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SECURITY CONCERNS AND EFFECT OF SLEEPLESSNESS OF AIRLINE CREW MEMBERS

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DECLARATION

This is to certify that Ms. ***ANSHITA SINGH***, a student of MBA (Aviation Management), SAP ID **500066955** of UPES has successfully completed her dissertation report on ***"SECURITY CONCERNS AND EFFECT OF SLEEPLESSNESS OF AIRLINE CREW MEMBERS"***, under my supervision.

Further, I certify that the work is based on the investigation made, data collected and analysed by her and it has not been submitted in any other University or Institution for award of any degree. In my opinion it is fully adequate, in scope and utility, as a dissertation towards partial fulfillment for the award of degree of MBA.

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CHAPTER 1 INTRODUCTION

1.1 Introduction

The International Civil Aviation Organization (ICAO, 2011) characterizes fatigue as 'a physiological condition of diminished mental or physical execution capacity coming about because of sleep misfortune or expanded wakefulness, circadian stage, or workload (mental or potentially physical action) that can debilitate a crew member's sharpness and capacity to securely work an aircraft or perform wellbeing related obligations'. Historically, airline crew members fatigue has been managed through prescriptive regulatory limits on flight and duty times; including a 16- h flight time limit for non- stop flights in commercial aviation (Flight Safety Foundation, 2005). However, advances in aircraft technology now allow flights longer than 16 h, which have the potential to increase fatigue (particularly during approach and landing) if they lead to greater acute sleep loss, extended periods of wakefulness and/or greater accumulation of time- on- task fatigue. If longer flights cause greater fatigue, then additional time may be required for recovery sleep on layovers and when crew members return home, before their next trip.

The number of flight operations in which a single sector exceeds a scheduled flight time of 16 h is increasing with the greater range of new-generation aircraft and the commercial demand for nonstop services. These are defined as "ultra-long-range" (ULR) operations and require flight crew to be on duty for up to 22 h. These long duty periods have the potential to increase fatigue-related operational risk, particularly during safety critical phases of flight such as the approach and landing phase.

In previous studies of long-haul operations of less than 16 h duration, high levels of sleepiness have been frequently demonstrated through flight crew or observer notes and objective measures such as the occurrence of micro sleeps. Excessive sleepiness can also be inferred from the level of sleep loss experienced, duration of periods of wakefulness required, and the necessity for flight crew to function through the nadir of their circadian rhythm.

The primary method in place to address the fatigue-related risk in ULR operations is the use of augmented crew, which enables flight crew to rotate through crew rest facilities during scheduled rest breaks and use the opportunity to sleep. The effectiveness of in-flight rest breaks as a mitigation for extended wakefulness on ULR flights depends on the amount and quality of sleep that crew members are able to obtain during the flight.

Subjective reports indicate that sleeping on board the aircraft is more difficult than sleeping at home, and that sleep during flight is disturbed by a range of factors with the most frequently cited being noise, turbulence, and having "thoughts on the mind." In previous studies of long-haul flights of between 6.2-15 h duration, retrospective surveys and in-flight questionnaires indicate that the average amount of sleep obtained is relatively short, averaging between 2.2 and 2.4 h.

There is currently very little objective information on how long or how well crew members may be able to sleep during in-flight rest breaks and the factors that might influence this sleep. A limited number of previous studies have used polysomnography to record sleep during flight. Findings from these studies indicate that rest opportunities earlier in a flight result in less sleep than later rest opportunities and that, not surprisingly, sleep is influenced by the timing of the rest period in relation to circadian phase and duration of prior wakefulness

Devouring just about 33% of our lives, sleep is a crucial and complex segment which is essential for human functioning (Banks and Dinges 2007). As a result, sleep loss or sleep deprivation can significantly interfere with and impair cognitive, motor and physiological functioning (Scott et al. 2006; Waters and Bucks 2011). It can likewise adversely influence one's feelings and mind-set states. Sleep misfortune and sub consecutive fatigue are related with decreases in perception (Lieberman et al. 2002), impedances in execution in the working environment (Harrison and Horne 2000), more noteworthy error rates (Gander et al. 2014) and at last decreases in safety (Akerstedt, 2003). Sleep hardship can have an exceptionally inconvenient effect on regular exercises, increasing the likelihood of human-error related accidents. Sleep deprivation or disruption among these workers can have serious consequences as has been observed in several catastrophic incidents and accidents (Horne and Reyner 1995). For example, fatigue has been found to play a key role in well-known serious industrial events such as the Chernobyl (1986) and Three Mile Island (1979) nuclear power plant explosions, when the Exxon Valdez ran aground (1989), the Challenger space shuttle crash (1986) and the running aground of the Shen Neng on the Great Barrier Reef (2010) (Reason 1990). Any industry which operates 24-h activities is highly susceptible to human error as a result of sleep deprivation (MooreEde, 2003) such as the nursing, medical, mining, maritime, and transport industries.

On the off chance that an individual crew member is fatigued and hence bound to make errors, CRM can help alleviate the impacts of fatigue so the errors are made less oftentimes or are gotten rapidly before they lead to an expanded safety hazard. In particular, the act of CRM requires a crew member to screen other crew members, air ship robotic automation, and the general flight circumstance and to recognize any presumed errors with a verbal test that must be recognized. Such crew coordination rehearses have been appeared in observational concentrates to be successful in distinguishing, catching, and adjusting pilot errors because of fatigue (Thomas and Ferguson,; Thomas et al., 2006; Petrilli et al., 2007; Helm Reich and Foushee, 2010; 2010Foushee et al., 1986).

1.2 The Biological Clock, Sleep, and Performance

Biological rhythms align our body functions with the environment. The periods of these rhythms vary from less than a second (e.g. firing of neurons) to close to a month (e.g.

menstrual cycle). Because of the adaptation to the daily rotation of the earth and its accompanying light/dark cycle, the most common rhythms repeat approximately every 24 hours (Figueiro, White, 2013; Arendt, 2010). Within the human body, these circadian rhythms (circa=approximately, die=day) regulate multiple body systems (e.g. temperature, alertness, and hormone production), coordinated by the biological clock, which is situated in the suprachiasmatic nuclei (SCN) of the hypothalamus. Although circadian rhythms are generated endogenously, they are aligned by exogenous factors, ensuring synchronization with the environment (Figueiro, White, 2013; Arendt, 2010). Sunlight, received through the eye, is the most important time cue for the biological clock, directing us to sleep at night and to be active during the daytime. Other cues, such as physical exercise, social activities, and nutrition, have a synchronizing effect that is much weaker (Harrington, 2001; Arendt, 2010; Haus, Smolensky, 2006).

