel veya psikolojik rahatsızlığa neden olacak sorular bulunmamaktadır. Ancak, böyle bir rahatsızlık hissettiğinizde istediğiniz zaman çalışmayı bırakabilirsiniz. Çalışmaya katılmak tamamen gönüllük esasına dayamaktadır. Elde edilen bilgiler sadece bilimsel araştırma ve yayınlarda kullanılacaktır. Çalışma kapsamında <u>hiçbir kişisel veri ya da kurum bilgisi istenmeyecek ve kullanılmayacaktır</u>.

Çalışma ile ilgili herhangi bir sorunuz olduğunda [redacted] adresinden ya da [redacted] numaralı telefondan Uzm. Psk. Gizem Serin'e ulaşabilirsiniz. Bu araştırmaya katıldığınız ve verdiğiniz destek için çok teşekkür ederiz.

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum.

İsim Soyisim/Rumuz Tarih
İmza

H. DEMOGRAPHIC INFORMATION FORM

1) Yaşınız: ________
2) Cinsiyetiniz: ☐ Kadın ☐ Erkek
3) Eğitim durumunuz:
    a. Lise
    b. Üniversite
    c. Yüksek Lisans
    d. Doktora
4) Mesleki eğitiminizi aldığınız okul:
    a. Askeri Havacılık Okulu
    b. Sivil Havacılık Okulu
5) Çalıştığınız pozisyon:
    a. Kaptan Pilot
    b. 2. Pilot (Yardımcı Pilot)
6) Sivil ticari havacılık alanında saatlik uçuş deneyiminiz: _________________
7) Bir ayda ortalama kaç saat uçuyorsunuz? ______________________________
8) Şu an kullandığınız uçağın tipi nedir?
    a. Geniş Gövde
    b. Dar Gövde
9) Son 3 yılda kaç defa kritik bir olay (incident) yaşadığınızı belirtiniz: ______
10) Normal uçuş şartları altında, uçuş sırasında hissettiğiniz stresin seviyesini belirtiniz:

Stressiz									**Çok Stresli**
0	1	2	3	4	5	6	7	8	9

I. AIRLINE PILOT BEHAVIOR INVENTORY

Pilot Davranış Ölçeği

Aşağıda bir pilotun uçuş öncesi, sırası ve sonrasında sergilediği bazı davranışlar verilmiştir. Lütfen, kendinizi işinizi yaparken düşündüğünüzde sunulan her bir davranışı ne sıklıkla sergilediğinizi verilen 6 basamaklı ölçek üzerinde ilgili kutucuğu işaretleyerek belirtiniz.

	Hiçbir zaman	Nadiren	Bazen	Oldukça sık	Sık sık	Neredeyse her zaman
1) Uçağın başına gelindiğinde gerekli teknik kontrolleri eksiksiz yerine getirmek	1	2	3	4	5	6
2) NOTAM'lar/ AIS/ MET brifing dokümanlarının uçaktan mevcut olup olmadığını kontrol etmek	1	2	3	4	5	6
3) Fark etmeden yanlış flap açısı set etmek	1	2	3	4	5	6
4) Kalkıştan sonra iniş takımlarını kapatmayı unutmak	1	2	3	4	5	6
5) Uçuş öncesi koltuğu sabitlemeyi (ayarlamayı) unutmak	1	2	3	4	5	6
6) Fark etmeden, uçulacak rota için kalkış brifingi yapmamak	1	2	3	4	5	6
7) Uçuş öncesi, uçulacak rota için kalkış brifingi yapmaya gerek duymamak	1	2	3	4	5	6
8) Kalkış için piste gelirken dış ışıkların açık olmadığını fark etmemek	1	2	3	4	5	6
9) Taksi sırasında bütün izinleri tekrar kontrol etmeye gerek duymamak	1	2	3	4	5	6
10) Normal şartlarda, taksi yaparken hız limitlerini aşmak	1	2	3	4	5	6
11) Checklistleri tamamlarken, bir ya da birden çok maddeyi unutmak	1	2	3	4	5	6

12) Kalkış sırasında, önden kalkan trafiğin türbülansını önemsememek	1	2	3	4	5	6
13) Transition (TA) irtifası geçilince tüm ana ve yedek altimetreleri 29.92 inHg/1013.3 (hPa) olarak ayarlamak ancak çapraz kontrolünü atlamak	1	2	3	4	5	6
14) Omuz bağlarını 10.000 feete ulaşmadan çözmek	1	2	3	4	5	6
15) Hedef irtifaya 1000 feet kaldığında call-out yapılmadığını sonradan fark etmek	1	2	3	4	5	6
16) Hedef irtifaya ulaşınca düz uçuş brifingi yapmamak	1	2	3	4	5	6
17) Dış etkenler müsaade etse de optimum irtifadan alçakta uçmak	1	2	3	4	5	6
18) İlgili hava alanlarının ATIS ve VOLMET'leri almamak	1	2	3	4	5	6
19) Buzlanma beklendiğinde "Engine Anti-iceing" veya "wing anti ice" sistemlerinin çalıştırılmadığını fark etmemek	1	2	3	4	5	6
20) Türbülans sırasında ATC bilgilendirmesi yapmayı unutmak	1	2	3	4	5	6
21) Türbülanstayken uygun sürat ve thrust/N1 değeri kullanmamak	1	2	3	4	5	6
22) Omuz bağlarını, 10.000 feet altına indikten sonra da bir süre takmamak	1	2	3	4	5	6
23) Kalkıştan sonra, normal şartlarda, iniş takımlarını kapatmayı bir süre ertelemek	1	2	3	4	5	6
24) İniş sırasında kuyruk rüzgârı limitlerini dikkate almayarak, uçağı inişe zorlamak	1	2	3	4	5	6
25) Sistemlerde yapılan değişiklikleri sesli olarak dile getirmemek	1	2	3	4	5	6
26) Kalkış sırasında, trafiğe odaklanıp motor enstrümanlarını ve hız göstergelerini kontrol etmeyi unutmak	1	2	3	4	5	6

27) İniş sırasında, steril kokpit kurallarını atlamak	1	2	3	4	5	6
28) Park sırasında, park freni yerine başka bir uygulamayı (örneğin nose wheel lock) çalıştırmak	1	2	3	4	5	6
29) Yoğun kalkış trafiği nedeniyle, taksi yaparken acele etmek	1	2	3	4	5	6
30) Checklistleri "ezbere" tamamlamak	1	2	3	4	5	6
31) Checkklistlerdeki maddelerin bazılarının (örneğin,flap settings) doğru ayarlarını okumak ancak ayarları set etmeyi unutmak	1	2	3	4	5	6
32) ATC izni olmadan sürat değişikliği yapmak	1	2	3	4	5	6
33) Uçuş bilgisayarına fark etmeden yanlış havaalanının bilgilerini girmek	1	2	3	4	5	6
34) Görerek şartlarda yaklaşırken, uçağın kontrolünü geç ele almak	1	2	3	4	5	6
35) İniş sırasında, iniş takımlarını aşağı almayı bir süreliğine unutmak	1	2	3	4	5	6
36) Yanlış taksi yolunu kullanmak	1	2	3	4	5	6
37) Bir ya da birden fazla checklisti atlamak	1	2	3	4	5	6
38) Kalkış sırasında, yanlışlıkla uçağın burnunu dik bir açıyla kaldırarak, kuyruğun piste sürtmesine neden olmak	1	2	3	4	5	6
39) Harici kontrolleri (extraneous inspection) tamamlamayı unutmak	1	2	3	4	5	6
40) Yanlış frekansa bağlanmak	1	2	3	4	5	6
41) Kalkış sırasında, steril kokpit kurallarını atlamak	1	2	3	4	5	6
42) Aletli iniş sistemi (ILS) ile iniş yaparken, uçağın kontrolünü geç ele almak	1	2	3	4	5	6
43) Tamamlanan bir checklistten sonra tamamlandığını sözlü olarak dile getirmemek	1	2	3	4	5	6

(“complete” olarak belirtmemek)						
44) Yolcu almak için yanlış kapıya yanaşmak	1	2	3	4	5	6
45) Hava Trafik Kontrolü’nden gelen değişiklik ya da izinleri yanlış anlamak	1	2	3	4	5	6
46) Uçağı park ederken “parking-brake”i aktive etmeyi unutmak	1	2	3	4	5	6
47) Dış etkenlere fix olup rutin monitoringi atlamak	1	2	3	4	5	6
48) Uçak otomasyon altındayken, monitoring yapmama	1	2	3	4	5	6
49) Görüş limitleri, yaklaşma limitlerinden düşük olsa da yaklaşmaya devam etmek	1	2	3	4	5	6
50) Divert etmek gerekirken inişe zorlamak	1	2	3	4	5	6
51) Yaklaşma sırasında sürat limitlerini aşmak	1	2	3	4	5	6
52) Uçuş planını yanlış yorumlanmak	1	2	3	4	5	6
53) Tasarruf amacıyla minimum yakıtla uçmak	1	2	3	4	5	6
54) ATC tarafından verilen irtifayı yanlış anlayarak yanlış irtifada uçmak	1	2	3	4	5	6
55) Zaman baskısı nedeniyle aceleci davranmak	1	2	3	4	5	6
56) Uçak stabil değilken yaklaşmaya devam etmek	1	2	3	4	5	6
57) Bazı SOP’leri uygulamayı unutmak	1	2	3	4	5	6
58) Database’e fark etmeden yanlış uçuş ağırlığı girmek	1	2	3	4	5	6
59) Yanlış FPM ile alçalmak	1	2	3	4	5	6
60) Yanlış FPM ile tırmanmak	1	2	3	4	5	6
61) Yakıt alımı sırasında yolcu alımına başlamak	1	2	3	4	5	6
62) Checklistleri tamamlarken sadece önemli görülen maddelere odaklanmak	1	2	3	4	5	6

J. CRM COMPETENCY SCALE

Aşağıda bir pilotun sahip olabileceği Ekip Kaynak Yönetimi yetkinlikleri ile ilgili maddeler yer almaktadır. Lütfen, kendinizi işinizi yaparken düşündüğünüzde sunulan her bir maddede ifade edilen durumun sizi ne ölçüde yansıttığını verilen 5 basamaklı ölçek üzerinde ilgili rakamın bulunduğu kutucuğu işaretleyerek belirtiniz.

Maddeler	Çok Zayıf	Zayıf	Kabul Edilebilir Seviyede	İyi	Çok İyi
1) Uçuş süresince ekip arkadaşlarının bilişsel ve fiziksel durumunu monitör edebilmek	1	2	3	4	5
2) Otomasyon seviyesini uçuşun fazına göre ayarlayabilmek	1	2	3	4	5
3) Ekip üyeleriyle doğru bilgi iletişimini sağlayabilmek	1	2	3	4	5
4) Ekip üyelerindeki yorgunluk durumunda, ekip üyesinin dikkatini dağıtmayacak ve işe odaklanmasını sağlayacak uyaranlar verebilmek	1	2	3	4	5
5) Yorgun olduğumda ekip üyelerine bunu deklare edebilmek	1	2	3	4	5
6) Manuel uçuş sırasında dış etmenlerden gelen dikkat dağıtıcıları etkili bir şekilde yönetebilmek	1	2	3	4	5
7) Uçuş emniyetini etkileyebilecek normal olmayan durumlarda sakinliğimi koruyabilmek	1	2	3	4	5
8) Ekip ile açık iletişim halinde olabilmek	1	2	3	4	5
9) Nerede, ne zaman ve kiminle iletişime geçeceğimi bilmek	1	2	3	4	5
10) Uçuş süresince yapılabilecek hataları zamanında tespit edebilmek	1	2	3	4	5
11) Otomasyon seviyesi iş yükünü artırdığında manuel kontrole geçebilmek	1	2	3	4	5
12) Değişen çevre ile ilgili bilgi sahibi olmak	1	2	3	4	5
13) Ekip üyelerinin gerekli bilgileri doğru anladığından emin olmak	1	2	3	4	5
14) Gerektiğinde ekip arkadaşlarımdan yardım isteyebilmek	1	2	3	4	5

15) Var olan operasyon talimatlarını uygulamak	1	2	3	4	5
16) Değişken iş yükünü ekibin görevlerini tamamlaması yönünde etkili bir şekilde değerlendirebilmek	1	2	3	4	5
17) Bir şeyler ters gittiğinde neyin ters gittiğini zamanında tespit edebilmek	1	2	3	4	5
18) Otomasyon sistemlerini uygun düzeyde kullanabilmek	1	2	3	4	5
19) Overload olup muhakeme yeteneğini kaybetmemek	1	2	3	4	5
20) Uçuş sırasında maksimum seviyede monitoring yapabilmek	1	2	3	4	5
21) Gerektiğinde ekip arkadaşlarımın iş yükünü hafifletebilmek	1	2	3	4	5
22) Kabin ekibini briefinglere dahil etmek	1	2	3	4	5
23) İletişimde ortak dili kullanmak	1	2	3	4	5
24) Briefinglerde acil durum planlarını ekip üyeleriyle etkili bir şekilde paylaşabilmek	1	2	3	4	5
25) Ekibin karar verme mekanizmalarını karar verme süreçlerine dahil edebilmek	1	2	3	4	5
26) Ekip içerisindeki koordinasyonu sağlayabilmek	1	2	3	4	5
27) Uçuş emniyetini etkileyebilecek normal olmayan durumlara önceden hazırlıklı olabilmek	1	2	3	4	5
28) Değişen sistemler ile ilgili bilgi sahibi olmak	1	2	3	4	5
29) Manuel uçuşta uçağı uygun yumuşaklıkta (smoothness) kullanabilmek	1	2	3	4	5
30) Kurallara uygun davranmak	1	2	3	4	5
31) Stres altında konsantrasyonumun devamlılığını sağlayabilmek	1	2	3	4	5
32) Ekip üyelerindeki yorgunluk durumunda, yorgun olan ekip üyesini normalden daha fazla monitör edebilmek	1	2	3	4	5
33) Tüm ekibin birbiriyle doğru ve açık bilgi paylaşımı sağlayabileceği bir iletişim ortamı oluşturabilmek	1	2	3	4	5
34) Duruma uygun karar verme stratejilerini kullanabilmek	1	2	3	4	5
35) Normal uçuş şartlarında bile oluşabilecek olumsuz koşullar için tetikte olabilmek	1	2	3	4	5
36) Uçuş sırasında sistemlerdeki değişikliği zamanında fark edebilmek	1	2	3	4	5

