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A Systematic Review of Literature Relating to the Relationship Between Physical Fatigue, Work Related Stress, Wellbeing and Safety Perception Amongst Maintenance Repair Organization Personnel In the Aviation Industry

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ABSTRACT

The primary focus of airline well-being interventions in relation to the management of crew fatigue and alertness little has been said about the areas of the well-being of maintenance personnel. The research study investigated the effect of physical fatigue, work-related stress, well-being, and safety perception among maintenance repair organizations MROs in Nigeria. We set out a study that intends to utilize cross-sectional survey design to survey three MROs and 119 Aircraft Maintenance personnel online. Our intention is to examine the effect of fatigue and work-related stress on mental health. This paper presents the study and research framework and reviewed relevant literature in the subject domain that are core and tangential to the study.

Keywords: Relationship, Physical Fatigue, Work Related Stress, Wellbeing, Safety Perception, Maintenance, Repair, Organization, Personnel, Nigeria, Aviation Industry

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1. INTRODUCTION

According to U.S. Reliability Center report, $300 billion are spent on plant maintenance and operation each year by the U.S. industry Latino (2018). It is estimated that approximately 80% of this is spent to correct the chronic failure of machines, systems, and human elements.

Annually, the cost of maintaining a jet aircraft is around $1.6 million, and approximately 11% of the total operating cost for an aircraft is spent on maintenance activities. Maintenance plays an important role in the aviation industry. In the absence of maintenance, most system parts deteriorate due to usage which results in wear and eventually failure of the part, which may compromise safety. Every organization requires maintenance to continue to ensure its operation most especially in an industry where the visible event that reflects the quality of service is an aviation event. However, the event that results in loss of life and or significant damage tends to get the most exposure to the public from the media industry.

Aircraft mechanics have the important responsibility of keeping the aircraft and its equipment working safely and efficiently. They service, repair, and overhaul various aircraft components and systems including the airframe, engines, electrical and hydraulic systems, propeller, avionics equipment, and aircraft instruments. In recent years, their work has changed greatly because of advances in computer technology, solid state electronics, and composite structural material. The aircraft mechanic employed by an airline performs either line maintenance work (for example routine maintenance, servicing or emergency repairs at airline terminal) or major repairs and periodic inspections at an airline overhaul base. The aircraft mechanic performs maintenance and repair jobs on small piston engines or large turbine-powered aircraft to airworthiness standards. Aviation maintenance occurs in a complex environment in which the mechanic performs various tasks that have time pressures, minimal feedback, and sometimes difficult conditions. These characteristics, in combination with the generic human tendency for error, will result in a variety of errors. Dhillon and Liu (2006).

Maintenance personnel workers work in continuously changing schedules making it difficult to maintain a regular healthy lifestyle routine. According to Pasha and Stakes (2018), work-related stress (WRS) affect the physical, social, and psychological health of aircraft maintenance workers and it has been indicated that they suffer from wellbeing issues (those relating to mental health). In addition, fatigue along with stress plays a vast role in the aviation industry and performance as ranked among the top five human factors issues in the environment years after year Lererman et al (2014).

According to Theophilus et al (2017) in the oil and gas sector it is estimated that up to 80% of the industrial accidents and incidents are due to human errors, for which fatigue was often partly responsible. Fatigue was also identified as a contributing factor within a shift working environment like the maintenance facility were employer have worked 12 hours shift working 29 consecutive days. With the usual work schedules in oil and gas environment operations are … periods in two guilt (day and night) has established that 12 hour shifts are not necessarily unfavorable when they are coupled with long work weeks and night work (Parthes (2012) also a common practice in MRO operation. Fatigue as a physiological state reduces the mental or physical performance capability of maintenance personnel. Accenting to (ICAO 2016) it can result from sleep loss, extended wake fullness, circadian phase, and mental or physical workload that impair, a person's alertness and ability to perform safety-related operational duties. In 2020 ICAO require aviation personnel particularly pilots, Engineers, and Air traffic Controllers (ATCO) to implement a fatigue risk management system that allows for a data-driven means of continuously monitoring and managing fatigue-related safety risk. In Reader, Paranel, and Kirwan (2016) study of safety culture amongst 7000 pilots in Europe 17% of the participant reported their well-being and 21% felt that fatigue was taken seriously within their organization.

Another study indicated that organizational wellness programmes created to promote healthy living habits have led to improvements in workers' health and job satisfaction. It is believed that interventions are required for MRO maintenance personnel, and airlines to take issues pertaining to WRS and fatigue, and its impact on maintenance personnel's well-being and safety outcomes is quite understood. In Nigeria, there has been little emphasis on understanding/identifying the relationship between WRS and fatigue and maintenance personnel wellbeing, and safety. This current study endeavors to examine the effect of fatigue and work stress on the safety and well-being of maintenance workers in MRO.

1.1 Statement of Problem

Following the requirement of ICAO that all aviation-related organization is required to implement a Fatigue Risk Management System (FRMS) in all areas from 2020 and beyond. MRO within Nigeria is not gathering information about work-related stress (WRS/Well-being issues and associated impacts on performance and safety. Along with the NCAA requirement that safety maintenance system (SMS) in MRO and Well-being threats are not identified in existing safety Management System. The existing SMS does not include specific processes for risk assessments in relation to WRS and impact on Wellbeing, and safety. With the SMS FRMS are not linked to the dimension of well-being and there is also the lack of a dedicated role/function with the airline or MRO to ensure the coordination and Management of Wellbeing. Support/Training programmes, safety promotion and intervention, and Management of risk partially to WRS and wellbeing. The specific problem is whether there is a relationship or effect, between work-related stress fatigue and wellness and safety for MRO personnel in Nigeria.