The increased health risk of workers exposed to irregular working hours is predominantly ascribed to disturbance of the biological clock (circadian disruption) (Figueiro, White, 2013; Arendt, 2010). Rotating between day and night shifts and travelling across time zones can both lead to a disturbance of the normal sleep/wake pattern and accompanying body functions. The biological clock attempts to adjust to the new sleep/wake pattern, but rarely reaches full adaptation because of its ability to adjust about 1.5 hour per day (Zee, Goldstein, 2010). Moreover, because peripheral organs have a rhythm of their own that can have another readjustment speed, the human body is not only out of phase with its environment, but it is internally desynchronized as well. These consequences induce digestive problems, fatigue, and sleep loss (Costa, 2003; Figueiro, White, 2013; Haus, Smolensky, 2006). The latter two, fatigue and sleep loss, are the most prominent effects of being exposed to irregular working hours, and vary depending on duty hours, work schedules, the number of time zones crossed, and individual tolerance (Zee, Goldstein, 2010; Åkerstedt, 2003; Sallinen, Kecklund, 2010). In addition, sleep can be disturbed as a result of noise or light or because of domestic and social responsibilities during the nonconventional sleeping times (Zee, Goldstein, 2010). The effects of sleep loss accumulate over time; several weeks with less than 6 hours of sleep may yield levels of fatigue that mimic total sleep deprivation (Åkerstedt, 2003). This can have detrimental effects on human performance and decision making, and might result in an increased number of errors and accidents (Arendt, 2010; Maislin, Mullington, Dinges, 2003; Folkard, Lombardi, Tucker, 2005).

1.3 Sleep and the Circadian Rhythm

Sleep performance plays a crucial role in our wellbeing as it is a biological need. It is therefore not surprising that rapid travel across time-zones can cause disruption to sleep patterns with implications for safety in aviation. Thus, as well as assessments of circadian phase (e.g. melatonin), circadian rhythm studies have also used behavioural assessments of jet lag such as sleep performance. Many studies (e.g. Lowden & Akerstedt, 1999) have used altered sleep parameters (objective and subjective) to represent the process of adaptation of the circadian rhythm following trans meridian travel.

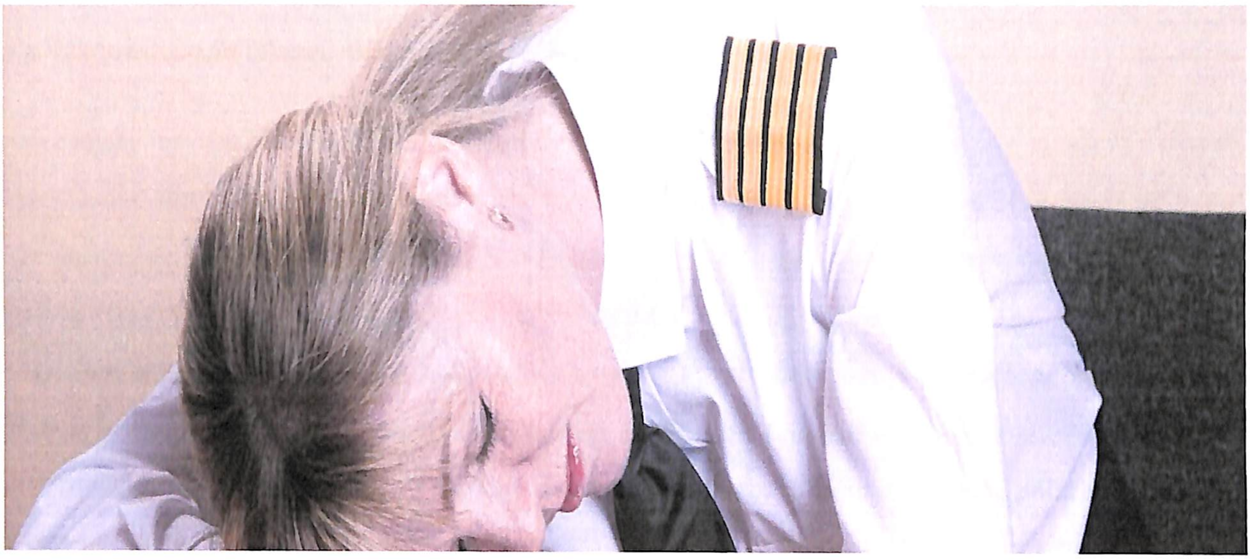
However, as sleep behaviour can be influenced by several factors other than a displaced body clock (e.g. cognition) sleep disruption alone may not be used as a marker of circadian desynchronise. Nevertheless, sleep disruption is the primary complaint of jet lag in the general population (Arendt, 2009; Waterhouse et al., 2000; 2002) and in long-haul cabin crew (Lowden & Akerstedt, 1999; Sharma & Srivastava, 2004). Both objective parameters such as displaced sleep times and subjective symptoms such as difficulty initiating, maintaining sleep and poor waking alertness are strongly associated with jet lag (Lowden & Akerstedt, 1999; Sharma & Schrivastava, 2000; Waterhouse et al., 2000; 2002; 2004).

One of the causes is that following Tran's meridian travel, adjusting sleep to the new local time is not favoured by the slow adapting circadian rhythm so that the two rhythms become uncoupled and sleep suboptimal. For example, following eastward travel, individuals may find it difficult to advance their sleep at a time of their circadian rhythm when BCT is high and melatonin low, properties that stimulate alertness. Conversely, sleep attempted on the rising phase of the BCT and falling phase of the melatonin is associated with more awakenings and shorter sleep (Lamond et al., 2003). The difficulty in advancing sleep is also due in part to directional asymmetry. The relationship between the sleep/wake cycle and the circadian rhythm is not unidirectional. Evidence suggests that the SCN regulates sleep through neural and hormonal pathways described earlier but sleep behaviour itself influences the SCN.

1.4 Behavioural Causes of Circadian Disruption: Sleep Disruption

The sleep wake/cycle and the endogenous circadian timing are closely related and both affect alertness levels and other physiological rhythms. There is also evidence that suggests that the sleep/wake cycle exerts influence on the SCN. For example, acute sleep loss (one bout of extended wakefulness) can directly influence neural activity in the SCN (Deboer, Detari, & Meijer, 2007) and longer consecutive hours awake affect the amplitude of circadian oscillation in performance. There is evidence that altered sleep patterns typical of shift work and jet lag can cause a reduction of melatonin levels. Burch et al. (2005) assessed melatonin levels in night, swing (day and night) and day workers post-work and post-sleep. They found that compared to day workers, night workers had altered melatonin excretion (45% lower), disrupted sleep, and greater symptom prevalence (e.g. feeling tired, sleepy, not alert). Subjects were also ranked on their sleep: work urinary 6-sulphatoxymelatonin ratio which is between 5 and 20 in day workers and close to one in non-day workers (Burch et al., 2005). In addition, workers with a ratio close to or less than one were 3.5 to 8 times more likely to experience symptoms (Burch et al., 2005). In a similar vein, Grajewski et al. (2003) assessed melatonin rates in cabin crew and teachers over a month and found that cabin crew experience increased circadian disruption, as measured by higher melatonin variability, than teachers. In addition, melatonin desynchronization was related to sleep displacement and number of time zones crossed.