37) Uçuş sırasında, uçuş emniyetini etkileyebilecek normal olmayan durumlarda panik yapmamak	1	2	3	4	5
38) Manuel uçarken, uçağın irtifa, hız ve thrust değerlerinin takibini atlamadan yapmak	1	2	3	4	5
39) Manuel uçuşta, uçuş planından sapmaları zamanında belirleyebilmek	1	2	3	4	5
40) Frekans iletişiminde kullandığım üsluba dikkat etmek	1	2	3	4	5
41) Var olan bilgimi beceriye dökebilmek	1	2	3	4	5
42) Uçuş süresince karşılaşabilecek tehditler için önceden önlem alabilmek	1	2	3	4	5
43) Ekip üyelerine davranışları ile ilgili etkili geribildirimler verebilmek	1	2	3	4	5
44) Uçuş emniyetini etkileyebilecek normal olmayan durumlarda görev dağılımını stresi azaltacak şekilde düzenleyebilmek	1	2	3	4	5
45) İşimi yaparken var olan bilgimi etkili bir şekilde kullanabilmek	1	2	3	4	5
46) Karar verme sürecinde ekibin fikirlerine önem vermek	1	2	3	4	5
47) Uçuş emniyetini etkileyebilecek normal olmayan durumlarda ekip arkadaşlarımın bilgisine güvenerek şartlara en uygun kararı verebilmek	1	2	3	4	5
48) Uçuş sırasında, uçuş emniyetini etkileyebilecek normal olmayan durumlarda sorunu değerlendirmek için zaman kazanabilmek	1	2	3	4	5
49) Uçuştan önce, uçuşa mental olarak hazırlanabilmek	1	2	3	4	5
50) Görev süresince yapılacak işlemlerin önceliğini belirleyebilmek	1	2	3	4	5
51) Değişken iş yükünü ekibe dengeli bir şekilde dağıtabilmek	1	2	3	4	5
52) Ekip üyeleriyle iletişimde kullandığım üsluba dikkat etmek	1	2	3	4	5
53) Uçuş emniyetini etkileyebilecek normal olmayan durumlarda prosedürlere güvenerek şartlara en uygun kararı verebilmek	1	2	3	4	5
54) Kendi durumsal farkındalığımı ekip üyeleri ile paylaşabilmek	1	2	3	4	5
55) Otomasyon sistemlerini ve göstergelerini doğru anlatabilmek	1	2	3	4	5
56) "Uçağın önünde olmak"	1	2	3	4	5

57) Uçuş sırasında emniyetini etkileyebilecek normal olmayan durumlarda, durumu doğru analiz edebilmek	1	2	3	4	5
58) Doğru prosedürleri doğru zamanda uygulayabilmek	1	2	3	4	5
59) Uçuş süresince kendi bilişsel ve fiziksel durumumu monitör edebilmek	1	2	3	4	5
60) Otomasyon sistemlerinin uçuş planına uygunluğunu kontrol edebilmek	1	2	3	4	5
61) Yorgun olduğumda "unfit" durumunu rapor etmekten çekinmemek	1	2	3	4	5
62) Aldığım kararların ve yaptığım davranışların sorumluluğunu üstlenebilmek	1	2	3	4	5
63) Karar verme sürecinde ekibi, fikirlerini söylemeye teşvik edebilmek	1	2	3	4	5
64) SOP'lere uygun davranmak	1	2	3	4	5
65) Yorgun olduğumda oluşabilecek hata yapma olasılığını engellemek amacıyla ekip üyelerinden beni daha fazla monitör etmelerini istemek	1	2	3	4	5
66) Ekibin durumsal farkındalığını artırabilmek	1	2	3	4	5
67) Ekip üyelerindeki yorgunluk durumunu tespit edebilmek	1	2	3	4	5
68) Uçuş emniyetini etkileyebilecek normal olmayan durumlarda kendi bilgime güvenerek şartlara en uygun kararı verebilmek	1	2	3	4	5
69) Assertive olmak	1	2	3	4	5
70) Ekip üyeleriyle bilgi iletişimini zamanında sağlayabilmek	1	2	3	4	5
71) Normal şartlarda maksimum seviyede durumsal farkındalığa sahip olabilmek	1	2	3	4	5
72) Var olan operasyon talimatları hakkında bilgi sahibi olmak	1	2	3	4	5
73) Ekip üyelerindeki stres belirtilerini fark edebilmek	1	2	3	4	5
74) Ekip içerisindeki çatışmaları etkili bir biçimde çözebilmek	1	2	3	4	5
75) Otomasyon sistemlerini ve göstergelerini doğru anlayabilmek	1	2	3	4	5
76) Otomasyon sistemlerindeki değişiklikleri zamanında tespit edebilmek	1	2	3	4	5
77) Bir ekip üyesinde yorgunluk oluştuğunda dinlenebilmesini sağlayacak uygun koşullar oluşturabilmek	1	2	3	4	5

78) Uçuş öncesi, uçuşta oluşabilecek ve uçuş emniyetini olumsuz etkileyebilecek normal olmayan durumları doğru analiz edebilmek	1	2	3	4	5
79) Manuel uçuşta, uçuş planını optimum performans sağlayacak şekilde düzenleyebilmek	1	2	3	4	5
80) Ekip üyelerindeki yorgunluk durumunda, ekip üyesinin uyanık kalarak işe devamını sağlayacak şartlar oluşturabilmek	1	2	3	4	5
81) Uçuş sırasında karar vermeden önce çevreden aldığım bilgileri doğru analiz edebilmek	1	2	3	4	5
82) Otomasyon sistemlerindeki değişiklikleri zamanında dile getirebilmek	1	2	3	4	5

K. AVIATION SAFETY CLIMATE SCALE

Aşağıda uçuş şirketlerinin emniyet iklimlerini belirten bazı cümleler verilmiştir. Lütfen, kendinizi işinizi yaparken düşündüğünüzde sunulan her bir maddede ifade edilen durumun şirketinizin emniyet iklimini ne ölçüde yansıttığını verilen 5 basamaklı ölçek üzerinde ilgili kutucuğu işaretleyerek belirtiniz.

	Kesinlikle katılmıyorum				Kesinlikle katılıyorum
1)Emniyeti artırıcı öneriler teşvik edilir.	1	2	3	4	5
2)Yönetim, gerçekten emniyet konularıyla ilgilenir.	1	2	3	4	5
3)Güvenlik konularında pilotlara danışılır.	1	2	3	4	5
4) Pilotlar, emniyet problemleriyle ilgili süpervizörler veya yöneticilerle açıkça konuşabilir.	1	2	3	4	5
5)Pilotlara, uçak şirketi dâhil, emniyet olaylarıyla ilgili geribildirim verilir.	1	2	3	4	5
6)Yönetim, uçuş emniyetini etkileyecek operasyonel konularda iyi bir anlayışa sahiptir	1	2	3	4	5
7)Yönetim, emniyeti firma operasyonlarının önemli bir parçası olarak ele alır.	1	2	3	4	5
8)Yönetim, emniyet olaylarına dâhil olan insanları suçlamak yerine olayların altında yatan faktörleri araştır.	1	2	3	4	5
9)Yönetim, pilotları emniyeti uçuş programına uymaktan daha önemli olduğunu düşünmeye teşvik eder.	1	2	3	4	5
10)Yönetim, emniyete yeterli kaynak sağlar.	1	2	3	4	5
11)Bilgileri tazelemek ve güncellemek için düzenli eğitim alınır.	1	2	3	4	5
12)Bir dizi acil durum için düzenli eğitim sağlanır.	1	2	3	4	5
13)Şirket eğitimi normal operasyonları güvenli bir şekilde sürdürmek için yeterli beceri ve deneyimi sağlar.	1	2	3	4	5
14)Yeni prosedürler ya da ekipmanlar uygulanıldığında eğitim alınır.	1	2	3	4	5
15)Uçak, emniyet standartlarını sağlar.	1	2	3	4	5
16)Gerektiğinde ekipmanlar güncellenir veya değiştirilir.	1	2	3	4	5
17)Bakım yapmak için yeterli kaynak sağlanır.	1	2	3	4	5
18) Emniyeti etkilen ve rapor edilmiş hatalar düzeltilir.	1	2	3	4	5

L. BASIC PERSONALITY TRAITS INVENTORY

Aşağıda size uyan ya da uymayan pek çok kişilik özelliği bulunmaktadır. Sizden istenen aşağıdaki kişilik özelliklerinin sizin için ne kadar uygun olduğunu belirtmenizdir.

	Hiç Uygun Değil	Uygun Değil	Kararsızım	Uygun	Çok Uygun
1)Aceleci	1	2	3	4	5
2)Yapmacık	1	2	3	4	5
3)Duyarlı	1	2	3	4	5
4)Konuşkan	1	2	3	4	5
5)Kendine güvenen	1	2	3	4	5
6)Soğuk	1	2	3	4	5
7)Utangaç	1	2	3	4	5
8)Paylaşımcı	1	2	3	4	5
9)Geniş/Rahat	1	2	3	4	5
10)Cesur	1	2	3	4	5
11)Agresif/Saldırgan	1	2	3	4	5
12)Çalışkan	1	2	3	4	5
13)İçten pazarlıklı	1	2	3	4	5
14)Girişken	1	2	3	4	5
15)İyi niyetli	1	2	3	4	5
16)İçten	1	2	3	4	5
17)Kendinden emin	1	2	3	4	5
18)Huysuz	1	2	3	4	5
19)Yardımsever	1	2	3	4	5
20)Kabiliyetli	1	2	3	4	5
21)Üşengeç	1	2	3	4	5
22)Sorumsuz	1	2	3	4	5
23)Sevecen	1	2	3	4	5
24)Pasif	1	2	3	4	5
25)Disiplinli	1	2	3	4	5
26)Açgözlü	1	2	3	4	5
27)Sinirli	1	2	3	4	5
28)Canayakın	1	2	3	4	5
29)Kzıgın	1	2	3	4	5
30)Sabit fikirli	1	2	3	4	5
31)Görgüsüz	1	2	3	4	5
32)Durgun	1	2	3	4	5
33)Kaygılı	1	2	3	4	5
34)Terbiyesiz	1	2	3	4	5
35)Sabırsız	1	2	3	4	5
36)Yaratıcı/Üretken	1	2	3	4	5

37)Kaprisli	1	2	3	4	5
38)İçe kapanık	1	2	3	4	5
39)Çekingen	1	2	3	4	5
40)Alıngan	1	2	3	4	5
41)Hoşgörülü	1	2	3	4	5
42)Düzenli	1	2	3	4	5
43)Titiz	1	2	3	4	5
44)Tedbirli	1	2	3	4	5
45)Azimli	1	2	3	4	5

M. MULTIDIMENSIONAL FATIGUE SYMPTOMS INVENTORY-SHORT FORM

Aşağıda kişilerin hayatlarının belli zamanlarında nasıl hissettiklerine dair cümleler verilmiştir. Son dört haftada bu cümleleri ne kadar sık deneyimlediğinizi belirtiniz.

	Hiç	Biraz	Kısmen	Sık Sık	Oldukça fazla
1) Bir şeyleri hatırlamakta güçlük çekiyorum	0	1	2	3	4
2) Kaslarım ağrıyor	0	1	2	3	4
3) Üzgün hissediyorum	0	1	2	3	4
4) Bacaklarımı güçsüz hissediyorum	0	1	2	3	4
5) Neşeli hissediyorum	0	1	2	3	4
6) Başımda bir ağırlık var	0	1	2	3	4
7) Yaşam dolu hissediyorum	0	1	2	3	4
8) Sinirli hissediyorum	0	1	2	3	4
9) Rahatlamış hissediyorum	0	1	2	3	4
10) Bitkin hissediyorum	0	1	2	3	4
11) Kafam karışık	0	1	2	3	4
12) Tükenmiş hissediyorum	0	1	2	3	4
13) Üzgün hissediyorum	0	1	2	3	4
14) Yorulmuş hissediyorum	0	1	2	3	4
15) Dikkatimi vermekte zorluk çekiyorum	0	1	2	3	4
16) Kollarımı güçsüz hissediyorum	0	1	2	3	4
17) Ağırkanlı hissediyorum	0	1	2	3	4
18) Gücümün tükendiğini hissediyorum	0	1	2	3	4
19) Tüm vücudum ağrıyor	0	1	2	3	4
20) Konsantre olamıyorum	0	1	2	3	4
21) Depresif hissediyorum	0	1	2	3	4
22) Yenilenmiş hissediyorum	0	1	2	3	4
23) Gergin hissediyorum	0	1	2	3	4
24) Enerjik hissediyorum	0	1	2	3	4
25) Normalden daha fazla hata yapıyorum	0	1	2	3	4
26) Üzerimde bir ağırlık var	0	1	2	3	4
27) Unutkanım	0	1	2	3	4
28) Yorgun hissediyorum	0	1	2	3	4
29) Sakin hissediyorum	0	1	2	3	4
30) Sıkıntılıyım	0	1	2	3	4

N. CURRICULUM VITAE

GİZEM SERİN ATIŞ

Research Assistant at Department of Psychology, TOBB University of Economics and Technology, Ankara, Türkiye

E-mail:

ORCID: [redacted]

Education Information

2016- Present	**Middle East Technical University, Graduate School of Social Sciences** Ph.D. Traffic and Transportation Psychology CGPA: 3,93
2014-2016	**Middle East Technical University, Graduate School of Social Sciences** M.Sc., Traffic and Transportation Psychology CGPA: 3,92
2009-2014	**Middle East Technical University** Bachelor, Psychology CGPA: 3,38