1.2 Purpose of Study

The purpose of the study was to determine the effect of work-related stress, and fatigue on the safety and well-being of MRO personnel.

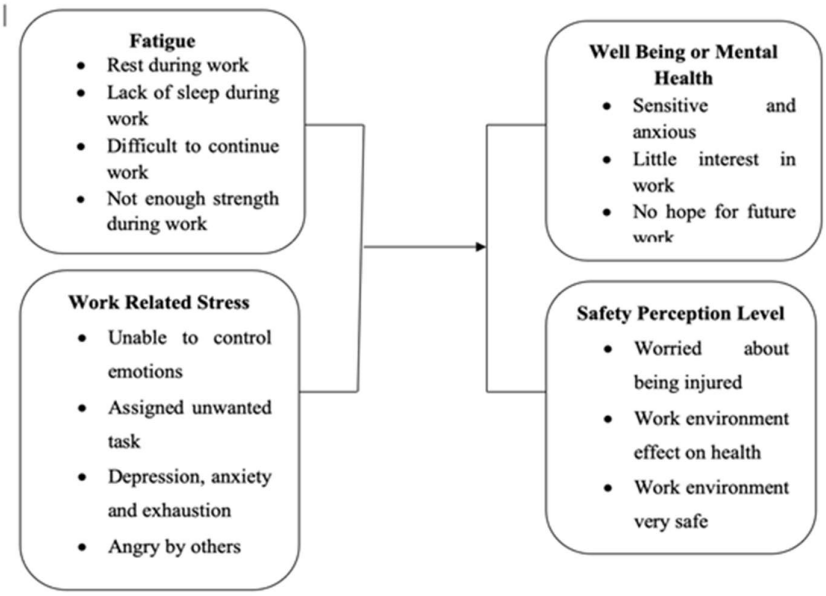

Figure 1 Conceptual Model

The independent variable is work-related stress and fatigue as measured by Kim, Yu, and Hyne (2022). Dependent varieties are well-being in the first case and safety perfective in the second case. While Well-being is measured by the Kim, Yu and Hymn (2002) and safety perfection is measured by Janssens Brett and Sueth (1995).

1.3 Study Objective

The main objective of the study is to examine the effect of physical fatigue and work-related stress on the wellbeing and Perception of the safety level of MRO workers in Nigeria Aviation.

Sub Objective

To examine the effect of fatigue and work-related stress on wellbeing
To examine the effect of fatigue and work-related stress on Perceived Safety Levels.

1.4 Research Question

This study will be guided by the following question.

(i) To what extent do physical fatigue and work-related stress affect Perceive Safety Levels?
(ii) To what extent do physical fatigue and work-related stress affect Well-being?

The study is considering two dependent variables in two cases Well-being and Perceived safety levels. The first dependent variable is Well-being is defined as an individual's emotional happiness, ability to live a creative life, and flexibility to cope with challenges encountered. In the process of life and Measured by Kim, Yu, and Hyne (2022).

Perceived Safety Level is defined as workers' perceptions regarding their MRO environment. Mensural by Janssens, Brett, and Smith (1995). The independent variables are physical fatigue and work-related stress is physical fatigue is defined as an experience in which daily life ability deteriorates due to exhaustion and is measured by Kim, Yu, and Hyne (2022). While work-related stress is defined as an experience in which daily life ability deteriorates due to exhaustion perceived discomfort anxiety and pressure measured by Kim, Yu, and Hyne (2022).

1.5 Significance of the Study

i. The research will add to the literature on well-being in the aviation industry in Nigeria.
ii. The research will help MRO managers and policymakers in the aviation industry to know the effect of stress and fatigue that affect safety and Well-being and how to better make policies that affect workers of MRO.
iii. The methodology of analysis will help to provide empirical evidence for factors of well-being and safety in MRO.

1.6 Scope of the Study

The scope of this research was limited to MRO workers currently operating in Nigeria Airlines that are willing to fill out the questionnaire.

2. LITERATURE REVIEW

2.1 Conceptual Literature

2.1.1 Concept of Stress

Stress has been viewed and defined from various themes. The stimulus-based theories define stress as the result of factors or elements that have a negative impact on the individual, for example, distracting noise or pressure at work. While the responding theories looked at the consequences of stress, such as various emotional and physical reactions. A further definition viewed stress from the development regarded stress as the interaction between demands and the resources available to the individual. When demands placed on an individual exceed his or her resources, stress develops. According to the Bio Psychosocial model that there exist a relationship between stress and health as shown in Figure 2.1.