Furthermore, Roach and colleagues (2002) found that habitual wake up times predicted melatonin DLMO at baseline in a study of simulated shift work. They also found that working nights significantly delayed the circadian rhythm possibly because of exposure to light. After seven nights of simulated shift work, a cumulative phase delays of 5.5 h (decimal time) was observed which corresponded to an average delay of 0.8 h (decimal) per day (Roach et al., 2002). Similarly, in a cross-sectional study, Papantoniou et al. (2014) demonstrated that night workers had lower levels of urinary melatonin compared to day workers and peak time occurred three hours later (08:42 h and 05:36 h respectively). In addition, phase delay was stronger among subjects with higher exposure to light at night and number of nights worked, indicating that behaviours such as exposure to light and disrupted sleep (e.g. night work) have important implications for circadian disruption. As chronic sleep disruption (e.g. sleep debt) associated with long-haul operations has serious implications for alertness and safety.



1.5 Function of Sleep

Sleep is defined as a state which is characterised by changes in brain wave activity which involve many areas of the nervous system and two different phases, NREM (Non-Rapid-eye-movement) and REM (Rapid-Eye-movement) sleep (Pressman & Orr, 1997). The function of sleep is not clear. However, different theories have been put forward. According to the restorative function (Horne, 1988), sleep may serve to restore the natural chemical balance in the nervous system. Evidence for this is that processing of information is impaired by lack of sleep as shown by sleep deprivation studies (Horne, 1998) and the secretion of sleep dependent hormones such as growth hormone involved in tissue synthesis and repair discussed earlier (Toates, 2002). The protective function rests on the notion that we are inactive at a time when we are most vulnerable (poor night vision) thus sleep increases our survival chances (Toates, 2002). According to the re-programming function, sleep serves to consolidate information in our memory (Toates, 2002). While the three processes may combine to explain sleep function, the restorative theory is the one that has implications for the wellbeing of long-haul cabin crew as chronic circadian disruption of the sleep/wake cycle as a result of jet lag leads to chronic sleep disturbances, daytime fatigue and reduced performance (Lowden & Akerstedt, 1999; Arendt et al., 2000; Waterhouse et al., 2000; Cho et al., 2000; 2001).

1.6 Regulation of Sleep, Wakefulness, Alertness and Performance

According to the Three-Process Model (Folkard, Akerstedt, Tucker, & Spencer, 1999), sleep/wake patterns are regulated by the homeostatic process (S) a circadian process (C) and the wake-up process (W). Process S represents the influence of habitual sleep/wake times which increases during wakefulness and decreases during sleep. Process C represents the circadian drive for sleep/wake determined by the SCN (independent of homeostatic process). Finally process W reflects sleep inertia, the feeling of sleepiness experienced on waking. Parameters are obtained from rated sleepiness after sleep/awake manipulations (visual analogue scale range 1 - 21, 3 = extreme sleepiness, 7 = sleepiness threshold, 14 = high alertness). Validity of the model was tested by laboratory studies as well as field studies using subjective alertness and EEG alpha and theta activity (typical of Stages 1 and 2 of sleep, Folkard et al., 1999). Overall, medium increased alpha activity was noted in subjected alertness below 7 (Folkard et al., 1999). The interaction of these three processes determines the timing of sleep and the degree of alertness, fatigue and performance. For example, from experimental studies Folkard et al. (1999) predicted sleep latency to start at around 0.5 minutes for the lowest level of predicted alertness (e.g. 1). Thus, sleep latency of more than 20 min is predicted by very high levels of predicted alertness (13 - 17). A refined estimation of process C (predicted from wake-up times) and other variables have increased the predictive power of the model in accounting for alertness on a variety of altered sleep/wake patterns (e.g. shift work) (Folkard et al., 1997). For example, the original model failed to predict the observed increase in accident risk over four successive night shifts (Knauth, 1995) as the model seemed to predict an increase in alertness as a result of the adjustment of process C (circadian component) over successive shifts. However, examination of alertness ratings in different night-shift patterns revealed a "first night compensatory effect" whereby subjects rated themselves more alert during the first night shift at the expense of the second night which had substantially lower ratings. A "time on shift" decline in alertness in subsequent night shifts was therefore noted and incorporated in the model. Despite the increase in predicted power, the model has two main limitations. The first relates to the notion that the phase of process C can be predicted by wake up time. While there is evidence that the circadian oscillator influences wakefulness more than sleep (i.e. spontaneous alertness early evening despite sleepless night) (Edgard, Dement and Fuller, 1993, p. 395), it is doubtful that wake times can reset process C as rapidly as proposed by the model, as evidence suggests that circadian adaptation to phase shifts is slower than wake up times (two to three days following westwards travel and four or more following eastwards travel, Cho et al., 2000; Arendt et al., 2000). Secondly, the model only predicts 60% of the rated alertness in shift work and between 25 - 96% of alertness in a sample of cabin crew (Suvanto, Harma, Ilmariner, & Partiner, 1993b) which suggests that there may be individual differences in the regulation of sleep related to genetic factors (e.g. age, whether subjects are "morning" or "evening" types, neuroticism), or the interaction between social/domestic factors and psychological factors (e.g. coping)

1.7 Characteristics of Sleep Propensity

There are three features of sleep propensity (sleepiness) that may help explain sleep problems and decreased alertness experienced in long-haul flying: the sleep gate, the forbidden zone and the mid-afternoon peak. The circadian rhythm (process C) affects sleep propensity, which means that sleepiness reaches its peak at night and is lowest during the day. Sleepiness increases in the late evening leading to a sleep gate, a window of opportunity where sleep is facilitated. This is associated with DLMO which further promotes sleep onset. It is worth noting that sleep onset latency (SOL) longer than 30 minutes is used in clinical settings to diagnose insomnia (Morin, 1993). As seen in the previous section, habitual sleep times (process S) also affect DLMO and sleepiness. Secondly, there is a forbidden zone for sleep whereby sleep propensity is very low in the early evening (usually between 18:00 h and 20:00 h), which ends at the opening of the sleep gate. Thirdly, there is a mid-afternoon peak in sleepiness (post-lunch dip in alertness). Of relevance is the notion of sleep consolidation (the ability to maintain sleep) which follows the rhythm of sleep propensity. That is, sleep consolidation has its peak after BCT minimum and starts to decrease as BCT increases until it reaches its nadir during the day. Sleep inertia (process W) refers to a feeling of confusion and cognitive dysfunction on awakening from sleep, especially deep sleep (SWS), during the night and following sleep deprivation, it can last up to two hours (Buysse, Barzansky, & Dinges, 2003). Thus, the ability to fall asleep, maintain sleep and feeling refreshed after sleep is the result of a fine balance between many processes.