Seminars And Courses

2013-2015	**Researcher** Global Road Safety in 10 Countries Project (RS10) Project Coordinator: Türker Özkan
Mar 2015- Jul 2018	**Project Assistant** "Yaklaşma Hızının Görsel Kontrolü: Optik Değişkenler ve Kontrol Stratejilerinin Araştırılması" Project Coordinator: Didem Kadıhasanoğlu
Oc 2022-Jan 2023	**Project Assistant** Yaklaşma Hızının Görsel Kontrolünde Algısal Kısıtların Göreve, Taşıt Dinamiklerine ve Çevresel Koşullara Bağlı Değişiminin İncelenmesi Project Coordinator: Didem Kadıhasanoğlu

Sept 2024-Jan 2025

Project Assistant
Yaklaşma Hızının Görsel Kontrolünde Algısal Kısıtların Göreve, Taşıt Dinamiklerine ve Çevresel Koşullara Bağlı Değişiminin İncelenmesi
Project Coordinator: Didem Kadıhasanoğlu

Conference Participation

- 1. Aviation, Space and Psychology Congress, İstanbul, TR, Guest Speaker
    - Fatigue Among Cockpit Crews
- 2. Aviation, Space and Psychology Congress, Online, Oral Presentation
    - Analyzing the Relationship between Crew Resource Management, Locus of Control and Pilot Behavior
- 5. Aviation, Space and Psychology Congress, İstanbul, TR, Oral Presentation
    - Analyzing the Relationship between Organizational Safety Climate, Locus of Control and Pilot Behavior
- 1. Aviation, Space and Psychology Congress, Scientific Committee Membership
- 2. Aviation, Space and Psychology Congress, Scientific Committee Membership
- 3. Aviation, Space and Psychology Congress, Scientific Committee Membership
- 4. Aviation, Space and Psychology Congress, Scientific Committee Membership
- 5. Aviation, Space and Psychology Congress, Scientific Committee Membership
- 6. Aviation, Space and Psychology Congress, Scientific Committee Membership
- 33. European Association for Aviation Psychology Conference, Dubrovnik, Croatia, Oral Presentation, Full-text publication
    - An Investigation of the Relationship between Multidimensional Fatigue and Flight Behaviors of Turkish Commercial Airline Pilots
- XVI. European Congress of Psychology, Moscow, Russia, Oral Presentation
    - Does the Mood at the Traffic Has an Effect on Job Performance?

Articles

- **Serin, G.,** Öz, C., Öz, B. & Lajunen, T. (2018). Türkiye'de Yaya Tutumları ve Yaya Davranışları Arasındaki İlişkinin İncelenmesi. *Journal of Traffic and Transportation Research, 1* (1) , 54-68 . Retrieved from https://dergipark.org.tr/tr/pub/tuad/issue/36875/420890

- **Serin, G.** & Öz, B. (2018). An Investigation of the Relationship between Multidimensional Fatigue and Flight Behaviours of Turkish Commercial Airline Pilots. In H. Becherstorfer, J. Lasry & M. Schwarz (Eds.), *Proceedings of the 33rd Conference of the European Association for Aviation*

Psychology: Connecting People, Organisations & Technology in Aviation 375-389) Groningen, Netherlands: European Association for Aviation Psychology. ISBN: 9789081525367

- **Serin Atis G.**, Ozic, A. B., Bukruk, T., Ozkaya, E. & Kantas Yorulmazlar, Ö. (2022). The association between commuting, mood, and job performance: The Structural Equation Modelling, *International Journal of Occupational Safety and Ergonomics*, doi: 10.1080/10803548.2021.2010970

- Kadıhasanoğlu, D**.** & **Serin Atış, G**. (2024). Controlling the Speed of a Vehicle: Visual Control of Acceleration and Deceleration, *Journal of Traffic and Transportation Research*. Article in Press.

Reports

- Özkan, T., Üzümcüoğlu, Y., Öztürk, İ, Öz, C., Fındık, G., **Serin, G**., . . . Yılmaz, Ş. (2015). Türkiye analizi: Takip çalışması sürücü ve ön koltuk yolcularının emniyet kemeri kullanımı. (Available upon request).

Thesis

- M. Sc. Thesis
    - Organizational Safety Climate, Precondition for Unsafe Acts and Unsafe Acts of Turkish Commercial Airline Pilots

Reviewer

- 2016-2018 - TRF: Traffic Psychology and Behavior
- 2020-2021 - Journal of Traffic and Transportation Research

O. TURKISH SUMMARY / TÜRKÇE ÖZET

YENİDEN YORUMLANAN EKİP KAYNAK YÖNETİMİ (EKY) BİLEŞENLERİNİN TİCARİ HAVAYOLU PİLOTLARININ EMNİYETSİZ DAVRANIŞLARI ÜZERİNDEKİ ETKİSİ: GÜVENLİK İKLİMİ, YORGUNLUK VE KİŞİLİĞİN ARACI VE DÜZENLEYİCİ ROLLERİ ÜZERİNE BİR ARAŞTIRMA

Giriş

Havacılık sektörü, teknolojik gelişmelere rağmen büyük ölçüde insan faktörüne dayanır ve kazaların çoğu insan hatasından kaynaklanmaktadır. Çeşitli çalışmalar, kazaların %70-80'inin insan hatasından kaynaklandığını göstermektedir (Wiegmann & Shappell, 2001). İnsan hataları arasında kazaların direkt nedeni olarak pilotları davranışları (unsafe acts) olduğu görülmüştür. Ulaşım literatüründe “safe” kelimesi genellikle “güvenli” kelimesi ile Türkçe literatürde yer alsa da havacılık literatüründe bu kelime “emniyetli” şeklinde Türkçeleştirilmiştir. Bu nedenle metnin geri kalanında “safe” kelimesinin Türkçe karşılığı olarak emniyetli, “safety” kelimesinin Türkçe karşılığı olarak “emniyet” kelimesi kullanılacaktır. Emniyetsiz davranışlar genellikle iletişim eksiklikleri, kötü karar verme, dikkatsizlik ve koordinasyon eksikliklerinden kaynaklanmaktadır (Reason, 1990). Bu tür davranışlar özellikle havacılıktaki hızla değişen ortamda kritik öneme sahiptir. Emniyetsiz davranışlar, kasıtsız hatalar veya kasıtlı ihlaller olarak farklı biçimlerde ortaya çıkabilir ve eğer risk faktörleri göz ardı edilirse felaketlere yol açabilir (Hobbs & Williamson, 2002). Örneğin, 1977'deki Tenerife felaketi, kokpit içindeki yetersiz koordinasyon ve iletişim eksikliklerinden kaynaklanmıştır (Weick, 1990).

Pilotların emniyetsiz davranışlarını ölçmek amacıyla nesnel ve öznel birçok farklı ölçüm yöntemi kullanılabilmektedir. Ancak bu yöntemlerin hem avantajları hem de dezavantajları bulunmaktadır. Nesnel yöntemlerin başlıcaları kokpit içerisindeki gözlemler veya simülatör çalışmalarıdır. Bu yöntemler pilotların davranışları geniş bir çerçevede değerlendirmeye ve ölçümlemeye olanak sağlar. Ancak bu yöntemler, gözlemcilerin yoğun eğitimini gerektirmekte ve gözlemcilerin güvenilirliği açısından soru işareti oluşturmaktadır. Aynı zamanda, özellikle simülatör çalışmalarında sonuçların genellenebilirliği düşüktür (Caponecchia et al., 2014; Mavin & Roth, 2014). Öznel yöntemlerin başında ise öz-bildirim yöntemi gelmektedir. Öz-bildirim yöntemi pilotların davranışlarının sıklığını kendi raporlamalarıyla ölçmeye dayanmaktadır. Serin (2016) ticari havayolu pilotlarının emniyetsiz davranışlarını ölçmek amacıyla Pilot Davranışları Envanteri (PDE) geliştirmiştir. Bu envanter, kuramsal olarak alanında uzman kişilerin görüşleri alınarak geliştirilmiştir. Kuramsal olarak geliştirilmiş olması pilotların davranış çeşitliliğini yansıtması açısından bir eksiklik olarak görülebilmektedir. Bu nedenle, bu envanterin pilotların davranış örneklerini artırmak amacıyla mülakatlarla desteklenmesi ve yenilenmesi gerekliliği düşünülmektedir. Literatürde, öz-bildirim ölçümlerinin sosyal olarak istenilen yanıtlamaya karşı savunmasız olabileceği öne sürülmüştür. Bu durum, katılımcıların soruları gerçek duruma uygun yanıtlamak yerine, araştırmacıların beklentileri ve toplumsal beklentiler doğrultusunda yanıtlaması anlamına gelmektedir (Lajunen & Summala, 2003; Yılmaz ve ark., 2022). Ancak, sosyal istenilirliğe dayalı yanıtlar katılımcıların anonimliği güvencelendiğinde azalabilmektedir (Lajunen & Summala, 2003).

Pilotların emniyetsiz davranışlarını ölçmek bu davranışları azalmada ve bu davranışlara etki eden faktörleri belirlemekte önemli olacaktır. Bu tür davranışların önlenmesi amacıyla Ekip Kaynak Yönetimi (EKY) geliştirilmiştir. EKY, ekip çalışması, iletişim, liderlik, karar verme gibi insan faktörlerini ele alarak uçuş emniyetini artırmayı hedefler (Helmreich & Foushee, 2010). 1970'lerde EKY uygulamaları başladıktan sonra, havayolu şirketleri bu eğitimi uçuş ekiplerine vermeye başladı ve bu uygulama dünya çapında yaygınlaştı. EKY'nin etkisi ve bu eğitimlerin ne kadar başarılı olduğu, çeşitli araçlarla ölçülmeye çalışılmıştır. Örneğin, Cockpit Management Attitudes Questionnaire (CMAQ) gibi anketler ve Line Operation Safety Audits (LOSA) gibi gözlem araçları bu ölçüm araçlarındandır (Helmreich, 1984; Merritt, 1996; O'Connor, 2002).

EKY, teknik becerilerle birlikte bilişsel, sosyal ve kişilerarası beceriler gerektirir ve etkili bir ekip performansı için tüm kaynakların doğru şekilde kullanılmasını amaçlar (Flin, 2002). İletişim, ekip yönetimi, liderlik, karar verme gibi becerileri geliştirmeyi hedefler. EKY'nin uygulanması, havacılıktaki ciddi kazaların çoğunun insan hatalarından kaynaklandığına dair farkındalık oluşturmuş ve emniyeti artırmaya yönelik bir adım olmuştur. 1979'da NASA tarafından düzenlenen bir çalıştayda "Kokpit Kaynak Yönetimi" terimi ortaya çıkmış ve ilk CRM eğitim programları, ABD'deki United Airlines ve Avrupa'daki KLM gibi havayolu şirketlerinde uygulanmaya başlanmıştır (Flin, 2002).

EKY'nin amacı zamanla genişlemiş ve kapsamı Ekip Kaynak Yönetimi olarak daha geniş bir alanı kapsayacak şekilde evrilmiştir. EKY, uçuş personelinin tüm kaynakları etkili bir şekilde kullanabilmesini öğretmeye çalışarak, hataları en aza indirgemeyi amaçlar. Ancak, EKY'nin etkinliği hakkında çeşitli çalışmalar yapılmış ve bunun emniyeti artırmadaki rolü üzerine çok sayıda araştırma gerçekleştirilmiştir (Flin, 2003; Helmreich, 1997). Bu araştırmalar, EKY beceri ve davranış ölçümlerinin uçuş emniyetini artırmada önemli olduğunu göstermiştir.

EKY'nin etkinliğini etkileyen faktörlerden biri de pilotların yorgunluk durumudur. Yorgunluk, görsel algı, dikkat, karar verme ve işleme gibi bilişsel ve psikomotor becerilerde bozulmalara yol açar. Yorgunlukla ilgili pek çok çalışma, bu durumun pilotlar arasında hataları ve emniyetsiz davranışları artırabileceğini göstermektedir (Killgore, 2009; Tucker, 2010). Örneğin, görsel performans düşüşü, dikkat eksikliği gibi faktörler kazalara yol açabilecek sorunlar yaratır (Quant, 1992; Rogé, 2003). Ayrıca, aşırı uyanıklık ve yorgunluk, pilotların karar verme süreçlerini olumsuz yönde etkileyebilir (Tyagi, 2009; Smith, 2002).

Bir diğer önemli faktör ise organizasyonel emniyet iklimidir. İyi bir emniyet iklimi, uçuş ekibinin emniyetli uçuş operasyonlarını sağlamak için kurallara uyum sağlamasını ve iş birliği yapmasını teşvik eder. Pozitif emniyet ikliminin, uçuş ekiplerinin emniyet davranışlarını güçlendirdiği ve hataları azaltmaya yardımcı olduğu gözlemlenmiştir (Zohar, 2014; Swedler, 2015). Organizasyonlar, bu tür bir emniyet kültürü oluşturmayı ve uçuş emniyetini teşvik etmeyi amaçlamalıdır. Ayrıca, yorgunlukla ilgili risklerin yönetilmesinde de kurum emniyet iklimi önemli bir rol oynar, çünkü uçuş süreleri ve dinlenme süreleri gibi faktörler uçuş emniyetini etkileyebilir.

Son olarak, kişilik özelliklerinin de pilotların emniyetsiz davranışları üzerinde etkisi olduğu görülmektedir. Bazı araştırmalar, pilotların belirli kişilik özelliklerine sahip olmalarının, uçuş emniyeti açısından önemli olduğunu öne sürmüştür. Özellikle dışa dönüklük, duygusal denge ve sorumluluk gibi faktörler, pilotların performansını etkileyebilir (Ma, 2023). Yüksek anksiyete ve stres gibi kişilik özellikleri, pilotların performansını olumsuz etkileyebilirken, uyumluluk ve sorumluluk duygusu yüksek olan pilotlar daha emniyetli davranışlar sergileyebilir (Boyd, 2005; Callister, 1999).