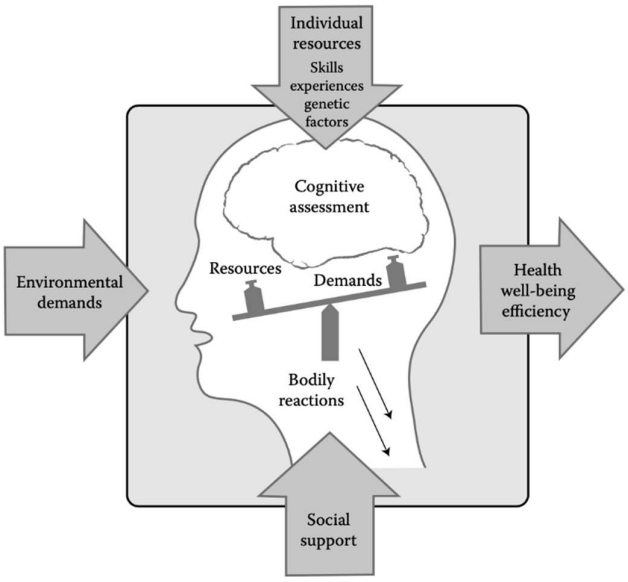

Figure 2.1.

In this model, the person is subjected to various demands, such as intense workloads, time constraints, shift work, experience, physical and mental health, personal abilities, and potentially, external support. If demand surpasses the person's resources, stress ensues, accompanied by both psychological and physiological reactions if the individual is exposed to these effects for an extended period of time. If a person is continually stressed or if there is not enough time to rest, the body is unable to normalize the physiological reactions in time for the next work session. Stress is also an unpleasant experience.

2.1.2 Conflict between Work and Private Life

Conflicts may arise from the interaction between work and private life. At the same time, having multiple roles can have positive aspects, such as increased self-confidence and greater financial freedom. There are several approaches to work-to-home conflicts. One is that time management becomes difficult, and it seems like there are not enough hours in the day. Another is that work causes stress and exhaustion, leading to the inability to engage in quality family time as much as one would like.

Several studies have described a connection between work-home conflicts and burnout (Mantinussen and Richardsen 2006; Mantinusses, Richardsen, and Burke 2007) and between work-home conflicts and reduced satisfaction with one's partnership, as well as reduced job satisfaction (Allen et al. 2000). Some studies have pointed to a so-called "crossover effect" between partners: Stress and tension experienced at work by one person are transferred to his or her partner, who subsequently has to deal with the stress by serving as a buffer (Westman and Etzion 1995). This transfer probably occurs because the person empathizes with his or her partner; however, a more direct effect is plausible because exhausted and frustrated partner, have "less to give" when they come home from work. That this can affect wellbeing and safety within the MRO domain.

According to a review provided by Orasanu (1997), stress may have the following effects:

- People make more errors
- Attention is reduced, causing tunnel vision or selective hearing
- Scanning (vision) becomes more chaotic
- Short-term memory is reduced
- Change of strategy; speed gains preference to accuracy. People act as though time limits apply. Strategies are simplified

All this have significant effect on safety and wellbeing.

2.2 Consequences of Stress

Stress has both short-term and long-term consequences. The following discusses an emergency situation and how this affects an individual in relation to job performance. A critical stress situation may arise when something unusual takes place during maintenance having time pressure. It is important to know typical reactions in such situations, be aware of how the MRO personnel responds to stress, and understand how it affects decisions made during the courses of maintenance.

It is difficult to measure how stress affects various cognitive functions. Ethical considerations are involved in exposing subjects to stressful situations in experiments to study how they react. A possible solution to this problem is to use a simulator to study how people handle various abnormal situations.

2.3 Pilot Work-Related Stress

Commercial aviation is a 24/7 business. The traveling public expects low-cost tickets and flexible flight schedules. This puts pressure on the operation (including flight scheduling and crew rostering) and has an impact for pilots. Pilot work anti-social hours and their working schedules are continuously changing. This can make it difficult to maintain regular 'healthy lifestyle' routines and access support and treatment.

Research indicates that sources of work-related stress (WRS) affect the physical, social, and psychological health of pilots. Recent studies demonstrate that pilots are suffering with same wellbeing issues as the general population (particularly those relating to mental health), and possibly to a larger extent (Pasha and Stokes 2018; Wu et al.2016). Overall, these studies have attempted to measure the prevalence of wellbeing issues (including mental health issues) and to understand the factors that contribute to this. However, these studies fall shorts in terms of providing a rich picture of the lived experience of pilots, and the complex relationship between individual wellbeing factors as conceptualized in the biopsychosocial approach (Engel 1977).

In addition, there has been little emphasis on understanding/identifying the following :(1) the relationship between WRS, pilot wellbeing, and safety, (2) how pilot adapt to WRS and associated coping/self-management techniques,(3) the role of other stakeholders (including airlines and the aviation authorities) in terms of supporting pilots and managing this problem, and (4) potential solution at different levels. This also need to be investigated among airline maintenance personnel.

2.4 Wellbeing and Mental Health

The term "wellbeing" includes various aspects of the way people feel about their lives, including jobs and their relationships with the people around them. Medical, psychological factors, and family and social factors including working conditions) are some of the determinations affecting a person's health and wellbeing (Engel 1977). None of these factors in isolation will definitively lead to wellness or illness. Rather, the interrelationships between all three pillars lead to a given outcome.