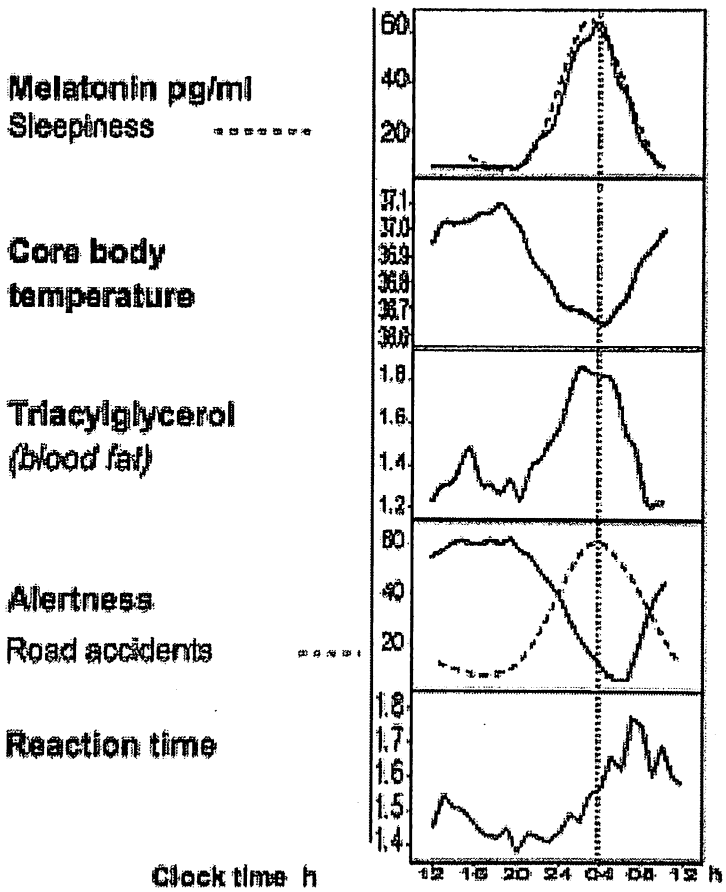


Figure shows that in entrained individuals alertness and performance reach their nadir at night during peak sleep propensity and fatigue and close to the low point of BCT and the peak of melatonin secretion. This explains why sleep that is attempted out of phase is shorter or split (e.g. five hours nocturnal and two, three hours diurnal) or difficult (e.g. missed sleep gate) and of poor quality and why the risk of accidents increases when working out of phase.

1.8 Problem Statement

Flight crew members are required to perform a number of physically demanding tasks. Many airline stewards report that they invest the vast majority of their flight energy in their feet. In any case, they are additionally tested emotionally, e.g., by necessities to play out various undertakings on a tight calendar, and by being the POC that all travellers look to for data, help, and backing. To put it plainly, one of the stressors of airline stewards is that they are consistently "on". Amassed sleep misfortune turns into a sleep obligation towards the finish of a week's worth of work, prompting expanded sleepiness (Roehrs, Carskadon, Dement, and Roth, 2000).

For long flights of over 8 hours, crew expansion, including a couple of extra crew members, can help moderate fatigue hazard especially when inflight rest offices, for example, bunks are accommodated crew members to sleep when they are not on obligation. Indeed, even on shorter flights, inquire about has indicated that short, controlled rests are an entrenched fatigue-alleviation system (Rosekind et al., 1994; Werfelman et al., 2009)

Given this situation, the fatigue and sporadic and long working hours (usually above eight hours per day) of pilots raises concern about the safety of air operations (Caldwell, 2005; Powell, Spencer, Holland, Broadbent, Petrie, 2007). The flights that start at dawn, those that end late at night, night flights, and the crossing of time zones change the sleep-wake cycle, the alert levels, and the decision-making of pilots during flights (Ingre, Leeuwen, Klemets, Ullvetter, Hough, Kecklund, et al. 2014). These factors can cause excessive sleepiness throughout the workday, which increases the propensity for unintentional sleep at work and risk of incidents or accidents at work (Caldwell, 2005; Goode, 2003). Ingre et al. (2014) have observed that unintentional sleep at work is a reflection of the work conditions and organization of pilots. The authors (Ingre et al. 2014) have also shown that unintentional sleep at work may compromise the safety of flights.

1.9 Objectives of the Study

- To study the effect of sleeplessness on airline crew members
- To study the various security issues emerged due to sleeplessness of airline crew members
- To investigate the level of sleeplessness among airline crew members
- To investigate the presence of any sleep disorders among airline crew members
- To find the solution for sleeplessness of airline crew members

CHAPTER 2 INDUSTRY PROFILE

2.1 Introduction

The civil aviation industry in India has developed as one of the quickest developing businesses in the nation during the most recent three years. India is as of now considered the third biggest domestic civil aviation in the world. India has become the third biggest domestic aviation advertise in the world and is relied upon to surpass UK to turn into the third biggest air passenger showcase by 2024

2.2 Market Size

India's passenger traffic developed at 16.52 percent year on year to arrive at 308.75 million in FY18. It developed at a CAGR of 12.72 percent during FY06-FY18.

Domestic passenger traffic developed YoY by 18.28 percent to arrive at 243 million in FY18 and is required to get 293.28 million in FY20E. International passenger developed YoY by 10.43 percent to arrive at 65.48 million in FY18 and traffic is relied upon to get 76 million in FY20E.

In FY18, domestic cargo traffic remained at 1,213.06 million tons, while international cargo traffic was at 2,143.97 million tons.

India's domestic and international aircraft developments became 7.93 percent YoY and 6.36 percent YoY to 2,153 thousand and 453.61 thousand during 2018-19, individually.

In FY19, passenger traffic in India remained at 344.70 million. Out of which domestic passenger traffic remained at 275.22 million while international traffic remained at 69.48 million. All out cargo traffic dealt with in India remained at 3.56 million tons during a similar time.

In FY19, domestic aircraft development remained at 2.15 million while international aircraft development remained at 0.45 million.

To oblige the rising air traffic, the Government of India has been moving in the direction of expanding the quantity of airports. As of now India has 103 operational airports in March 2019. India has imagined expanding the quantity of operational airports to 190-200 by FY40.