Sonuç olarak, EKY, uçuş emniyetini artırmada kritik bir rol oynamaktadır. Ancak, EKY'nin etkinliğini etkileyen yorgunluk, kişilik özellikleri ve kurum emniyet iklimi gibi faktörler de göz önünde bulundurulmalıdır. Bu faktörlerin etkili bir şekilde yönetilmesi, uçuş emniyetini artırmaya yardımcı olabilir.

Bu çalışma, ticari havayolu pilotlarının EKY ve emniyetsiz davranışlar arasındaki ilişkisinin daha derinlemesine anlaşılmasını hedeflemektedir. Bu amaçla, çalışma 1'de PDE'nin yenilenmesi ve EKY yetkinliklerini öz-bildirim yöntemiyle ölçümleyecek bir araç geliştirilmesi amaçlanmıştır. Aynı zamanda, pilotların emniyetsiz davranışlarını yordayan faktörlerin belirlenmesi, kurum emniyet iklimi ve yorgunluğun EKY ve emniyetsiz davranışlar arasındaki ilişkideki aracı rolünün belirlenmesi ve kişilik özelliklerinin bu ilişkideki düzenleyici rolünün belirlenmesi amaçlanmaktadır.

Çalışma 1: Pilot Davranışları Envanterinin Revize Edilmesi ve EKY Yetkinlikleri Ölçeğinin Geliştirilmesi

Giriş

EKY, havacılık endüstrisinde hataları yönetmek ve uçuş emniyetini sağlamak için önemli bir rol oynar. İnsan faktörlerinin havacılık kazalarındaki etkisinin fark edilmesiyle EKY'in önemi artmış, 2001'den itibaren yolcu taşıyan pilotlar için EKY eğitim programları zorunlu hale getirilmiştir. Bu eğitimler, iletişim, iş birliği, durum farkındalığı, karar verme, iş yükü, yorgunluk ve stres yönetimi gibi teknik olmayan becerileri geliştirmeyi amaçlamaktadır (Çetingüç, 2016).

EKY eğitim programlarının etkili olması, öğrenilen bilgilerin davranışlara dönüşmesine bağlıdır. EKY'i değerlendirmek için tutum ve davranışlara odaklanan çeşitli ölçüm araçları geliştirilmiştir. Örneğin, Kokpit Yönetim Tutumları Ölçeği ile EKY'e yönelik olumlu tutumlar tespit edilmiştir (Helmreich & Wilhelm, 1991). Ancak, EKY davranışlarını değerlendiren çalışmalar sınırlı kalmış ve sonuçlarda fikir birliği sağlanamamıştır. Thomas (2004), iş birliği ve durum farkındalığı gibi özelliklerin hata yönetimiyle ilişkili olduğunu bulurken, Serin (2016) EKY davranışları ile emniyetsiz davranışlar arasında bir ilişki bulamamıştır.

EKY davranışlarını değerlendirmek için kapsamlı davranışsal göstergeler geliştirilmiştir, ancak bu araçların kullanımı özel eğitim ve kokpitte gözlem gerektirdiği için araştırmacılar için erişimi sınırlıdır. Bu nedenle, kolay uygulanabilir, öz-bildirime dayalı yeni EKY ölçüm araçlarına ihtiyaç duyulmaktadır. Ayrıca, EKY eğitim programlarının başarısı, pilotların öğrendikleri becerileri iş ortamında uygulayabilme yeterliliğine bağlıdır (MacLeod, 2021). Günümüzde bu eğitimler, yeterliliğe dayalı yaklaşımlarla birleştirilerek bu becerilerin uygulanabilirliği artırılmaya çalışılmaktadır (Başdemir, 2020).

Bu bağlamda, Çalışma 1, Türkiye'deki ticari havayolu pilotlarının EKY yeterliliklerini keşfetmeyi ve kolay uygulanabilir, öz-bildirime dayalı bir EKY yetkinlik ölçüm aracı geliştirmeyi hedeflemektedir.

Yöntem

Katılımcılar

Yaşları 30 ila 54 arasında değişen 12 ticari havayolu pilotu ile mülakatlar gerçekleştirilmiştir. Bunlardan 5 tanesi F/O olarak çalışmakta, 7 tanesi de kaptan pilot olarak çalışmaktadır.

Prosedür

İlk olarak, ODTÜ İnsan Araştırmaları Etik Kurulu'ndan etik izin alınmıştır. Katılımcılarla online görüşme yöntemiyle mülakatlar gerçekleştirilmiştir. Görüşme başlangıcında katılımcılara çalışmanın amacı ile ilgili bilgi verilmiş ve çalışmaya gönüllü katıldıklarına dair sözlü onay alınmıştır (Onam Formu için EK B'ye bakınız).

Ölçekler

Katılımcılarla, demografik soruları, EKY yetkinlikleri ve emniyetsiz davranışlar ile ilgili soruları içeren yarı yapılandırılmış mülakatlar gerçekleştirilmiştir. Mülakat soruları için EK C'ye bakınız.

Sonuçlar

Pilot Davranış Envanteri Revizyonu

PDE maddelerinin revizyonu için katılımcılar tarafından ifade edilen her hata ve ihlal, birebir kaydedilerek bir Word dosyasına yazılmıştır. Maddeler, mastar formunda ve birinci tekil şahıs zamirleriyle liste haline getirilmiştir. Orijinal PDE 'de yer alan maddeler de bu listeye eklenmiştir. İlk madde havuzu toplamda 138 davranış maddesinden oluşmuştur.

Araştırmacılar, listeyi okuyarak tekrar eden maddeleri işaretlemiş ve bu maddelerden sadece bir tanesi havuzda bırakılmıştır. İlk değerlendirmeyi takiben, madde havuzunda 72 madde kalmıştır. Bu maddelerden 40 tanesi, orijinal PDE'deki maddelerle birebir örtüşmektedir. İkinci değerlendirme, kaptan pilot ve EKY eğitmeni olan bir uzman tarafından gerçekleştirilmiştir. Değerlendirme, maddelerin havacılık terminolojisine ve emniyet prosedürlerine uygunluğu temel alınarak yapılmıştır. Bu aşamada, madde havuzunda 68 madde kalmıştır.

Son olarak, maddeler aktif olarak uçuş yapan 6 pilot uzmana gönderilmiştir. Uzmanlardan, verilen hata ve ihlal türlerinin tanımlarını inceleyerek her bir maddeyi en uygun boyuta atamaları istenmiştir. Değerlendirme sonucunda, 68 maddenin 57 tanesi aynı boyutlara yerleştirilmiş ve bu durum uzmanlar arasında %83'lük bir fikir birliği olduğunu göstermiştir. Kalan maddelerden 5 tanesi, en az üç uzman tarafından aynı boyuta atanmıştır. Ancak, uzmanlar 6 madde üzerinde uzlaşamamış ve bu maddeler envanterden çıkarılmıştır. Sonuç olarak, PDE'nin son hali 62 maddeden oluşmuş ve PDE-R olarak isimlendirilmiştir.

EKY Yetkinlikleri Ölçeği Geliştirilmesi

Katılımcılar tarafından ifade edilen her bir yetkilik, bire bir kaydedilerek bir Word dosyasına yazıldı. Tüm yetkinlikler liste halinde bir araya getirilmiş ve birinci tekil şahıs zamirleriyle mastar biçiminde yeniden düzenlenmiştir. Bu aşamada oluşturulan ilk madde havuzu 165 maddeden oluşmaktadır. Liste taranarak tekrar eden maddeler işaretlenmiş ve yalnızca bir tanesi havuzda bırakılmıştır. Bu değerlendirme sonrasında havuzda 98 madde kalmıştır.

İkinci değerlendirme, kaptan pilot ve EKY eğitmeni olan bir uzman tarafından gerçekleştirilmiştir. Değerlendirme, maddelerin teorik benzerlikleri ve EASA ana yetkinlikler çerçevesine uygunluğu temel alınarak yapılmıştır. Bu aşamadan sonra havuzda 82 madde kalmıştır. Daha sonra, bu maddeler aktif olarak uçuş yapan 6 havayolu pilotu uzmana gönderilmiş, uzmanlardan, EASA ana yetkinlik boyutlarının tanımlarını inceleyerek her bir maddeyi en uygun boyuta atamaları istenmiştir. Değerlendirme sonucunda 75 madde, uzmanlar arasında %91'lik bir fikir birliği ile aynı boyuta atanmıştır. Ancak, 7 madde konusunda üç uzman aynı boyutu seçerken diğer üç uzman farklı görüş bildirmiştir. Bu durum, söz konusu maddelerin ifade sorunları içerdiğini göstermiştir. Bu 7 madde yeniden yazılmış ve uzmanların netlik konusundaki görüşleri alınmıştır. Uzmanlar maddelerin net olduğunu onayladıktan sonra bu maddeler ölçekte yer almıştır. Sonuç olarak, EKY-YÖ'nün son hali 82 maddeden oluşmuştur.

Tartışma

Çalışma 1, ticari havayolu pilotlarının EKY yetkinliklerini değerlendirmek için EKY-YÖ adında yeni bir ölçek geliştirmiş ve pilotların emniyetsiz davranışlarını ölçen PDE ölçeğini revize etmiştir. Çalışmada, aktif olarak uçan 12 ticari pilotla yarı yapılandırılmış görüşmeler gerçekleştirilmiş ve içerik analizi uygulanmıştır. Bu analiz sonucunda EKY-YÖ ölçeği 82 maddeden oluşmuş ve altı temel boyutta sınıflandırılmıştır: *bilgi ve prosedürlerin uygulanması, iletişim ve koordinasyon, uçuş yönetimi, liderlik ve ekip çalışması, durumsal farkındalık ve karar verme ile iş yükü yönetimi*.

PDE-R ise 62 maddeye indirilmiş ve *beceri tabanlı hatalar, karar hataları, algısal hatalar ve ihlaller* olmak üzere dört temel boyuta ayrılmıştır. Çalışmada kullanılan nitel yöntemler, ölçeklerin kapsamını genişletmiş ve teorik temellerini güçlendirmiştir. Pilotların ve EKY eğitmenlerinin katılımı sayesinde bilgi çeşitliliği sağlanmış, ölçeklerin içeriği havacılık jargonuna ve emniyet düzenlemelerine uygun şekilde yapılandırılmıştır.

Bu çalışmanın EKY-YÖ ve PDE-R ölçekleriyle elde edilen kuramsal ve ampirik bilgiler, uçuş emniyeti ve havacılık psikolojisi literatürüne katkıda bulunmayı hedeflemektedir. İlerleyen araştırmalarda bu ölçeklerin emniyet açısından kritik değişkenlerle ilişkileri incelenecek ve uçuş emniyetinin artırılmasına yönelik önemli bilgiler sunulacaktır.

Çalışma 2: EKY Yetkinlikleri, Kurum Emniyet İklimi, Yorgunluk, Kişilik Özellikleri ve Pilotların Emniyetsiz Davranışları Arasındaki İlişkini İncelenmesi

Giriş

EKY eğitim programlarının amacı, mürettebat üyelerine EKY uygulamalarını etkili bir şekilde kullanmayı öğretmek ve olumsuz olaylara yol açmadan emniyetsiz davranışları yönetmektir (Helmreich & Foushee, 2010). Ancak, literatürde EKY ile ticari havayolu pilotlarının emniyetsiz davranışları arasındaki ilişkiyi inceleyen sınırlı sayıda çalışma bulunmaktadır. Thomas (2004) tarafından yapılan bir araştırma, durumsal farkındalık, dikkat, bilgi paylaşımı ve karar verme becerilerinin uçuş sırasında yapılan hatalarla olumsuz ilişkili olduğunu göstermiştir. Buna karşılık, Serin (2016), EKY'nin davranışsal yansımaları ile öz-bildirime dayalı emniyetsiz davranışlar arasında anlamlı bir ilişki bulamamıştır. Bu çelişkili sonuçlar, bu ilişkinin daha fazla araştırılması gerektiğini göstermektedir.

Pilotların emniyetsiz davranışlarını etkileyebilecek diğer bir önemli faktör yorgunluktur. Yorgunluk, uzun saatler boyunca uçma, gece operasyonları, zaman dilimi değişiklikleri ve sınırlı uyku nedeniyle sıkça yaşanan bir sorundur (Caldwell, 2012; Olaganathan vd., 2021). Literatürde yorgunluğun psikomotor yetenekler, dikkat, görsel algı ve problem çözme becerileri üzerindeki olumsuz etkileri iyi bir şekilde belgelenmiştir (Killgore vd., 2009; Tucker vd., 2010). Yen ve arkadaşları (2009) tarafından yapılan bir çalışma, pilotların fiziksel ve zihinsel yorgunluk belirtileri yaşadığını ve bunun, karar verme süreçlerinde ve emniyet prosedürlerine uyumda olumsuz sonuçlara yol açtığını ortaya koymuştur.

Yorgunluk yönetimi stratejileri (örneğin, kokpitte uyku molaları ve artan aydınlatma) etkili olsa da bu tedbirlerin başarıya ulaşması için pilotların yorgunluk belirtilerini tanıması ve iletişim kurması gerekmektedir. EKY'nin burada önemi bir kez daha ortaya çıkmaktadır, çünkü EKY uygulamaları, yorgunluğun etkilerini azaltarak emniyetsiz davranışların yönetiminde yardımcı olabilir.

Kurum emniyet iklimi de emniyetsiz davranışlar üzerinde etkili olabilir. Pozitif bir emniyet iklimi, emniyeti önceliklendiren, açık iletişim sağlayan ve emniyet kaygılarını bildirmeyi teşvik eden bir ortam olarak tanımlanır (Zohar, 2010). Pilot örneklemleri üzerinde yapılan çalışmalar, pozitif bir emniyet ikliminin emniyet uyumunu ve katılımını artırdığını göstermiştir (Fernandes vd., 2018). Ayrıca, pozitif bir emniyet iklimi yorgunluk yönetiminde de etkili olabilir, çünkü kurumlar, pilotların dinlenme ihtiyaçlarını belirleyerek operasyonel riskleri minimize edebilir.