The World Health Organisation (WHO 2005) defines mental health as a state of wellbeing in which every individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community. A mental health illness generally means the presence a diagnosed psychiatric condition using an accepted diagnostic manual (WHO 2005). Mental ill health includes a spectrum of disorders, some of which can be deliberating and impact on a person's daily functioning (including their ability to work). The experience of distress and disability is closely associated with the definition of a mental disorder (Telles Correia et al. 2018).

The concept of mental well-being is linked to that of mental health. Mental well-being is defined as a dynamic state in which the individual is able to develop their potential, work productively and creatively, build strong and positive relationships with others, and contribute to their community. It is enhanced when an individual is able to fulfill their personal and social goals and achieve a sense of purpose in society (Foresight Programme 2008). Critically, certain MH illnesses such as anxiety and depression can have a negative impact on mental wellbeing. 'Mental well-being at work' is determined by the interaction between the working environment, the nature of the work, and the individual (NICE 2009). Work can have negative effects on mental health particularly in the form of stress. In relation to the management of mental well-being and common mental health problems, the National Institute for Health and Clinical Excellence (NICE) recommends a range of psychological therapies (referred to as the Stepped Care Model) to treat people with depression and anxiety disorders (NICE 2011). As depicted in Fig 2.2. Stepped CARE is a five-step system of delivering and monitoring treatments.

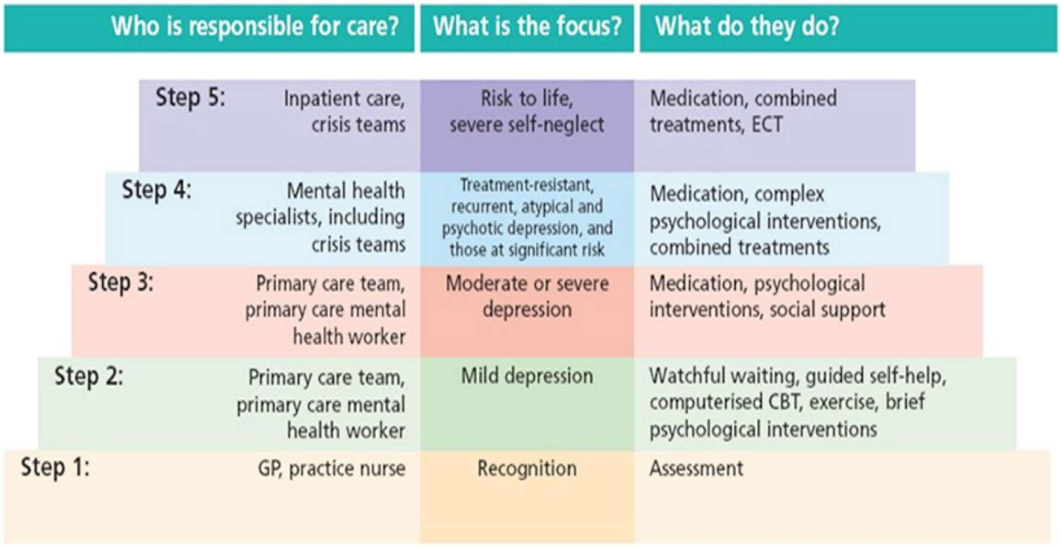

Figure 2.2.

2.5 Stress and Work-Related Stress

Stress is any experience or sensation that creates physiological, psychological, and behavioral imbalances within a person (Flinchbaugh et al. 2015; Houtman and Jettinghoff 2007; Lazarus 1990). Stress is not a medical condition. However, research shows that prolonged stress is linked to psychological conditions such as anxiety and depression, as well as physical conditions such as heart dieses, back pain, and headache (NICE 2019). Self-assessment scales are used to promote awareness in relation to stress, to determine the degree and type of stress that is being experienced, and to assess how well stress coping skills are working. These include the Perceived Stress Scale (Cohen, Kamarck and Mermelstein (1983) and the Ardell Wellness Stress Test (Ardell 1977).

Work-Related Stress (WRS) is defined as the response people may have when presented with work demands and pressures that are not matched to their knowledge and abilities, and which challenge their ability to cope (Leka, Griffiths and Cox 2003). Things outside the workplace, like family problems, or debt can be responsible for stress (personal stressor). A person experiencing stressful life events may find that he/she is less able to cope with the demands of work, even though work is not the cause and/or may not have been a problem before.

Workplace stress is becoming more prevalent across different occupations, including those working in 'high-stress occupations' such as nurses, paramedics, teachers, and firefighters. Around half of European workers consider stress to be common in their workplace, and it contributes to around half of all lost working days (European Agency for Safety and Health in Work 2019). Like many other issues surrounding mental health, stress is often misunderstood or stigmatized (European Agency for Safety and Health in Work 2019). Critically, individuals vary in relation to their ability to cope successfully with stress, including WRS. Stress coping is an important psychological construct that moderates/mediates the relationship between stressors and behavioral outcomes such as flying performance (Joseph 2016). Humans use either adaptive or maladaptive strategies to cope with stress.

The substitution of maladaptive coping with more adaptive coping is an important component of therapeutic interventions and prognoses. Monat and Lazarus (1991) define stress management as a general treatment approach, such as good nutrition and exercise, to a wide variety of adaptations and health problems.