Further, the rising interest in the area has pushed the quantity of airplanes working in the segment. Starting at July 2018, there were about 620 aircraft being worked by scheduled airline administrators in India. The quantity of airplanes is relied upon to develop to 1,100 planes by 2027

2.3 Aviation Industry Employment Overview

A great many people associated with air transport work for the overall bunch of organizations that qualify as significant airlines. Most airline labourers are not pilots or professionals, two particular occupations that the advisory group was explicitly charged to ponder

Three particular aviation-related transportation occupations: airline pilots, aircraft mechanics, and plane design specialists. Pilots and experts are locked in vigorously despite the fact that not only in air transport; aeronautics designers are bound to work in aircraft fabricating. As well as can be expected decide from looking at data from changed sources, the airlines utilize among half and 66% of the people utilized as pilots and a littler extent of aircraft mechanics.

A significant explanation individuals are worried about ensuring that the aviation industry has the representatives it needs and that all people have equivalent access to employments in this industry is that aviation occupations are generally seen as steady employments—energizing, fulfilling, and, maybe generally significant of all, lucrative.

The airlines have been seen as paying high wages comes from the decreased motivators for cost control that existed under guideline. There is high pace of efficiency development.

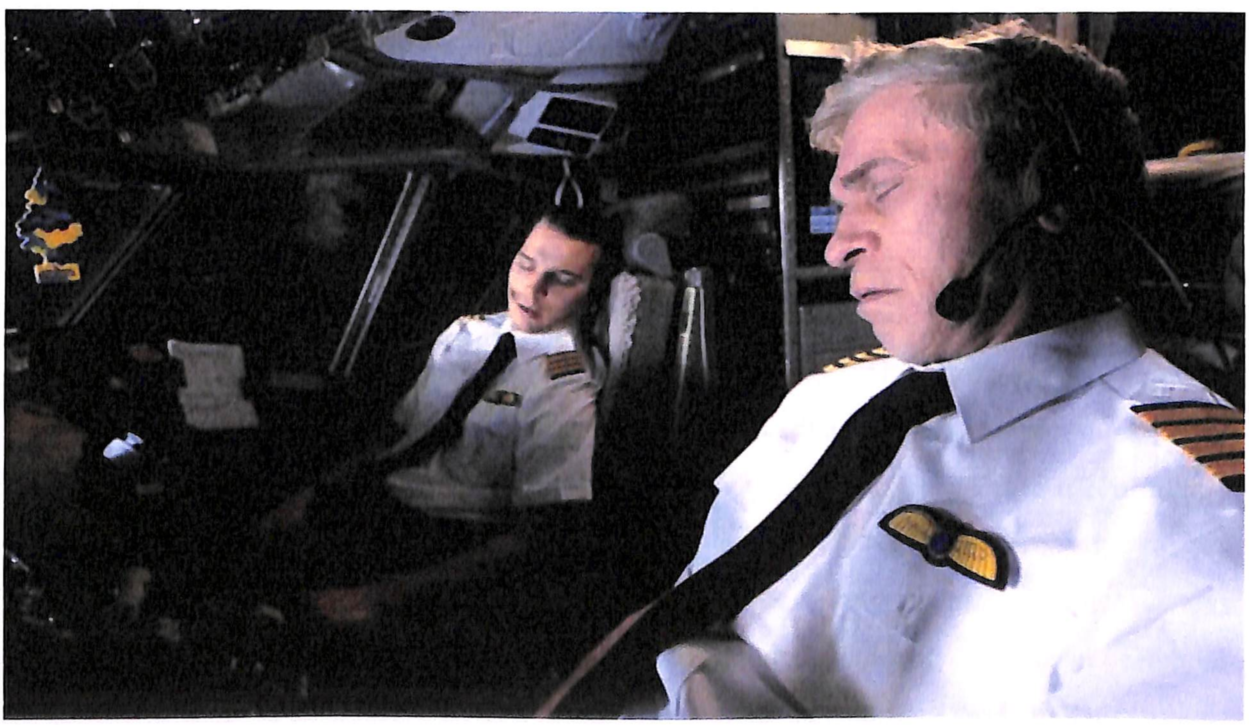
Deregulated rivalry has brought lower passages to passengers and has extended travel, however it has additionally put weight on the industry to change the terms and states of work. In the post-deregulation period, airlines are not obliged to charge similar tolls and are permitted to enter new markets, much of the time nearly voluntarily. There is presently a solid motivating force to diminish work costs and to utilize lower work costs as a focused device. In the event that an airline can bring down its work costs, it can charge lower passages in its current markets and go into new markets.

With the decrease in passengers, airlines that had not as of now been working proficiently either failed or came exceptionally near that. The organizations that endure were those that taken up some slack and cut expenses however much as could reasonably be expected. Low-charge bearers did similarly well during this troublesome time post-September 11, and for the individuals who needed to fly, both on business and for individual reasons, kept on buying tickets. The airline industry turned out to be increasingly proficient in general, since it had to do as such, and the long-term influences of this are very positive – higher benefits because of lower costs. Work remains its greatest expense, and for certain airlines, it's 40 percent of their general spending plan. Worker's organizations that speak to the different portions of aviation, including mechanics, pilots, flight chaperons, and others, have as of late been in savage dealings with airlines over representative advantages and pay rates. This will probably proceed for a long while.

CHAPTER 3 LITERATURE REVIEW

Introduction

An especially significant part of avionics safety improvement with the end goal of the advisory group's work has been the joint utilization of procedural, social, and technological frameworks to recognize crew errors on the flight deck and to encourage their remedy or relief. Such errors can come from an assortment of human factors including fatigue. One approach known to decrease dangers from errors is crewing asset the executives (CRM) (see Helmreich and Foushee, 2010). CRM preparing is commanded by the Federal Aviation Administration (FAA) for the pilots of all Part 121 administrators to encourage compelling crew correspondence, coordination, and the utilization of fitting assets to forestall error. This efficient preparing is intended to upgrade the capacity of crews to execute as a group so as to diminish the potential for human error and improve safety on the flight deck. Such preparing underscores the significance of correspondence and meeting with one another in regards to potential safety dangers (counting crew members' own fatigue state), overseeing such dangers, affirming moves being made, and cross-checking data from the two instruments and outer sources. The intention is to improve situational awareness, problem solving, and decision making.