Son olarak, pilotların kişilik özelliklerinin de emniyetsiz davranışlar üzerinde etkili olabileceği belirtilmiştir. Literatürde, sürücü öfkesi ve düşmanlık, duygusal stabilite eksikliği ve yüksek his arayışı gibi kişilik özelliklerinin sürücüler arasında emniyetsiz davranışlarla ilişkili olduğu gösterilmiştir. Ancak, pilot örneklemleri üzerinde kişilik özelliklerinin etkileri daha az belirgin olabilir, çünkü işe alım süreçlerinde kişilik değerlendirmeleri yapılmaktadır. Bununla birlikte, kişilik özellikleri, EKY ve emniyetsiz davranışlar arasındaki ilişkiyi düzenleyen bir düzenleyici olarak ele alınabilir.

Çalışma, EKY yetkinlikleri ile emniyetsiz davranışlar arasındaki ilişkileri incelemenin yanı sıra, organizasyonel emniyet iklimi ve yorgunluğun aracı rolünü ve kişilik özelliklerinin bu ilişkideki düzenleyici etkisini araştırmayı amaçlamaktadır. Ayrıca, EKY-YÖ ve revize edilmiş PDE ölçeklerinin faktör yapıları ve psikometrik özellikleri analiz edilecektir.

Yöntem

Katılımcılar

Yaşları 25 ila 62 arasında değişen 176 ticari havayolu pilotu ana çalışmaya katılmıştır. Bunlardan 91'i kaptan pilot, 85'i F/O olarak çalışmaktadır. Ticari havayollarındaki toplan uçuş süresi, son aydaki toplam uçuş süresi ve ortalama stres düzeyleri için Tablo 1'e bakınız.

Ölçekler

Demografik bilgi formu için Ek H'ye bakınız.

EKY-YÖ için Ek I'ya bakınız.

PDE-R için Ek J'ye bakınız.

Havacılık Emniyet İklimi Ölçeği için Ek L'ye bakınız.

Temel Kişilik Özellikleri Envanteri için Ek M'ye bakınız.

Çok Boyutlu Yorgunluk Semptomları-Kısa Versiyon için Ek N'ye bakınız.

Prosedür

Veriler katılımcılardan online veri toplama metoduyla toplanmıştır.

Sonuçlar

EKY-YÖ Faktör Yapısı ve Psikometrik Özellikleri

Yapılan analizler sonucunda EKY-YÖ için 4-boyutlu yapının uygun olduğu bulunmuştur. Toplam 49 madde bu faktörlerden birine yerleşmiştir. Kalan 33 madde ise boyut yükleri .40 sınırını geçemediğinden ölçekten çıkarılmıştır. İlk boyut, *Uçuş İzleme ve Yönetim Yetkinlikleri* olarak isimlendirilmiş ve toplam 21 maddeden oluşmuştur. Bu boyutta temel olarak pilotların uçuş boyunca izleme ve uçuş planı ve sistemlerini yönetimi ile ilgili maddeler bulunmaktadır. İkinci boyut, *Yorgunluk ve İş*

Yönetimi olarak isimlendirilmiş ve 13 maddeden oluşmuştur. Bu boyutta temel olarak pilotların hem kendileri hem de diğer ekip üyeleri için yorgunluk semptomlarını ve iş yüklerini yönetim yetkinlikleri ile ilgili maddeler bulunmaktadır. Üçüncü boyut ise *Ekip İletişim ve Koordinasyon Yetkinlikleri* olarak isimlendirilmiş ve toplam 15 maddeden oluşmuştur.

İç tutarlılık katsayıları EKY-YÖ'nün güvenilir bir ölçek olduğunu göstermiştir. Aynı zamanda, test-tekrar test güvenilirlik katsayıları kabul edilebilir seviyede olup, güvenilirliğini göstermiştir (bkz. Tablo 3).

PDÖ-R'nin Faktör Yapısı ve Psikometrik Özellikleri

Yapılan analizler sonucunda PDÖ-R'nin 4-boyutlu yapı için uygun olduğu görülmüştür. Toplam 53 madde bu 4 faktörden birine yerleşmiştir. İlk boyut, 27 maddeden oluşmuş olup *yetenek-bazlı hatalar* olarak isimlendirilmiştir. İkinci boyut 10 maddeden oluşmakta ve karar hataları ile ilgili maddelerden oluştuğundan *karar hataları* olarak isimlendirilmiştir. Üçünü boyut ise 7 maddeden oluşmakta ve unutma ile ilgili maddeleri içerdiğinden *hafıza hataları* olarak isimlendirilmiştir. Son boyut ise temelde bilinçli prosedürel sapmaları içeren 8 maddeden oluştuğundan *prosedürlere uymama* boyutu olarak isimlendirilmiştir. Boyutların iç tutarlılık katsayıları PDE-R'nin güvenilir bir ölçek olduğunu göstermiştir.

Hiyerarşik Regresyon Analizi Sonuçları

PDE-R boyutlarının açıklanan değişkenler olarak yer aldığı dört farklı hiyerarşik regresyon analizi gerçekleştirilmiştir. Bu analizlerin her birinde, ilk basamağa yaş, ticari havayollarında toplan uçuş süresi, son ayda gerçekleştirilen uçuş süresi ve stres düzeyi kontrol değişkenleri olarak eklenmiştir. İkinci basamakta kişilik özellikleri açıklayıcı değişkenler olarak yer almıştır. Üçüncü basamakta yorgunluk semptomları açıklayıcı değişkenler olarak eklenmiştir. Dördüncü basamakta kurum emniyet boyutları açıklayıcı değişken olarak yer alırken son boyutta EKY-YÖ'nün boyutları açıklayıcı değişken olarak eklenmiştir.

Beceriye dayalı hataların açıklanan değişken olduğu ilk analizde, nevrotiklik ile bu davranışlar arasında pozitif yönlü bir ilişki bulunurken deneyime açıklık ile negatif yönlü bir ilişki olduğu bulunmuştur. Aynı zamanda, zihinsel yorgunluğun bu davranışlarla pozitif yönlü ilişkisi oldu görülmüştür. Kurum emniyet iklimi boyutları ile anlamlı bir ilişki bulunmazken EKY-YÖ'nün yorgunluk ve iş yönetimi boyutu ile negatif yönlü bir ilişki olduğu görülmüştür.

Karar hatalarının açıklanan değişken olduğu ikinci analizde, nevrotiklik ile bu davranışlar arasında pozitif yönlü bir ilişki bulunmuştur. Benzer şekilde, zihinsel yorgunluk ve duygusal yorgunluk ile pozitif yönlü ilişkili olduğu görülmüştür. Ancak, kurum emniyet iklimi boyutları ve EKY-YÖ boyutları ile anlamlı bir ilişki bulunamamıştır.

Hafıza hatalarının açıklanan değişken olduğu üçüncü analizde, nevrotiklik ile bu davranışlar arasında pozitif yönlü bir ilişki bulunmuştur. Bunun yanı sıra olumsuz değerlik boyutu ile negatif yönlü bir ilişki bulunmuştur. Aynı zamanda zihinsel yorgunluk ile pozitif yönlü bir ilişki saptanırken genel yorgunluk semptomları ile negatif yönlü bir ilişki görülmüştür. Kurum emniyet iklimi boyutları ile anlamlı bir ilişki bulunmazken EKY-YÖ'nün ekip iletişim ve koordinasyon yetkinlikleri boyutu ile negatif yönlü bir ilişki olduğu görülmüştür.

Prosedürlere uymama davranışlarının açıklanan değişken olduğu son analizde, nevrotiklik ile bu davranışlar arasında pozitif yönlü bir ilişki bulunurken sorumluluk boyutu ile negatif yönlü bir ilişki saptanmıştır. Aynı zamanda zihinsel yorgunluk ile pozitif ilişkili olduğu görülmüştür. Ancak, kurum emniyet iklimi boyutları ve EKY-YÖ boyutları ile anlamlı bir ilişki bulunamamıştır.

EKY Yekinkileri ile Pilot Davranışları Arasındaki İlişkide Kurum Emniyet İlkini ve Yorgunluğun Aracı Rolü

Kurum emniyet iklimi ve yorgunluğun aracı rolünü belirlemek amacıyla 12 farklı aracılık analizi yapılmıştır. Bu analizlerde yaş, ticari havayollarında toplan uçuş süresi, son ayda gerçekleştirilen uçuş süresi ve stres düzeyi kontrol değişkenleri olarak bulunurken PDE-R boyutları açıklanan değişkenler ve EKY-YÖ boyutları açıklayıcı değişkenler olarak analize eklenmiştir. Kurum emniyet iklimi ve yorgunluk ölçeklerinin toplam skorları aracı değişkenler olarak her bir analize eklenmiştir.

Analiz sonuçlarına göre, kurum emniyet iklimi ve yorgunluk, EKY yetkinlikleri ve beceriye dayalı hatalar arasındaki ilişki ile EKY yetkinlikleri ve karar hataları arasındaki ilişkiye aracılık etmiştir. Buna göre, pilotlar EKY yetkinliklerini yüksek olduklarını raporladıklarında kurum emniyet iklimine karşı pozitif tutumlar raporlarmış ve daha az yorgunluk semptomları deneyimlediklerini belirtmişlerdir. Dolayısıyla daha az beceriye dayalı hatalar ve karar hataları yaptıklarını raporlamışlardır.

EKY Yekinkileri ile Pilot Davranışları Arasındaki İlişkide Kişilik Özelliklerinin Düzenleyici Rolü

Kişilik özelliklerinin düzenleyici rolünü belirlemek amacıyla 72 farklı düzenleyici analizi yapılmıştır. Bu analizlerde yaş, ticari havayollarında toplan uçuş süresi, son ayda gerçekleştirilen uçuş süresi ve stres düzeyi kontrol değişkenleri olarak bulunurken PDE-R boyutları açıklanan değişkenler ve EKY-YÖ boyutları açıklayıcı değişkenler olarak analize eklenmiştir. Temel Kişilik Özellikleri Envanterinin boyutları ise analizde düzenleyici değişkenler olarak yer almıştır.

Yapılan analizlerde prosedürlere uymama davranışı için iki analizin anlamlı olduğu görülmüştür. Sonuçlara göre nevrotiklik düzeyinin uçuş izleme ve yönetim yetkinlikleri ve prosedürlere uymam davranışı ile yorgunluk ve is yönetimi yetkinlikleri ve prosedürlere uymama davranışı arasındaki ilişkide düzenleyici rolü olduğu görülmüştür. Bu rol nevrotiklik düzeyi düşük olduğunda ortaya çıkmış ancak yüksek nevrotiklik düzeyinde anlamlı bir fark bulunmamıştır.

Tartışma

EKY-YÖ'nün Boyut Yapısının ve Psikometrik Özelliklerinin Değerlendirilmesi

Bu çalışmada, 49 maddeden oluşan EKY-YÖ'nün üç boyutlu yapısı gösterilmiştir: uçuş izleme ve yönetimi, yorgunluk ve iş yönetimi ve ekip iletişimi ve iş birliği. Bu üç faktörlü yapı, EASA (2023) temel yetkinlik çerçevesi, Helmreich ve arkadaşlarının (1997) Line/LOS kontrol listesi ve O'Connor ve arkadaşlarının (2002) NOTECHS çerçevesi tarafından önerilen EKY yetkinliklerinin çok boyutlu doğasını desteklemiştir. Ayrıca, EKY-YÖ, boyutlar arasında çapraz yükleme olmayan bir faktör yapısı sergilemiştir; bu da pilotların yetkinlik algılarında boyutlar arasındaki pratik ayrımı göstermektedir.

Boyutlar, ticari havayolu pilotları arasında EKY yeterliliklerinin farklı yönlerini ortaya koymaktadır. Örneğin, uçuş izleme ve yönetimi yeterlilikleri, prosedürler ve düzenlemelerle ilgili bilgi uygulamasını, manuel kontrol ve otomasyon altındaki uçuş yönetimi yeterliliklerini içermektedir. Bu faktör, EASA çerçevesindeki durum farkındalığı ve karar verme süreçlerinden ayrı olarak ele alınsa da bu yetkinliklerin pratikte birbirinden ayrılmaz olduğunu göstermektedir. Pilotlar, uçuş planındaki sapmaları yönetmek ve sistemdeki çevresel değişikliklere göre karar almak zorundadır.

Yorgunluk ve iş yönetimi yetkinlikleri, pilotların ve ekip üyelerinin yorgunluk ve iş yükünü yönetme ile ilgilidir. Bu faktör ayrıca, yorgunluk belirtilerini tespit etme ve önlemek için liderlik yetkinliklerini de kapsamaktadır. EASA çerçevesindeki liderlik, bu çalışmada yorgunluk ve iş yönetimi ile iç içe geçmiş bir faktör olarak bulunmuştur. Bu durum, pilotların ekip üyelerinin yorgunluk ve iş yükünü yönetmek için liderlik yetkinliklerini kullanmalarının gerekliliğinden kaynaklanmaktadır.

Ekip iletişimi ve koordinasyon yetkinlikleri, ekip üyeleri arasında açık iletişim ve uçuş operasyonlarında etkili koordinasyonu içermektedir. Bu faktör, ekip karar verme süreçlerini de kapsamaktadır. EASA çerçevesinde karar verme, ayrı bir bileşen olarak ele alınsa da bu çalışma pilotların etkili ve uygun kararlar almak için açık iletişim ve koordinasyonu birbirinden ayrı görmediklerini göstermektedir. Ekip üyelerinin bilgileri paylaşarak koordineli bir şekilde çalışması, hataları azaltmaya ve doğru kararlar almaya yardımcı olabilir.