Common stress coping strategies include exercise, the practice or relaxation techniques (i.e, deep breathing, yoga, and meditation), and seeking social support and/or social participation/engagement. The practice of healthy behaviours strengthens the person's resistance to stress (Marimoto and Shimada 2015). As such, stress management and the practice of healthy behaviours underpins wellness and a healthy life style. These include the Ways of Coping Questionnaire (WCQ) (Folkman and Lazarus 1988), the COPE Inventory (Carver Scheier and Weintraub 1989) and stress coping resources. Inventory (Matheny, Aycocle, Curlette and Junker 1993).

2.6 Pilot Mental Health

In a survey commissioned by the British airline pilots association (BALPA), Steptoe and Bostock (2011) found an increased incidence of, and a positive correlation between, reported symptoms of anxiety and depression and fatigue, and work patterns amongst a sample of commercial pilots in Brazil found the prevalence of pilots with common mental disorders (CMD), such as mixed anxiety and depression, to be 6.7% (Feijo, Luiz and Camara 2012).

A systematic review of aircraft-related suicide in the United States indicates that pilot suicide account for less than 1% of aircraft fatalities (Lewis, Whinnery and Webster 2014). Following the German Wings 9525 accident (2015), the issue of pilot suicide and detecting/managing increased attention. Research undertaken by Bor, Eriksen Dakes, and Scragg, (2017) suggests that common psychological problems in pilots include adjustment disorder, mood disorder, anxiety and occupational stress, relationship problems, sexual dysfunction, and alcohol problems.

In a recent large-scale survey of airline pilots, 12.6% of respondents met the threshold for experiencing depression in the last fortnight (Wu et al. 2016). Similarly, a systematic review of 20 studies examining depression in airline pilots found that the prevalence of airline pilots ranged from 1.9 to 12.6% (Pasha and Stokes 2018). As reported by Pasha and Stokes (2018), pilots experience several occupational stressors such as disrupted circadian rhythms and fatigue, which are recognized as being associated with the development of mood disorders.

2.7 Workplace Stress and Risk Assessment

The European Commission (EU) has introduced measures to ensure the safety and health of workers. The 1989 Council Directive (89/391) makes employers responsible for making sure that employees are not harmed by work, including through the effects of WRS (European Agency for Safety and Health in Work 2019). The Safety, Health and Welfare at Work Act (2005) requires employers to put in place systems of work which protect employees from hazards which could lead to mental or physical ill health. Risk assessment for stress involves the same basic principles and processes as for other workplace hazards. Risk pertaining to WRS must be addressed and managed using a risk assessment process, involving participation and consultation, and the application of the principles of prevention (European Agency for Safety and Health in Work 2019).

The hazards must be identified, the risks assessed, and control measures identified, implemented, and evaluated. Furthermore, the European Pact for Mental Health and Well-being recognises the changing demands and increasing pressures in the workplace and encourages employers to implement additional, voluntary measures to promote mental wellbeing (European Pact for Mental Health and Well-being 2008).

2.8 Wellbeing and Mental Health

Airlines follow existing guidance pertaining to the aero-medical assessment of pilots, as mandated by the regulatory authorities. The health of a commercial airline pilot is assessed annually. Licenses and flying privileges can be suspended if serious health problems (including MH issues) are detected. Given that their license is at stake, pilots are likely to underreport MH issues. Furthermore, pilots are not likely to approach aero-medical examiners for help. Currently, sources of WRS and wellbeing factors (spanning the three pillars of wellbeing) are not properly defined within existing airline safety management systems. As such, it is difficult to assess whether a particular safety event (for example, over-speed in landing) follows from an error linked to a well-being problem (which, in turn, can be attributed to a source of WRS), or a training deficit. Furthermore, there is no risk assessment in relation to WRS and well-being issues.

Presently, the primary focus of airline well-being interventions is in relation to the management of crew fatigue and alertness. The 'Fatigue Management Guide for Airlines Operators' specified by the International Air Transport Association (IATA), the International Civil Aviation Organisation (ICAO), and the International Federation of Airline Pilots Association (IFALPA) (2015) describe a science-based and operationally oriented fatigue management processes. Fatigue Risk Management Systems (FRMS) have been advanced by a number of airlines including EasyJet and Singapore Airlines (Skybrary 2019 a, b, c, d,). Typical, airline FRMS provides outputs to crew pairing/roistering and flight scheduling systems to ensure that risks pertaining to fatigue are managed from an operational perspective.

Operational reporting is a key component of any SMS (Cahill 2010). Currently, specific well-being/WRS issues using the existing SMS reporting system (i.e, voluntary and mandatory safety reporting tools). Anecdotally, it is known that pilots do not report wellbeing issues (including MH), using existing safety reporting systems. In terms of organizational structure, pilots can report issues to their head of flight operations and/or chief pilot. However, this is rarely done.

Airline CRM training addresses the socio-cognitive dimensions of task performance (for example, teamwork, briefing, and decision-making) and crew management of threats, to avoid errors and/or unacceptable aircraft states as outlined in the TEM model (Helmereic et al. 1999). Typically, airlines classify threats in relation to high-level taxonomies such as crew, aircraft, and the environment (Cahil 2010; Cahil, McDonald and Losa 2011), the crew state is conceived in relation to fatigue, situation awareness, and crew competency (i.e, training level and fight experience). Critically, the TEM model does not comprehensively address the crew state as conceived from a bio-psycho-social perspective. As part of CRM training, safety behaviors such as the performance of crew briefings and checklists at different flight phases (as mandated by EASA) are introduced. The impact of fatigue on alertness is also addressed. Stress management is also part of the CRM syllabus as defined by EASA (2017a, 2019).