Sleep deprivation and fatigue have been widely tested in the aviation industry using the Psychomotor Vigilance Task (PVT) developed by Dinges and Powell (1985) (see also Lim and Dinges 2008). PVT performance has been shown to consistently decline with reduced sleep (Dinges et al. 1997; Russoetal.2005). However, despite being considered the "gold standard" for measuring fatigue in an aviation context, much remains unknown about the task and what it measures with a paucity of findings highlighting its relationship with real-world tasks. Several measures may have promise, including the Profile of Mood States (POMS) (McNair et al. 1971) questionnaire, a rating scale used to evaluate transient, distinct mood states. This measure has been proven to be valid among healthy adult populations, has a high internal consistency and is sensitive to fatigue (Terry et al. 2003). Further, POMS may be able to help in the forecast of flight execution changes since Previc et al. (2009) discovered flying errors following 24–28 h consistent attentiveness crested in accordance with tops in abstract fatigue, controlled by the POMS

Truth be told, the work exercises of pilots are perplexing and require different skills, both technical and social ones. Among them we can make reference to the capacity to think, adapt to operational changes, work under pressure, work as a team, anticipate the consequences of a set of signals, and interpret these signals for fast decision making (Itani, 2009). With excessive sleepiness, some of these skills can be compromised, and with them, the safety of flights.

Expending right around 33% of our lives, sleep is a fundamental and complex segment which is basic for human working (Banks and Dinges 2007). Thus, sleep misfortune or sleep hardship can significantly meddle with and impair psychological, engine and physiological working (Scott et al. 2006; Waters and Bucks 2011). It can likewise adversely influence one's feelings and disposition states. Sleep misfortune and sub successive fatigue are related with decreases in cognizance (Lieberman et al. 2002), impairments in execution in the work environment (Harrison and Horne 2000), more noteworthy mistake rates (Gander et al. 2014) and at last decreases in wellbeing (Akerstedt, 2003). Sleep hardship can have a profoundly adverse effect on regular exercises, improving the probability of human-mistake related mishaps. Sleep deprivation or disruption among these workers can have serious consequences as has been observed in several catastrophic incidents and accidents (Horne and Reyner 1995). For example, fatigue has been found to play a key role in well-known serious industrial events such as the Chernobyl (1986) and Three Mile Island (1979) nuclear power plant explosions, when the Exxon Valdez ran aground (1989), the Challenger space shuttle crash (1986) and the running aground of the Shen Neng on the Great Barrier Reef (2010) (Reason 1990). Any industry which operates 24-h activities is highly susceptible to human error as a result of sleep deprivation (Moore Ede, 2003) such as the nursing, medical, mining, maritime, and transport industries.

One industry which has received relatively limited attention, despite the high risks at stake, is the commercial aviation industry. Commercial airline pilots are subjected to highly demanding, complex and stressful work environments, long duty periods and disrupted circadian rhythms as a result of round-the-clock operations – all key factors which add to administrator fatigue (Sadeghniiat-Haghighi and Yazdi 2015). Moreover, sleep disruption and fatigue are proposed to be overflowing among the business pilot populace with a 2012 review directed by the European Cockpit Association expressing that over half of pilots reported encountering fatigue levels which they found to impair their capacities while on obligation (European Cockpit Association 2012). Loss of sleep and fatigue are proposed as significant reasons for pilot blunder (Helmreich 2000). Furthermore, pilot fatigue has been on the U.S. National Transport Safety Board's Most Wanted Transportation Safety Improvements list since its inception in 1990 (National Transportation Safety Board 1990). From a flying performance perspective, as fatigue increases, accuracy and timing decline, attention narrows, reductions in performance are accepted and pilots abilities to integrate information from individual flight instruments into a significant overall pattern decreases (Caldwell and Caldwell 2003). Lapses or disregard for vital aspects of flight tasks ensue and reductions in ability to efficiently time share mental resources occur. Following 20–24 h continuous wakefulness, pilots' control of even basic flight parameters has been shown to significantly deteriorates (Previc et al. 2009). As result, it is imperative to better predict when operators are likely to experience fatigued-based reductions in performance utilising valid and reliable psychological and/or cognitive tests which are quick and easy-to-administer (Lopez et al. 2012).

A variety of studies have demonstrated significant reductions in performance on basic cognitive tasks in sleep-deprived and fatigued individuals (Dinges et al. 1997; Caldwell et al. 2003). According to Lopez et al., (2012) use of such tasks hold great promise as potential predictors of declining performance among sleep-deprived and fatigued individuals in real-world tasks such as driving long-haul trucks or flying an airplane. Nevertheless, the degree to which simple cognitive tasks can be utilised to predict reductions in performance in "real-world" tasks remains unclear, warranting further investigation. Prior research has found that physiological measures acquired from eye-tracking and electroencephalogram (EEG) tests are often difficult and expensive to implement in real-world environments. Furthermore, these measures do not appear to reliably predict sleep deprived and fatigued-related impairments or performance on criterion tasks (Caldwell et al. 2004). Even with greater reliability and validity, these measures still have little connection between the theoretical constructs underlying those assessments and errors in real-world tasks those assessments and errors in real-world tasks.

According to the International Civil Aviation Organisation's (ICAO) manual of evidence-based training, problem-solving and decision-making is a key construct required by pilots for safe and effective flight (ICAO Manual, 2013). Pilots can be required to innovatively respond to unique challenges, novel task demands and makes timely and correct decisions in chaotic situations (Adams 1993), without which the outcome could have catastrophic effects. Furthermore, during flight, pilots are required to conduct numerous tasks concurrently. For example, pilots must manage the status of the aircraft system and anticipate future tasks as well as conduct their primary tasks such as flying, navigation and communications. There may be the reason to believe that problem solving and multi-tasking may correlate well with flight performance during sleep deprivation and fatigue. Solving mathematical calculations has been employed in previous sleep deprivation and fatigue research have been found to indicate declines in problem-solving performance with increasing time awake (Thomas et al. 2000; Kaliyaperumal et al. 2017). Furthermore, divergent tasks such as multi-tasking and flexible thinking have consistently been found to be susceptible to loss of sleep and fatigue (Goel et al. 2009). General subjective capacity is viewed as the best indicator of pilot by and large execution (Olea and Ree 1994; McHenry et al. 1990; Ree et al. 1994). Also, fluid insight is related with the prefrontal cortex, as are official capacities, of which incorporate dissimilar reasoning and imagination and are especially defenceless against sleep hardship (Harrison and Horne 2000; Crisp and Meleady 2012). Regardless of whether these factors are identified with execution under states of sleep hardship and fatigue are yet to be resolved.