Sonuç olarak, 3 faktörlü yapı, veriye en uygun olan yapı olarak kabul edilmiştir. Teorik EKY-YÖ yapısı 6 faktörlü olsa da veri tabanlı analiz 3 faktörlü yapıyı daha uygun bulmuştur. Bu farkların iki ana nedeni olabilir: pilotların bazı bileşenleri ayrılmaz olarak görmesi ve örneklem büyüklüğünün nispeten düşük olması, bu da faktörlerin ayrılmasında zorluk yaratabilir. EKY-YÖ, ticari havayolu pilotlarının EKY yeterliliklerini ölçmede önemli bir katkı sağlayacaktır.

EKY-YÖ, güvenilirlik (iç güvenilirlik ve test-tekrar test güvenilirliği) ve geçerlilik (birleştirici ve ayırt edici geçerlilik) açısından iyi psikometrik özellikler göstermektedir. EKY-YÖ faktörleri için Cronbach’s alpha katsayıları ile ölçülmüştür. Özellikle, EKY-YÖ faktörleri Cronbach’s alpha katsayıları olarak .87 ve üzeri değerler göstermektedir. Bu güvenilirlik ölçümü, EKY-YÖ'nün EKY yetkinliklerini ölçmede güvenilir bir araç olduğunu göstermektedir.

PDÖ-R’nin Boyut Yapısı ve Psikometrik Özelliklerinin Değerlendirilmesi

Yenilenmiş 53 maddelik PDE-R, ticari havayolu pilotlarının emniyetsiz davranışlarını ölçmek için geliştirilmiş bir araçtır ve dört faktörlü bir yapıya sahiptir: beceriye dayalı hatalar, karar hataları, hafıza hataları ve prosedürlere uymama davranışları. Bu faktörler, ticari havayolu pilotlarının emniyetsiz davranışlarının farklı yönlerini yansıtmaktadır.

Beceriye dayalı hatalar, uçuş prosedürlerinin hatalı uygulanması ve teknik bilgi eksikliklerinden kaynaklanan hataları kapsar. Bu hatalar genellikle alışkanlık haline gelmiş ve otomatikleşmiş davranışlardan doğar. Karar hataları, yanlış kararlar almayı veya duruma uygun olmayan prosedürlerin uygulanmasını içerir. Hafıza hataları ise bir şeyin unutulması veya yanlış olduğunu fark etmeme durumlarını ifade eder. Prosedürlere uymama davranışları ise, kasıtlı olarak uçuş prosedürlerinden sapma davranışlarını kapsar.

PDE-R, güvenilirlik açısından iyi sonuçlar sunmuştur. Faktörlerin Cronbach's alpha katsayıları .70 ve üzeri değerlerde bulunmuş, test-tekrar test güvenilirliği ise bir ay sonra yapılan testte .75 ve üzeri korelasyonlar göstermiştir. Bu sonuçlar, aracın güvenilirliğini destekler.

Geçerlilik açısından, EKY-YÖ ile yapılan karşılaştırmalar PDE-R'nin EKY yetkinliklerinden farklı bir yapıyı ölçtüğünü göstermektedir. İki araç arasındaki düşük ila orta düzeydeki negatif korelasyonlar, her iki aracın farklı yapıları ölçtüğünü ve PDE-R'nin pilotların emniyetsiz davranışlarını EKY yetkinliklerinden ayırt etme konusunda etkili olduğunu kanıtlamaktadır.

Sonuç olarak, revize edilmiş PDE-R, ticari havayolu pilotlarının emniyetsiz davranışlarını ölçmek için güvenilir ve geçerli bir araç olarak ortaya çıkmıştır. Bu revize versiyon, daha fazla maddeden oluştuğu için önceki versiyona göre daha geniş bir davranış örneği sunmaktadır ve pilotların uçuş sırasındaki emniyetsiz davranışlarını daha etkili bir şekilde değerlendirmektedir.

Hiyerarşik Regresyon Analizi Sonuçlarının Değerlendirilmesi

Bu çalışma, ticari havayolu pilotlarında kişilik özelliklerinin emniyetsiz davranışlarla olan ilişkisini incelemiştir. Çalışmada, pilotların beceriye dayalı hatalar, karar hataları, hafıza hataları ve prosedürlere uymama davranışı gibi dört tür emniyetsiz davranışla kişilik özelliklerinin ilişkisi ele alınmıştır. Elde edilen bulgular, kişilik özelliklerinin bu emniyetsiz davranışlarla anlamlı ilişkiler gösterdiğini ortaya koymuştur.

İlk olarak, nevrotiklik tüm emniyetsiz davranış faktörleriyle pozitif bir ilişki göstermiştir. Yani, yüksek nevrotiklik sahip pilotlar, beceriye dayalı hatalar, karar hataları, hafıza hataları ve prosedürlere uymam davranışları gibi daha fazla emniyetsiz davranış raporlamışlardır. Bu bulgu, literatürdeki önceki çalışmalarla uyumludur ve nevrotiklik, kaygı, sabırsızlık ve endişe gibi özelliklerle ilişkilendirildiği belirtilmektedir (Gençöz & Öncül, 2012; McCrae, 2010). Yüksek nevrotiklik sahip bireyler, stresli durumları daha fazla algılar ve bu durum, bilişsel süreçlerde aksamalara yol açarak hataların artmasına neden olabilir (Mohiyeddini et al., 2015; Schneider, 2004). Uçuş operasyonları, doğal olarak stresli durumlar içerdiği için, nevrotikliği yüksek pilotlar, bu stresle daha fazla başa çıkmakta zorluk çekebilirler.

Deneyime açıklık ise beceriye dayalı hatalarla negatif bir ilişki göstermiştir. Bu bulgu, sürüş bağlamındaki araştırmalarla çelişmektedir; o araştırmalarda yüksek deneyime açıklık, daha fazla kural ihlaliyle ilişkilendirilmiştir (Hussain et al., 2020; Wei et al., 2021). Ancak havacılıkta, yüksek deneyime açıklık düzeyine sahip pilotlar, uçuş becerilerinde daha fazla kendine güven duyarlar ve bu güven, beceriye dayalı hataların azalmasına yol açar. Pilotlar, uçuşa dair birçok farklı durumu öğrenip tekrar ederler, bu nedenle kendine güven duyan pilotlar, uygun davranışları seçerek hatalardan kaçınabilirler.

Olumsuz değerlik ise hafıza hatalarıyla negatif bir ilişki göstermiştir. Bu, literatürde beklenmedik bir bulgudur çünkü Olumsuz değerlik, genellikle kaygı, sinirlilik ve stresle ilişkilendirilir (Gençöz & Öncül, 2012). Ancak bu çalışma, yüksek olumsuz değerliliğe sahip pilotların, daha az hafıza hatası yaptığını ortaya koymuştur. Bu durum, yüksek olumsuz değerliliğe sahip kişilerin daha fazla kaygı hissettiği ve duygusal başa çıkma stratejileri kullandığı, bu sayede duygusal düzenlemelerini daha iyi yaparak, bilişsel süreçlerini (örneğin hafızayı) daha iyi yönetebildikleri anlamına gelebilir.

Sorumluluk ise prosedürlere uymama davranışları ile negatif bir ilişki göstermiştir. Yani, yüksek sorumluluğa sahip pilotlar, prosedürlere ve düzenlemelere daha çok uyum sağlamakta ve daha az prosedür dışı uyumsuzluk sergilemektedir. Bu bulgu, önceki sürücü örneklemleriyle uyumludur (Tinella et al., 2022). Yüksek sorumluluk düzeyine sahip pilotlar, emniyeti daha fazla ön planda tutar ve prosedürleri takip etme eğilimindedirler. Bu pilotlar, uçuş emniyeti konusunda daha dikkatli ve sorumlu olduklarından, kurallara ve prosedürlere uyum gösterirler.

Dışadönüklük ve ulaşabilirlik ise bu emniyetsiz davranış faktörleriyle anlamlı bir ilişki göstermemiştir. Sürücülerde, yüksek dışadönüklük ve düşük hoşgörü seviyelerinin daha fazla emniyetsiz davranışla ilişkilendirildiği bulgulara rastlanmış olsa da (Hussain et al., 2020; Tinella et al., 2022), bu çalışmada dışadönüklük ve hoşgörünün pilotlardaki emniyetsiz davranışlarla anlamlı bir ilişkisi bulunmamıştır. Bunun nedeni, dışadönüklük ve hoşgörünün daha çok kişilerarası davranışlarla ilişkili olabileceğidir. Örneğin, dışadönük ve hoşgörülü pilotlar, ekip içi iletişimde daha etkili olabilir, bilgi paylaşımı ve iş birliği yapabilirler. Bu da emniyetli uçuş için önemli olan etkin EKY yetkinlikleriyle ilişkilendirilebilir. Gerçekten de dışadönüklük ve hoşgörü, EKY-YÖ boyutlarıyla pozitif bir ilişki göstermiştir, bu da bu kişilik özelliklerinin etkin EKY yetkinlikleriyle bağlantılı olabileceğini gösterir.

Sonuç olarak, bu çalışma, kişilik özelliklerinin ticari havayolu pilotlarında emniyetsiz davranışları öngörmedeki önemli rolünü vurgulamaktadır. Özellikle nevrotikliğin ve deneyime açıklığın beceriye dayalı hatalar, nevrotikliğin karar hataları, nevrotikliğin ve olumsuz değerliliğin hafıza hataları, nevrotikliğin ve sorumluluğun ise prosedürlere uymama davranışları üzerindeki etkilerini ortaya koymuştur. Ayrıca, bu çalışma, olumsuz değerliliğin emniyetsiz davranışlarla ilişkilendirilmesi üzerine yapılan ilk çalışmalardan biridir ve bu konuda gelecekte yapılacak araştırmalar için önemli bir temel oluşturmaktadır.

Yorgunluk semptomları açısından bakıldığında ise zihinsel yorgunluk, duygusal yorgunluk ve genel yorgunluk semptomlarının, ticari havacılıkta pilotların raporladığı emniyet ihlalleri ve hatalar üzerindeki etkilerini incelemiştir. Sonuçlar, zihinsel yorgunluğun, beceri temelli hatalar, karar hataları ve hafıza hatalarıyla pozitif bir ilişki gösterdiğini ortaya koymuştur. Bu, literatürde yorgunluğun bilişsel yetenekler üzerinde olumsuz etkiler yarattığına dair birçok çalışmanın bulgularıyla uyumludur. Yorgunluk, psikomotor yeteneklerde bozulmalara, görsel performansın düşüşüne, dikkat eksikliğine, çalışma belleği kapasitesinin azalmasına, bilgi işleme hızının ve kalitesinin düşmesine ve akıl yürütme yeteneğinde bozulmalara yol açmaktadır (Jackson vd.., 2011; Killgore vd.., 2009; Linde & Bergström, 1992). Ticari havayolu pilotları, uzun uçuş saatleri, sık zaman dilimi değişiklikleri ve sınırlı uyku süresi gibi faktörler nedeniyle yorgunluk semptomlarıyla sıkça karşılaşmaktadır (Caldwell, 2012; Gawron, 2016). Bu nedenle, zihinsel yorgunluğu yüksek olan pilotların bilişsel yeteneklerindeki bozulmalar nedeniyle daha fazla hata yapmaları beklenmektedir.

Duygusal yorgunluk da karar hataları ve prosedürlere uymama davranışları ile pozitif bir ilişki göstermiştir. Duygusal yorgunluk, kronik duygusal tükenmişlik ve depresif hislerle karakterizedir ve bu durum sürekli dikkat kaybına yol açabilir (Linden vd., 2005; Orena vd., 2013; Österberg vd., 2009). Bu durum, pilotların kritik bilgileri algılamada zorluk yaşamasına, dolayısıyla hatalı kararlar almasına neden olabilir. Ayrıca, duygusal tükenmişliğin, emniyet motivasyonu ve emniyet uyumuyla negatif ilişkili olduğu da literatürde yer almaktadır (Chen & Li, 2020; Liu vd., 2024). Bu da duygusal yorgunluk yaşayan pilotların emniyet prosedürlerine uymada azalma yaşadığını ve bu nedenle daha fazla prosedürlere uymam davranışı sergileyebileceğini gösterir.

Bununla birlikte, genel yorgunluk semptomlarının hafiza hatalarıyla negatif bir ilişki gösterdiği bulunmuştur. Genellikle, yorgunluk semptomları yaşayan bireylerin hafıza hataları yapma olasılığı yüksektir çünkü yorgunluk bilişsel işlevlerde azalmaya yol açar (Neri vd., 1992; Smith vd., 2002; Tyagi vd., 2009). Ancak, ticari havacılıkta pilotlar, bu literatürle ters bir eğilim göstermiştir. Pilotlar, yorgunluk semptomlarını (örneğin, bitkinlik ve tükenmişlik) daha iyi algılayabilir ve bu durumlarda uygun prosedürleri uygulamak için kontrol listelerini takip etme eğiliminde olabilirler. Bu nedenle, genel yorgunluk semptomları yüksek olan pilotlar, hafıza hatalarından daha az etkilenmiş olabilirler. Bu ilişki hakkında daha fazla bilgi edinmek için gelecekte yapılacak çalışmalar önemlidir.

Sonuç olarak, bu çalışma, zihinsel ve duygusal yorgunluğun ticari havacılıkta emniyet ihlallerine ve hatalara olan etkisini vurgulamaktadır. Ayrıca, genel yorgunluk semptomlarının hafıza hatalarıyla olan negatif ilişkisi, gelecekte yapılacak çalışmalarda daha ayrıntılı olarak incelenmesi gereken ilginç bir bulgu sunmaktadır. Duygusal yorgunluğun, karar hataları ve prosedürlere uymama davranışları üzerinde öngörücü bir etkisi olduğu da bu çalışmada vurgulanmaktadır.