As such, airlines must include general stress management training as part of their CRM syllabus. Specific stress management modules have been successfully implemented and positive outcomes realized (Moriarty 2015). However the guidance materials dose not explicitly mentions WRS, techniques for managing WRS/well-being issues, and stress coping behaviors while on and off duty. This includes issues related to the biological pillar (i.e., including both crew relation and the crew members' broader social relationships).

As reported by Joseph (2016), coping strategies relate to crew interaction styles and are of relevance to CRM. Specifically, coping is linked to how social and cognitive challenges in the aviation environment are handled and pertain to situational awareness and decision-making (Fornette et al. 2012) it should be noted that the EASA document 'Crew Resource Management in Practice" (2017a). However, the is no actual guidance pertaining to the implementation of such resilience and stress-coping training. Evidently, there is nothing preventing airlines from elaborating on EASA's guidance material.

Following CRM and TEM concepts, pilots follow strict procedures in terms of crew briefing at the pre-flight planning and briefing stage (Cahill 2010). However, existing airline briefing processes (linking to TEM constructs) do not address WRS/wellbeing issues. Moreover, specific pre-flight checklists (i.e standard operating procedures –SOP) do not include human factor checks in relation to crew well-being and the joint crew state (Cahill 2010). Such issues are understood by pilots to have a bearing on safety and should be raised in crew briefings (Cahill 2010; Cahill et al.2011), it could be argued that WRS is already addressed as part of pre-flights.That is, it is formalized in the duty/responsibility of the pilot to refuse to fly when he or she feels unfit to fly. Anecdotally, it is known that often fail to 'call in sick' given operational pressures. Furthermore, stigma in relation to MH can impact on a pilot's willingness to declare themselves as suffering.

2.9 Fatigue Risk Associated with Traffic Volume and ATCO's

Alertness

The word 'fatigue' is used widely in the field of human factors, yet it is rarely defined and can mean different things in different contexts. The word 'fatigue ' can refer to physical weariness, emotional exhaustion, the degradation of skill that results from performing a mentally demanding task over an extended period, chronic fatigue related to weeks of work without adequate rest, and finally, an unmet need for sleep. Sleepiness can occur for two related reasons. The first is sleep deprivation, the second is the effect of 24-hour rhythms on human performance. Recent research has shown that moderate sleep deprivation of the kind experienced by shift workers can produce effects very similar to those produced by alcohol.

After 18 hours of being awake, mental and physical performance on many tasks is affected as though the person had a blood alcohol concentration of 0.05 percent. Boring tasks that require a person to detect a rare problem, like some inspections jobs are most susceptible to fatigue effects hour circadian rhythms in human error, with many aspects of human performance being at a low ebb in the early hours of the morning. Memory and reaction time are at their worst at around 4 am and the chance of error is increased. There appears to be an increased risk of maintenance errors on night shifts. Dawson, and Reid. (1997).

It has been found that when maintenance technicians are experiencing sleepiness, they are at increased likelihood of errors involving failures to carry out intentions, such as memory lapses and perceptual errors. Sleepiness, however, seems to be less likely to lead to mistakes of thinking such as procedural misunderstandings. Hobbs, and Williamson. (2003).

Fatigue

Fatigue is a physiological state of reduced mental or physical performance capability resulting from sleep loss, extended wakefulness, circadian phase, and mental, or physical workload that can impair a person's alertness and ability to perform safety-related operational duties (ICAO, 2016). ATCOs suffer from fatigue during night shifts due to lower body temperature and circadian dysrhythmia (Tirilli, 2004). To improve aviation safety, the International Civil Aviation Organization (ICAO) requires Air Navigation Services Providers (ANSPs to implement Fatigue Risk Management Systems (FRMS) in 2020. An FRMS is a data-driven means of continuously monitoring and managing fatigue-related safety risks, based on scientific principles, knowledge, and operational experience, which aims to ensure that relevant personnel are performing at adequate levels of alertness (ICAO, 2016).

The U.S. National Transportation Safety Board has listed fatigue as one of its "most wanted" safety improvements continually since 1996. Extrapolating this to the wider aviation domain, means that all staff are valuable to the negative effects of fatigue and are generally the worst placed to identify the problem. Fatigue risk management has demonstrated potential in preventing operational errors, incidents, and accidents within flight operations in airlines for many years (Balkin, Horrey, Graeber, and Czeisler, 2011), but thus far has not been widely implemented in ANSPs Standardization of fatigue reporting tools and shared experiences should provide benefits across the aviation industry, enhancing the safety of operations based on shared learning and processes.

ANSPs will be able to have a better understanding of fatigue-related occurrences permitting them to develop effective fatigue mitigation strategies. The aims of this research are to evaluate air traffic controller officers' (ATCOs) operational flexibility, manage the risks related to fatigue, and improve ATCOs' safety performance based on guidelines from FRM.