Maintaining awareness of the work environment, comprehending the information it holds and predicting how the situation will develop are some of the critical factors in the prevention of industrial accidents (Jones and Endsley 2000; Stanton et al. 2001). Situational awareness is another of the core competencies identified by the ICAO are essential for safe and effective flight (International Civil Aviation Organisation 2013). Pilots need to have an awareness of the aircraft state in its environment and be able to project and anticipate changes (International Civil Aviation Organisation 2013). It is viewed as a basic standard for the protected and effective activity of complex powerful frameworks, for example, an aircraft (Sarter and Woods 1991). Situational mindfulness has reliably been seen as powerless to sleep hardship and fatigue (Caldwell et al. 2004; Sexton et al. 2000; Tucker et al. 2010). Not only does situational awareness fall under the realm of executive functions which are associated with the prefrontal regions of the brain (Thomas et al. 2000), loss of situational awareness manifests itself in the operator as the failure to continue responding appropriately or even in responding to the situation completely inappropriately. Furthermore, decreased situational awareness has been referred to as a casual factor in several aviation mishaps (Taylor 1990). It is therefore proposed that situational awareness may also have the ability to predict flight performance changes.

Sleep deprivation and fatigue have been widely tested in the aviation industry using the Psychomotor Vigilance Task (PVT) developed by Dinges and Powel (1985). PVT performance has been shown to consistently decline with reduced sleep (Dinges et al. 1997; Russo et al.2005). However, despite being considered the "gold standard" for measuring fatigue in an aviation context, much remains unknown about the task and what it measures with a paucity of findings highlighting its relationship with real world tasks. Several measures may have promise, including the Profile of Mood States (POMS) (McNair et al. 1971) questionnaire, a rating scale used to evaluate transient, distinct mood states. This measure has been proven to be valid among healthy adult populations, has a high internal consistency and is sensitive to fatigue (Terry et al. 2003). Further, POMS may be able to help in the forecast of flight execution changes since Previc et al. (2009) discovered flying blunders following 24–28 h ceaseless wakefulness crested in accordance with tops in emotional fatigue, controlled by the POMS.

Lindbergh's observations and circadian rhythm imbalances are familiar phenomena to aircrew. DE synchrony occurs when changing environmental cues (e.g., meals, daylight, work-sleep schedules) conflict with existing biological rhythms. Problems commonly associated with desynchronise usually manifest after transoceanic and transcontinental flights.

Air crew sleep is extremely significant in the current scenario of commercial operations. With the given speed and range of current aircraft operations, aircrew fatigue is becoming a limiting factor in aircraft operations. Current business aircraft cross time zones at nearly a similar rate as the earth turns, and it is these quick Trans meridian advances that lead to the syndrome commonly referred to as Jet Lag or Rapid Time Zone Change Syndrome. On arrival at their destination, individuals find themselves out of synchrony with the social and time cues of their new surroundings. It is usually associated with excessive daytime sleepiness; sleep onset insomnia and frequent arousals from sleep, particularly in the latter half of the night. Gastro - intestinal discomfort is common.

Cabin crew structure a significant piece of the business airlines, they structure a significant piece of the flight crew liable for flight security. To the extent the passenger is concerned, maybe more significant than the aircrew; the business passenger comes in contact just with the lodge crew and structures an impression about the airline through this association. Sleeplessness corrupts consideration, transient memory, and basic leadership; quickly the whole occupation substance of lodge crew endures. In actuality, lodge crew would little be able to bear to be 'fly slacked' and present a poor picture of the airline.

The relationship between psychological wellness and prosperity, and work hours is of developing premium and worry with an expanding group of proof proposing longer work hours antagonistically influence emotional wellness over an assortment of occupations (Dembe, Erickson, Delbos, and Banks, 2005). Different examinations have distinguished a relationship among extra time and expanded work routines with expanded danger of specialist fatigue (Åkerstedt, Fredlund, Gillberg, and Jansson, 2002; Park, Kim, Chung, and Hisanaga, 2001), stress (Maruyama and Morimoto, 1996), and discouragement (Proctor, White, Robins, Echeverria, and Rocskay, 1996; Shields, 1999). A few meta-investigations, for example, those by Sparks, Cooper, Fried, and Shirom (1997) and Spurgeon, Harrington, and Cooper (1997) condensed these examination discoveries. The writing recommends that longer work hours are related with antagonistic impacts on laborers' emotional well-being. Further examination concerning work hours and attending factors adding to laborers' emotional wellness is justified.

Psychological wellness issues, which can be inconvenient to personal satisfaction, can likewise impact work execution (Butcher, 2002). Contingent upon occupation, psychological wellness issues can have genuine boundless results. The emotional wellness of business airline pilots has been found to impact flight execution (Butcher, 2002). Inside the aviation industry, the potential occurrence of emotional well-being issues among pilots is a genuine worry because of activity of multi-million euro airframes and the lives of at least 500 passengers. This death toll and gear was as of late featured on March 24, 2015, when co-pilot Andreas Lubitz, having kept the skipper out of the cockpit, slammed Germanwings Flight 9525 into the French Alps murdering 150 passengers and crew. Further examination found that Lubitz had a background marked by serious melancholy. This deadly episode isn't secluded. On October 31, 1999, 30 minutes after take-off from New York City, an Egypt Air Boeing 767 encountered a quick drop killing 217 people. Uncertain proof proposed that the accident was intentionally brought about by the help first official (Aviation Safety Network, 1999). Besides, on December 19, 1997, Silk Air Flight 185 smashed after a fast drop from cruising elevation on course from Jakarta, Indonesia to Singapore murdering 104 ready. In the resulting occurrence report, it was recommended that the commander was experiencing "multi-business related challenges" (Aviation Safety Network, 1997). As indicated by Butcher (2002), psychological wellness issues among pilots have been recognized, yet the degree, inceptions, or level of these issues among dynamic airline pilots is as of now obscure in light of the fact that no unequivocal epidemiological investigations on paces of mental issue have been led for this gathering.

One factor proposed to strongly affect psychological well-being, explicitly melancholy, is long work hours (i.e., over 8 hours; Proctor et al., 1996). Pilots flying for European-based air transporters can fly as long as 13 hours for each obligation day (European Union Air Operations [EU-OPS]-Subpart Q). Business pilots appointed to U.S.- based flights can fly as long as 9 hours for each obligation day dependent on a two-pilot crew (Federal Aviation Administration [FAA]-14 CFR Part 117). Pilots flying for U.K. - based transporters are allowed to fly as long as 13 hours for every obligation day (Civil Aviation Authority [CAA-UK]-CAP 371) while business pilots working Chinese-based flights can go through as long as 14 hours on obligation for each day, in spite of the fact that flight time can't surpass 10 hours (China Civil Aviation Regulations [CCAR]-Section 135). These flight time restrictions executed by different aviation guideline specialists recommend further assessment is required worldwide with respect to pilot work hours