Bu çalışma, kurum emniyet iklimi boyutlarını, kontrol değişkenleri, kişilik faktörleri ve yorgunluk semptomları sonrasında modele dahil etmiştir. Kontrol değişkenleri, kişilik faktörleri ve yorgunluk semptomları ile açıklanan varyans dışarıda bırakıldığında, kurum emniyet iklimi boyutlarının, ticari havayolu pilotlarının gerçekleştirdiği emniyetsiz davranışların hiçbiriyle anlamlı bir ilişki göstermediği bulunmuştur. Literatürde, pozitif bir emniyet ikliminin sürücülerdeki hata ve ihlallerle negatif bir ilişki içinde olduğu belirtilmiştir (Chu vd., 2019; Öz vd., 2010, 2013; Şimşekoğlu & Nordfjærn, 2015; Zhang vd., 2018). Ancak, bu çalışmada, kurum emniyet iklimi ile pilotların emniyetsiz davranışları arasındaki ilişki desteklenememiştir. Bu durumun olası bir nedeni, pozitif bir emniyet ikliminin, ekip üyelerinin emniyeti önceliklendirme ve emniyeti artırmak için gerekli kaynakları sağlama algılarıyla ilişkili olmasıdır (Gao vd., 2013; Zohar, 2010). Havacılık psikolojisi literatürü de pozitif bir emniyet ikliminin, emniyet uyumu ve emniyet katılımı ile pozitif bir ilişki içinde olduğunu öne sürmüştür (Fernandes vd., 2018; Lin, 2012; Maneechaeye & Potipiroon, 2022a, 2022b; Xu vd., 2022).

Bu çalışmalarda ölçülen emniyet uyumu ve emniyet katılımı, kurallara ve prosedürlere uyum gösterme tutumları ve emniyet ile ilgili meselelerde (örneğin kaza bildirimleri) yer alma niyetleriyle ilgilidir. Kurumun emniyet iklimine yönelik olumlu tutumları olan pilotlar, emniyet kurallarına uyum sağlama ve emniyet ile ilgili meselelerde yer alma konularında olumlu tutumlar sergilemektedir. Bu bağlamda, EYK eğitimlerinin, emniyet uyumu ve katılımı geliştirmede önemli araçlar olduğu önerilmiştir (Reason, 1990; Shappell vd., 2007; Von Thaden vd., 2006).

Pozitif emniyet iklimi, emniyetin önemine dair ortak değerler, algılar ve inançlarla karakterize edilir ve EKY eğitim programları, bu ortak değerlerin, inançların ve algıların oluşturulmasında organizasyonlara yardımcı olabilir. Bu nedenle, etkili EKY eğitim programları, pilotların emniyet katılımı ve uyumu konusundaki tutumlarını ve niyetlerini geliştirmelerine yardımcı olabileceği gibi, mevcut tüm kaynakları etkin bir şekilde kullanmayı öğretme konusunda da önemli olabilir. Bu durum, organizasyonun emniyet iklimine yönelik olumlu tutumların, emniyetsiz davranışlar yerine etkili EKY uygulamalarında kendini gösterebileceğini göstermektedir. Bir başka deyişle, kurumun emniyet iklimine olumlu tutumları olan pilotlar, uçuş emniyetini sağlamak için mevcut tüm kaynakları kullanma konusunda daha istekli olabilirler. Ancak, bu olumlu tutumlar doğrudan emniyetsiz davranışların sıklığını azaltmada etkili olmayabilir. Sonuç olarak, bu tutumların EKY ile emniyetsiz davranışlar arasındaki ilişkiyi açıklayan olası bir aracılar olarak ele alınması, emniyetsiz davranışların doğrudan açıklayıcıları olarak ele alınmasından daha değerli bilgiler sunabilir.

Özetle, bu çalışma kurum emniyet ikliminin, ticari havayolu pilotlarının öz bildirimlerine dayalı emniyetsiz davranışlarını açıklamada anlamlı bir sonuç sağlamadığını göstermektedir. Ancak, bu bilgi, gelecekteki çalışmalar için kurum emniyet iklimi ile emniyetsiz davranışlar arasındaki olası alt mekanizmaları incelemek adına faydalı olabilir.

Bu çalışmada, kontrol değişkenleri, kişilik faktörleri, yorgunluk semptomları ve kurum emniyet iklimi faktörlerinden sonra EKY-YÖ boyutları modele dahil edilmiştir. Kontrol değişkenleri, kişilik, yorgunluk semptomları ve organizasyonel emniyet ikliminin emniyetsiz davranışlara etkisi dışarıda bırakıldığında, EKY-YÖ boyutlarının beceriye dayalı hatalar ve hafıza hataları ile anlamlı ilişkiler gösterdiği bulunmuştur.

Sonuçlar, yorgunluk ve iş yükü yönetiminin (YİY), beceriye dayalı hatalarla negatif ilişki içinde olduğunu göstermektedir. Yüksek YİY yetkinliklerine sahip pilotlar, düşük YİY yetkinliklerine sahip pilotlara göre daha az beceriye dayalı hata yapmaktadır. Bu durum, pilotların hem kendi yorgunluk semptomlarını hem de diğer ekip üyelerinin yükünü etkili bir şekilde yönetebilmelerine duydukları güveni yansıtmaktadır. Yorgunluk ve iş yükü yönetimi, pilotların yorgunluk ve iş yükü durumlarını gözlemleyerek ve buna göre hareket ederek, bu durumların sonuçlarını ortadan kaldırmalarını gerektirir. Literatürde, yorgunluğun bilişsel performans üzerindeki olumsuz etkileri açıkça belirtilmiştir (Killgore vd., 2009; Linde & Bergströme, 1992; Olaganathan vd., 2021; Quant, 1992; Roach vd., 2012; Tucker vd., 2010; Tyagi vd., 2009). Bilişsel performanstaki bozulma, teknik bilgilerin uçuş yönetimine uygulanmasını, otomasyon sistemlerinin ve değişen çevrenin izlenmesini, değişikliklerin tespit edilmesini ve uygun önlemlerin alınmasını etkileyebilir. Bu durum, beceriye dayalı hataların meydana gelmesine yol açabilir. Durum farkındalığı ve dikkatli olma düzeyinin yüksek olması, pilotların yorgunluk semptomlarının etkilerini yönetmelerine yardımcı olabilir ve dolayısıyla emniyetsiz davranışları azaltabilir.

Ayrıca, ekip içi iletişim ve iş birliği (Eİİ), hafıza hataları ile negatif ilişki göstermektedir. Yüksek Eİİ yetkinliklerine sahip pilotlar, düşük Eİİ yetkinliklerine sahip pilotlara göre daha az hafıza hatası yapmaktadır. Literatür, iletişim sorunlarının havacılık kazalarına önemli katkılarda bulunduğunu ve hataların meydana gelme olasılığını artırdığını göstermektedir (Alharasees vd., 2023; Brown & Rantz, 2010; Kanki, 2010; Mearns vd., 2001; Yıldız, 2024; Zieja vd., 2023). İyi iletişim ve iş birliği yetkinliklerine sahip pilotlar, uçuş operasyonları sırasında kritik bilgileri paylaşarak ve prosedürleri koordineli bir şekilde yerine getirerek hataları önleyebilirler.

Ancak, EKY-YÖ boyutlarının, karar hataları ve prosedür uyumsuzluğu ile anlamlı bir ilişkisi bulunmamıştır. Bunun birkaç olası nedeni vardır. Birincisi, kişilik faktörleri ve yorgunluk semptomlarının yüksek tahmin gücüdür. Bu faktörler, EKY-YÖ boyutlarından önce modele dahil edilmiştir ve sonuçlar, bu faktörlerin karar hataları ve prosedür uyumsuzluğundaki varyansı büyük ölçüde açıkladığını göstermektedir. Bu da EKY-YÖ boyutlarının tahmin gücünü düşürmüş olabilir. Diğer bir olasılık, örneklem büyüklüğüdür. Genel olarak, her bir açıklayıcı için yaklaşık 10 katılımcı gerekmektedir (Wilson Van Voorhis & Morgan, 2007). Bu çalışmada 21 açıklayıcı modele dahil edilmiştir, bu da örneklem büyüklüğünün 210 olması gerektiği anlamına gelmektedir. Küçük bir örneklem büyüklüğü, ilişkilerin tespit edilme olasılığını düşürebilir. Bu nedenle, gelecekteki çalışmaların daha büyük örneklem gruplarıyla EKY-YÖ boyutları ve karar hataları arasındaki ilişkiyi incelemesi önerilmektedir.

Sonuç olarak, bu çalışma, YİY ve Eİİ yetkinliklerinin, öz bildirime dayalı beceriye dayalı hatalar ve hafıza hatalarının sıklığı üzerindeki önemli rolünü vurgulamaktadır. Gelecekteki çalışmalar, EKY yetkinliklerinin ve bu yetkinliklerin emniyetsiz davranışlarla ilişkisini daha büyük örneklem gruplarıyla inceleyebilir.

Kurum Emniyet İklimi ve Yorgunluğun Aracı Rolünün Değerlendirilmesi

Bu çalışmada, Hayes Macro 4.0 kullanılarak yapılan meditasyon analizi, ticari havayolu pilotlarının kurum emniyet iklimi ve emniyetsiz davranışlarının aracılık rolünü incelemiştir. EKY boyutlarının açıklayıcı, PDÖ boyutlarının ise açıklanan değişkenler olarak kullanıldığı on iki meditasyon analizi yapılmıştır. Bu analizlerin altısı anlamlı sonuçlar vermiş ve beceri temelli hatalar ile karar verme hataları anlamlı analizlerdeki açıklanan değişkenler olmuştur.

Sonuçlar, EKY boyutlarından yüksek yetkinlik seviyelerine sahip pilotların, kurum emniyet iklimine karşı olumlu tutumlar sergilediğini, daha düşük yorgunluk semptomları yaşadığını ve ayrıca daha az beceri temelli hata ve karar verme hatası yaptığını göstermiştir. Önceki çalışmalar, pozitif bir emniyet ikliminin, emniyet uyumu ve emniyet katılımı konusunda olumlu tutumlar ve niyetlerle ilişkili olduğunu ortaya koymuştur. EKY eğitim programlarının, emniyet ile ilgili ortak değerler, inançlar ve algılar oluşturarak emniyet uyumu ve katılımı konusunda tutumları ve niyetleri iyileştirmede önemli araçlar olduğu vurgulanmıştır.

EKY eğitim programları, pilotlara EKY yetkinliklerini öğretmeyi amaçladığı için, artan EKY yetkinlikleri, kurum emniyet iklimine yönelik olumlu değerlendirmelerle sonuçlanabilir. Hem yüksek EKY yetkinlik seviyeleri hem de kurum emniyet ikliminin olumlu değerlendirmeleri, emniyete öncelik verme tutumlarını vurgular; bu da yorgunluk farkındalığını artırma ve yorgunluk semptomlarını azaltmak için uygun önlemleri alma olasılığını artırabilir. Sonuçta, yorgunluk semptomlarındaki azalma, görsel tarama, dikkat eksiklikleri, bilgi işleme hız ve kalitesindeki azalmalar gibi bilişsel yeteneklerdeki düşüşün ortadan kaldırılmasına yol açabilir. Bu bilişsel yeteneklerdeki azalma, pilotların bilgi uygulamalarını yönetme ve emniyetli uçuşlar sağlama yeteneklerini artırarak beceri temelli hatalar ve karar hatalarını önlemeye yardımcı olabilir.

Meditasyon analizi, iki önemli sonuca ulaşmıştır. Birincisi, EKY-YÖ'nün tüm yetkinlik faktörlerinin, kurum emniyet iklimine yönelik olumlu tutumlar ve düşük yorgunluk semptomları ile birleştiğinde beceri temelli hatalar ve karar verme hatalarını yapmada rol oynadığını göstermiştir. Hiyerarşik regresyon analizinde bazı EKY-YÖ faktörlerinin beceri temelli hatalar ve karar verme hatalarıyla anlamlı bir ilişki göstermemesi, meditasyon analizinde anlamlı ilişkiler ortaya çıkarmıştır. Bu, EKY yetkinliklerinin, diğer emniyette kritik faktörlerle vurgulanarak, beceri temelli hatalar ve karar hatalarının azaltılmasındaki tahmin gücünün artırılabileceğini göstemektedir. Ayrıca, kurum emniyet iklimi ve yorgunluk semptomları, EKY-YÖ'nün tüm faktörleri ile beceri temelli hatalar ve karar verme hataları arasındaki ilişkide kısmi aracılık yapmaktadır. Bu, EKY yetkinliklerinin beceri temelli hatalar ve karar verme hataları üzerinde doğrudan bir tahmin gücüne sahip olduğunu göstermektedir.

İkinci önemli sonuç, beceri temelli hatalar ve karar hataları için anlamlı aracılıklar bulunmuş olmasıdır; bunlar havacılık kazalarının başlıca doğrudan nedenleridir. Bu sonuçlar, EKY eğitim programlarının nihai hedeflerine ulaşmadaki etkinliğini desteklemektedir. EKY eğitim programlarının nihai amacı, uçuş operasyonları sırasında insan hatalarını azaltmaktır. İlk başlatıldıklarından beri, EKY eğitim programları evrilmiş, gözden geçirilmiş ve kapsamları genişletilmiştir; ancak nihai hedef aynı kalmıştır. EKY yetkinliklerinin, beceri temelli hatalar ve karar verme hataları ile negatif ilişkili olduğu bildirilmesi, bu eğitim programlarının, kazaların başlıca nedenlerini azaltarak havacılık kazalarını azaltma beklenen sonuçlarını verdiğine dair bir kanıt sunmaktadır.

Bu çalışma, EKY yetkinliklerinin, kurum emniyet iklimine dair olumlu algılar ve düşük yorgunluk semptomları ile birleştiğinde, beceri temelli hatalar ve karar hatalarının sıklığını azaltma üzerindeki önemini vurgulamaktadır. Beceri temelli hatalar ve karar hataları, havacılık kazalarının başlıca nedenleri olduğundan, daha yüksek EKY yetkinlik seviyeleri, kurum emniyet iklimine dair olumlu algılar ve düşük yorgunluk semptomları, havacılık kazaları için koruyucu bir faktör olabilir.