Fatigue Risk Management Principles

In recent years, comprehensive fatigue risk management approaches have been adopted in aviation and road transport, supplementing, or in some cases replacing, older Hours of Service (HOS) approaches. Fatigue Risk Management Systems (FRMSs) have been promoted by the International Civil Aviation Organization (ICAO, 2008), the Federal Aviation Administration (2010), the European Aviation Safety Agency (EASA, 2009) the Civil Aviation Safety Authority of Australia (CASA, 2009a), and agencies in the road and rail transport industries Gertler, Popkin, Nelson & O'Neil, 2002). The FAA has defined FRMS as a data-driven and scientifically based process that allows for continuous monitoring and management of safety risks associated with a fatigue-related error. It is part of a repeating performance improvement process. This process leads to continuous safety enhancements by identifying and addressing fatigue factors…" (FAA, 2010, p. 3).

Fatigue risk management is an application of the Safety Management System (SMS) model, through which hazards are identified and risk is managed with a comprehensive approach

that extends beyond regulatory compliance (FAA, 2011a). FRMS can be integrated within an existing SMS or can be developed as a stand-alone system. The following principles can be found in the fatigue risk management literature:

- An FRMS requires a systemic approach, involving company policies, incident reporting, and analysis systems, proactive risk assessment, and the other elements of a general safety management system (Australian National Transport Commission, 2004; FAA, 2010; Transport Canada, 2007a, 2007d).
- Effective fatigue risk management requires a partnership between the employer and the employee, as each can contribute uniquely to solutions (Dawson, 2000; Fletcher, 2007; Transport Canada, 2007b, 2007c).
- It is unrealistic to aim for "zero fatigue" in all cases. An appropriate objective for fatigue risk management is to ensure that risks are as low as reasonably practical (Stewart & Holmes, 2008).

Most of the fatigue risk management approaches in the industry have been designed for continuous-control tasks such as driving a vehicle or operating an aircraft. In such tasks, one of the major fatigue-related threats is an unwanted sleep episode, in the form of either an extended period of sleep or a microsleep. In maintenance, falling asleep at work is not the main hazard created by fatigue. Rather, a fatigued maintainer is at increased risk of maintenance errors due to impaired mental functioning. This distinction, while seemingly trivial, has important implications for fatigue risk management in aviation maintenance.

3. CHARACTERISTICS OF MAINTENANCE WORK THAT CAN ASSIST WITH FATIGUE MANAGEMENT

Although maintenance personnel must contend with significant fatigue risks, some characteristics of aircraft maintenance provide opportunities to mitigate the hazards presented by fatigue. First, maintenance tasks tend to be self-paced rather than externally paced, as defined by Broadbent (1953). Although much maintenance work is performed under time pressure, a maintainer conscious of impaired performance may be able to pause a task, trade speed for accuracy, or repeat a step as necessary.

Second, in some cases, there are opportunities to modify methods of task performance in maintenance. In many cases, task cards can be modified, and error-capturing barriers such as secondary inspections or operational/ functional checks can be introduced. Third, maintenance organizations sometimes have the flexibility to choose the time at which certain tasks are performed. In such cases, it may be possible to schedule the most safety-critical tasks, or those most susceptible to fatigue, at times when fatigue will have the least impact. Finally, maintainers are rarely required to travel across time zones while on duty. Consequently, jet lag and travel-related circadian rhythm disruption, which are major considerations for flight crew FRMS, are not usually relevant in the maintenance environment. The exception is when maintainers must travel to a remote work site to perform a task. In summary, maintenance organizations face a unique set of fatigue-related challenges but also have access to a unique set of potential solutions. As a result, FRMS in maintenance can involve a wider range of countermeasures than comparable systems developed for flight crews or vehicle drivers.

3.1 Fatigue Mitigation for Safety Intervention

The interaction of lack of sleep and circadian factors can be especially troubling and circadian rhythms influence almost every aspect of performance Dongen and Dinges, 2005).

In general, the quality of performance follows the pattern of our internal body temperature (a standard marker of the biological clock) in that low body temperature (often observed between the hours of 03:00 and 05:00) is associated with lower alertness, slower reaction times, and poorer accuracy than periods of higher body temperature. ATCOs performing monotonous monitoring tasks cause the aversive experience of mental effort and depleted physical resources over time.

Compensating for these natural variations in body activation requires mental effort and controlled mental processing and attention. That resource might be only available for a short duration (Kurzban, Duckworth, Kable, and Myers, 2013) It is not surprising that night workers often perform more poorly than their daytime counterparts (Folkard and Tucker, 2003;). Alertness can vary in parallel with the circadian biological clock and sleep-wake cycle (Mulhall et al., 2019). Within a 24-hour period, the output of the circadian pacemaker and the drive for sleep interact to determine the level of alertness and performance (Borbély, Daan, Wirz-Justice, and Deboer, 2016). Furthermore, due to the influence of the circadian rhythm on alertness, the operator's performance can also vary from hour to hour and day to day. For example, driving performance can vary with the time of day, with performance becoming increasingly impaired during the early hours of the morning, around the time night shift workers are commuting home (Matthews et al., 2012).

Studies examining the benefits of napping, with naps from a matter of 30 seconds up to two hours, have indicated that benefits accrue to the person including maintaining cognitive performance as well as reducing sleepiness (Hartzler, 2014). Sleep loss may cause malfunctioning of arousal and activation. If this malfunctioning is not corrected by effort, there is a decrement in performance. Traditional explanations of the decrement in performance have addressed decreasing arousal and rising fatigue over time. The effects of time-on-task and time of test demonstrated that the effect of sleep loss is generally stronger during the afternoon and during the second session (between the 10th and 20th minutes), and sleep loss affects the strategy of allocating more attention resources to the most probable location by leveling the allocation priorities (Sanders and Reitsma, 1982).

Monotony on monitoring tasks requires compensation to stay awake. Therefore, a short break will relieve the mental effort so that it can recuperate over time. Appropriate breaks in aviation are recommended as effective in promoting fatigue recovery. Just 10 – 20 minutes of napping have demonstrated many positive effects on performance, alertness, health, and happiness. Allowing a 20 minutes power nap mid-shift will enhance memory, alertness, productivity, and creativity and will increase employees' ability to achieve optimum performance (Autumn, Monica, Jitendra, and Bharat, 2016). Several breaks under suitable circumstances with appropriate safeguards can help to ensure operational safety. However, handovers between controllers during shift change or for a break, for example, may increase the risk of occurrences. The break should be viewed as a fatigue risk management tool for ATCOs and the supervision of handovers for a break needs careful supervision within air traffic control units. Efforts are undertaken at many air traffic control units to reduce occurrences at these handover times which can be defined as the passing of control authority from one outgoing ATCO to another takeover ATCO (Euro-control, 2016; IAA, 2019). Based on the literature review, both traffic volume and ATCOs' fatigue levels have impacts on ATCOs' safety performance leading to occurrences. The specific definition of occurrence is any safety-related event that could endanger an aircraft, its occupants, or any other person and includes in particular an accident or serious incident. (Patriarca, Cioponea, Di Gravio,

and Licu, 2018). There is a need to investigate the relationship between traffic volume, occurrences, and fatigue to develop effective FRMS in air traffic management.

Table 1: Frequency and Percentage of Participants' Demographical Variables Consisted with Ages, Working Experience and Gender

	Category	Frequency	Percentage
Age	23 – 30	6	10.53
	31 – 40	17	29.82
	41 – 50	29	50.88
	Over 50	5	8.77
Gender	Male	47	82.46
	Female	10	17.54
Experience	1 - 10 years	26	39.39
	11 – 20 years	16	24.24
	21 – 30 years	12	18.18
	Over 30 years	4	6.06

(Patriartca, Cioponea, Di Gravio, and Licu, 2018).

There is a need to investigate3 the relationship between traffic volume, occurrences, and fatigue to develop effective FRMS in Air Traffic Management.

4. EXAMINING THE RELATIONSHIP OF HUMAN FACTORS INFLUENCE HUMAN

Physical Fatigue:

Fatigue is defined as a subjective feeling that exists at a point in a continuum and leads to complete exhaustion, which results from physical, mental, and emotional activities. It is an experience that negatively affects the stability of social, mental, and physical aspects of – and degrades one's ability to engage with – daily life. It also does not improve with rest.

In a study on aircraft maintenance personnel, the majority of respondents said that they made a mistake at work when they felt tired. In addition, according to a study by Camden et al., most serious safety-related accidents occurred at night, and the primary cause of the accident was fatigue. Moreover, aircraft mechanics who worked in shifts said they made more mistakes at work when they felt tired. Similarly, in a study on airline crew, the cabin crew who felt tired were negatively impacted at work, demonstrating poor attention and memory, poor response speed, and poor communication during work

Psychological Stress:

Stress refers to a state in which homeostasis is threatened; all situations or physical environments encountered on a daily basis can cause stress. Stress is sometimes affected by the external environment, but it is an experience of internally perceived negative emotions such as discomfort, anxiety, or pressure felt by an individual.
A study by Kerr et al. and another by Bashir and Ismail Ramay showed that stress had a negative effect on work performance. For instance, when pilots are exposed to high stress, they can make hasty decisions due to missing important points or failing to predict the next

step. The pilot's negative psychology and anxious mental state have been shown to cause unsafe behavior. These studies led us to propose the following hypothesis:

Mental Health:

Mental health refers to an individual's emotional happiness, ability to live a creative life, and flexibility to cope with the challenges encountered in the process of life, and is defined in terms of satisfaction or happiness. Jahoda suggested positive attitudes toward oneself, personal growth, autonomy, integration, adaptability, environmental mastery – including healthy interpersonal relationships – and true perception of reality as the fundamental categories of mental health.

5. CONCLUDING REMARKS

In a mental health study, it was found that mental health problems such as depression or anxiety appear more in people being treated due to work accidents. Through this study, the correlation between errors occurring during work and mental health can be inferred. In addition, in a human error study, it was found that a railway crew's efforts for mental health management had a positive effect on safe operations. Because efforts to improve mental health are correlated with the reduction of human errors, it can be inferred that human errors can negatively affect mental health. First, physical fatigue is defined as an experience in which daily life ability deteriorates due to exhaustion, and it is constructed using an equivalent interval scale of four questions derived from previous studies. Second, psychological stress is defined as an experience of negative emotions such as internally perceived discomfort, anxiety, and pressure, and is constructed using equivalent internal scales of our questions derived from previous studies. Mental health is defined as the ability to pursue emotional happiness and live a creative life in a harmonized state of emotional, psychological, and social happiness.

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