Kişilik Özelliklerinin Düzenleyici Rolünün Belirlenmesi

Bu çalışmada, kişilik özelliklerinin, EKY-YÖ ve PDÖ arasındaki ilişki üzerindeki düzenleyici rolü incelenmiştir. Toplamda 72 moderasyon analizi yapılmış, burada EKY-YÖ faktörleri tahmin edici değişkenler, PDE-R faktörleri ise bağımlı değişkenler olarak kullanılmıştır. Bu analizlerden ikisi, prosedürel uyumsuzluk konusunda anlamlı sonuçlar ortaya koymuştur.

Sonuçlar, uçuş izleme ve yönetim yetkinlikleri (UİY) ile prosedürlere uymama davranışları arasındaki ilişkinin, nevrotiklik ile düzenlendiğini göstermektedir. Aynı şekilde, YİY ile prosedürlere uymama davranışları arasındaki ilişki de nevrotiklik tarafından düzenlendiği gösterilmiştir. Bu düzenleme, düşük nevrotizm seviyelerinde anlamlı olup, yüksek nevrotiklik seviyelerinde anlamlı bir etkisi bulunmamıştır. Bu sonuç, yüksek UİY ve YİY yetkinliklerine sahip pilotların, nevrotiktik seviyeleri düşükse daha az prosedürlere uymama davranışları sergilediğini göstermektedir. Orta ve yüksek nevrotizm seviyelerinde düzenleyici etkisi anlamlı bulunmamıştır. Bu durumun olası nedeni, nevrotikliğin karakteristiğiyle ilgili olabilir. Nevrotiklik, durum kaygısı ile ilişkili olabilir. Durum kaygısı, geçici bir duygusal durum olup, kaygı, sinirlilik ve sabırsızlık hissi ile tanımlanırken, özellik kaygısı ise durumlar arasında kararlı bir kaygı ve sinirlilik ile ilgilidir (Spielberger vd., 1970). Düşük nevrotiklik, özellikle acil durumlar gibi stresli durumlarda pilotlar için yapıcı bir rol oynayabilir. Çünkü acil durumlar, pilotların kaygılarını ve sinirliliklerini daha iyi kontrol etmelerini sağlayabilir. Bu da pilotların UİY ve YİY yetkinliklerine güvenmelerine yardımcı olarak, prosedürlere uymama davranışları yapmadan başarılı bir şekilde davranışları uygulamalarını sağlayabilir.

Ayrıca, pilotların genel nüfusa göre daha düşük nevrotiklik seviyelerine sahip oldukları belirtilmektedir (Chang vd., 2018; Chaparro vd., 2020; Glicksohn & Naor-Ziv, 2016). Ancak, ticari hava yolu pilotları arasında hala bireysel farklılıklar bulunmaktadır. Bu farklılıklar, durum kaygısı ile birleşerek prosedürlere uymama davranışları yapma riskini azaltıcı bir etki yaratmaktadır. Çalışmanın düzenleyici sonuçları, düşük nevrotikliğin yapıcı rolü hakkında bilgi sunmaktadır.

Önemli Notlar

Bu çalışmanın örneklemi, farklı organizasyonlardan aktif olarak uçan ticari hava yolu pilotlarından oluşmuştur. Veriler çevrimiçi olarak ve kartopu örnekleme yöntemiyle toplanmıştır. Pilotlara ulaşmak için maksimum çaba harcanmış olsa da sonuçların genellenebilirliği bir dezavantaj olabilir. Gelecek çalışmaların, bu çalışmanın sonuçlarını doğrulaması önerilmektedir. Anket paketi, farklı değişkenlere odaklanan 6 farklı ölçüm aracını içermektedir. Bu nedenle, pilotların tamamlaması için ortalama 45 dakika süren birçok soruyu yanıtlaması istenmiştir. Katılımcılara, ankete aynı IP adresinden erişirlerse devam edebilecekleri bildirilmiş olmasına rağmen, çoğu katılımcı anketi tek oturumda tamamlamayı tercih etmiştir. Bu da yanıtlar sırasında dikkat düzeylerinin düşmesine neden olmuş olabilir. Ayrıca, anketler öz-bildirime dayanmaktadır ve bu da sosyal olarak istenen yanıtlar verme eğilimini artırabilir (Yılmaz vd., 2022). Literatür, öz-bildirim anketlerinde sosyal olarak istenen yanıtlar verme eğiliminin anonimlik sağlandığında azalabileceğini önermektedir (Lajunen & Summala, 2003). Katılımcılara, ankete katılmadan önce, anket paketinin kişisel ve organizasyonel kimliklerine dair herhangi bir soru içermediği ve yanıtların tamamen anonim olarak tutulacağı açıkça belirtilmiştir. Ancak, yine de katılımcılar görüşlerini yansıtma konusunda tereddüt edebilirler. Gelecek çalışmalar, sosyal olarak istenen yanıtlar verme eğiliminden etkilenebilecek değişkenleri incelemek için daha objektif ölçümler kullanabilir.

Pratik Çıkarımlar

Bu çalışmanın bulguları, havacılık psikolojisi ve havacılık endüstrisi için önemli pratik uygulamalar sunmaktadır. EKY-YÖ ile pilotların EKY yetkinliklerini belirlemek ve geliştirilmesi gereken alanları ortaya koymak mümkündür. Bu ölçek, eğitim programlarının tasarlanması, pilotların gelişimini izleme ve kurumların emniyet iklimini değerlendirme açısından değerli bir araçtır. Ayrıca, PDE ölçeğinin revizyonu, pilotların emniyetsiz davranışlarının sıklığını belirleyerek bu davranışların azaltılmasına yönelik hedeflenmiş önlemler geliştirilmesine olanak sağlar. Bu ölçümler, bireysel pilot performansının izlenmesinin yanı sıra kurumların emniyet performansının da değerlendirilmesine yardımcı olabilir.

Bu çalışma, pilotların emniyetsiz davranışlarının belirleyicileri hakkında EKY yetkinlikleri, yorgunluk belirtileri, kişilik özellikleri ve organizasyonel güvenlik iklimi açısından değerli bilgiler sağlamaktadır. Farklı EKY yetkinlikleri ile farklı emniyetsiz davranış türleri arasındaki ilişkinin belirlenmesinin, bu tür davranışların azaltılmasına katkı sağlayacağı düşünülmektedir. Havayolu şirketleri, pilotlarının sergiledikleri emniyetsiz davranış türlerini belirleyerek, bu davranışlarla ilişkilendirilen EKY yetkinliklerini geliştirmeyi hedefleyebilir. Ayrıca, kişilik özellikleri ile emniyetsiz davranış türleri arasındaki ilişki, pilot alım süreçlerinde kişilik değerlendirmelerinin etkinliği hakkında bilgi verebilir. Pilotlar, kişilik değerlendirmeleri aracılığıyla belirli özelliklere göre işe alınırken, aralarındaki küçük varyasyonlar hala mevcut olabilir. Bu varyasyonlar, özellikle düzenlemelere uyumsuzluklar ve standart operasyon prosedürlerinde hatalar gibi emniyetsiz davranışlar sergileyerek kendini gösterebilir.

Mevcut çalışmanın bulguları, aynı zamanda, yorgunluk belirtilerinin emniyetsiz davranışların sıklığı üzerindeki kritik rolünü vurgulamaktadır. Belirli düzenlemeler, pilotların yorgunluklarını önlemek amacıyla minimum dinlenme sürelerini belirlemiştir. Örneğin, EASA, bir sonraki uçuş görevi öncesinde 12 saatlik minimum bir dinlenme süresi belirlemiştir. Bu süre, uçak park pozisyonuna gelip motor kapattığında başlamaktadır. Ancak, ulaşım süresi ve kişisel ihtiyaçların karşılanması gibi faktörler göz önünde bulundurulduğunda, bu minimum dinlenme süresi, yorgunluktan tam anlamıyla iyileşmek için yeterli olmayabilir ve zamanla biriken yorgunluk sorununa yol açabilir. Bu çalışmanın sonuçları, kurumların uçuş operasyonlarını planlarken bu hususları göz önünde bulundurması gerektiğini ve yorgunlukla ilgili emniyetsiz davranışları azaltmak için önlem alması gerektiğini gösterebilir.

Ayrıca, bu çalışmanın bulguları, organizasyonların daha pozitif ve proaktif bir güvenlik iklimi oluşturma konusunda nasıl ilerleyebileceğine dair değerli bilgiler sunmaktadır. Kurumsal emniyet iklimi ile pilotların emniyetsiz davranışları arasında doğrudan bir ilişki olmasa da emniyet ikliminin, yorgunlukla birlikte, CRM yetkinlikleri ile emniyetsiz davranışlar arasındaki ilişkideki aracılık rolü, kurumların emniyet iklimini geliştirerek emniyetsiz davranışları ve sonuç olarak uçuş emniyetini artırabileceklerini göstermektedir. Sonuç olarak, güçlü bir emniyet ikliminin geliştirilmesine öncelik veren kurumların, uçuş emniyetini artırma, daha iyi sonuçlar elde etme ve insan hatası ile ilişkili riskleri en aza indirme konusunda daha başarılı olabileceği söylenebilir.

Sonuç

Bu çalışma, havacılık psikolojisi alanına önemli katkılar sunmayı hedeflemiştir. EKY, pilot hatalarını önlemek ve azaltmak için kritik bir öneme sahiptir. Yıllar içinde gelişen EKY eğitim programları, ekip üyelerinin teknik olmayan becerilerini artırarak, tüm mevcut kaynakları etkili şekilde kullanmalarını sağlamayı amaçlamaktadır. Ancak, bu programların etkililiği üzerine çeşitli sorular bulunmaktadır. EKY becerilerini ve davranışlarını ölçmek için geliştirilen mevcut

araçlar, uzmanlık ve eğitim gerektiren gözlemci değerlendirmelerine dayanmaktadır. Bu nedenle, bu çalışma, EKY'yi ölçmek için kullanıcı dostu ve kolayca uygulanabilir bir ölçüm aracı geliştirmeyi amaçlamıştır. Bunun sonucunda, EKY Yetkinlikleri Ölçeği (EKY-YÖ) geliştirilmiş ve güvenilirliği ile geçerliliği doğrulanmıştır.
Ayrıca, ilk olarak geliştirilmiş Pilot Davranış Envanteri (PDÖ) gözden geçirilmiş ve ticari hava yolu pilotlarının emniyetsiz davranışlarını ölçmeye yönelik daha fazla örnek eklenmiştir. Bu PDE-R de güvenilir bir ölçüm aracı olarak değerlendirilmiştir. Bu durum, gelecekteki araştırmaların, emniyetsiz davranışların sıklığını ve olası altında yatan nedenleri incelemeleri için önemli bir fırsat sunmaktadır.

Çalışma ayrıca, kişilik özellikleri, yorgunluk belirtileri, kurum emniyet kültürü ve EKY yetkinliklerinin, emniyetsiz davranışların açıklayıcıları olup olmadığını incelemiştir. Yapılan analizler, bu faktörlerin emniyetsiz davranışlar üzerinde etkili olduğunu göstermektedir. Özellikle, yüksek EKY yetkinlikleri, pozitif kurum emniyet iklimine sahip olmak ve düşük yorgunluk belirtileri ile birlikte, uçuş kazalarının en yaygın nedenlerinden olan beceriye dayalı hatalar ve karar hatalarını azaltma potansiyeline sahiptir. Bu sonuçlar, EKY yetkinliklerinin emniyetsiz davranışları azaltmadaki önemini vurgulamaktadır.

Ayrıca, bu çalışmada kurum emniyet kültürü ve yorgunluk belirtilerinin, EKY yetkinlikleri ile emniyetsiz davranışlar arasındaki ilişkide aracılık rolü oynadığı bulunmuştur. Yüksek EKY yetkinliklerine sahip pilotların, pozitif bir emniyet iklimine sahip olduklarında ve yorgunluk belirtileri düşük olduğunda, emniyetsiz davranışları daha az sergilediği gözlemlenmiştir. Bu bulgu, kurum güvenlik ikliminin ve yorgunluğun bu ilişkiyi nasıl şekillendirebileceğine dair daha fazla araştırma yapılması gerektiğini ortaya koymaktadır.

Çalışma, ayrıca kişilik özelliklerinin EKY yetkinlikleri ile emniyetsiz davranışlar arasındaki ilişkide düzenleyici rolünü incelemiştir. Özellikle, nevrotikliğin UİY ve YİY ile prosedürlere uymama davranışları arasındaki ilişkide düzenleyici olarak rol oynadığı bulunmuştur. Bu bulgu, kişilik özelliklerinin, özellikle de nevrotikliğin, emniyetsiz davranışların yönetilmesinde önemli bir rol oynadığını göstermektedir. Nevrotikliği düşük olan pilotların, stresli durumlarla başa çıkmada daha başarılı olabileceği ve bu durumun emniyetsiz davranışları azaltabileceği düşünülmektedir.

Sonuç olarak, bu çalışma, EKY yetkinliklerinin ve emniyetsiz davranışların açıklayıcıları konusunda önemli bir anlayış geliştirmiştir. Ayrıca, kurum emniyet iklimi ve yorgunluk belirtilerinin aracılık rolü ve kişilik özelliklerinin düzenleyici etkisini inceleyerek, bu ilişkileri daha iyi anlamamıza olanak tanımaktadır. Bu çalışma, güvenilir ve geçerli ölçüm araçları geliştirmiş olup, gelecekteki araştırmalara EKY yetkinlikleri, emniyetsiz davranışlar ve bunlarla ilişkili faktörleri incelemek için değerli araçlar sunmaktadır.

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YAZARIN / AUTHOR

Soyadı / Surname : SERİN ATIŞ
Adı / Name : GİZEM
Bölümü / Department : Psikoloji / Psychology

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