Various past examinations have explored the connection between work hours and wellbeing (Proctor et al., 1996; Sparks et al., 1997; van der Hulst, 2003). The psychological well-being of move labourers has additionally gotten some consideration (Harrington, 2001; Kim et al., 2002). Conversely, investigate looking at amount of work hours and labourers' emotional wellness is a lot sparser (Spurgeon et al., 1997). In any case, existing proof causes worry about the negative effect of longer work hours on the wellbeing and prosperity of labourers (Harrington, 2001; Spurgeon et al., 1997; van der Hulst, 2003). In a meta-investigation dependent on 21 examinations, Sparks and associates (1997) found a little however critical positive connection between longer work hours and less fortunate mental wellbeing. Besides, subjective examination of an extra 12 investigations bolstered these discoveries (Sparks et al., 1997). Utilizing the outcomes from the Third European Working Conditions Survey, finished by 21,703 labourers in up close and personal meetings over the 15 European Union member states in 2000, Boisard, Gollac, Valeyre, and Cartron (2003) found that of the individuals who worked 30 to 35 hours out of every week, 27% and 19% reported encountering pressure and generally speaking fatigue, separately, because of work. While, of those representatives who worked 45 hours or more for every week, 39% and 33% reported encountering pressure and by and large fatigue, separately, because of work. The scientists presumed that the recurrence of reported emotional well-being issues was altogether related with work time

Albeit long work hours seem, by all accounts, to be related with emotional well-being issues, the potential impact of jumbling factors (i.e., statistic factors, work requests, work attributes, and character) may likewise assume a job in this relationship (Spurgeon et al., 1997; van der Hulst, 2003). Past research has utilized the quantity of hours functioned as a pointer of assignment requests (van der Hulst, 2003). Notwithstanding, such a methodology can't unmistakably isolate the impacts of employment requests and long work hours. Essential relationships between work hours and wellbeing impacts give restricted data. As per van der Hulst (2003), inability to control for covariates may add to uncertain discoveries in examinations of work hours and psychological well-being.

As per the writing, a few variables related with long work hours and wretchedness or nervousness incorporate sleep disruptions, sentiments of fatigue, and signs of fatigue (e.g., micro sleeps; Samel, Wegmann, and Vejvoda, 1997; Sirois, Trutschel, Edwards, Sommer, and Golz, 2009). As of not long ago, no distributed examinations have researched to what degree self-reported gloom or tension because of work hours may be clarified by sleep disruption and fatigue balanced for singular pilots' statistic qualities. The motivation behind the present examination was in this way to research the distinctions in self-reported wretchedness or uneasiness among European-enrolled business airline pilots, and afterward to additionally explore the degree to which these distinctions could be clarified, at first by singular statistic attributes (e.g., age, position, business), and accordingly by their encounters of fatigue in the cockpit, encounters of micro sleeps in the cockpit, and sleep aggravation because of work routine.

Inadequate sleep has recently been related with expanded danger of mental issue (Vandeputte and de Weerd, 2003). The sleep aggravations a few times each month or every week, coming about because of pilots' failure to receive ordinary sleeping examples that elevate appropriate rest because of work routines, almost multiplied and significantly increased, individually, the respondents' likelihood of reporting gloom or uneasiness, featuring the solid relationship between these two factors. Raggatt (1991) discovered sleep aggravations among long-separation mentor drivers, due most eminently from long hours in the driver's seat (50 hours or more for each week), were reliably related with pressure results and negative wellbeing outcomes. Besides, Raggatt (1991) proposed that fatigue is communicated in a recurrent example where endeavours to manage long hours improves the probability of maladaptive adapting endeavours, bringing about upset sleep, fatigue, and in the end pressure results.

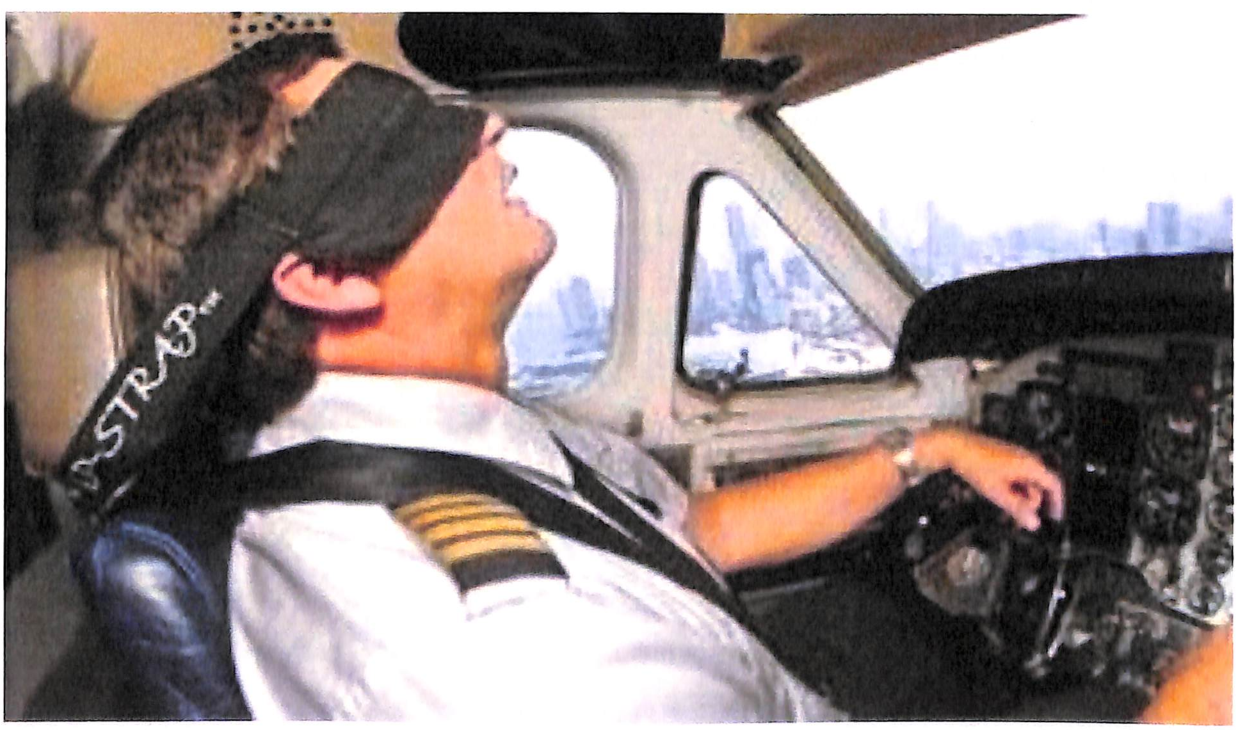
Utilizing drug to tackle the issue can cause issues as well. Dr. Neil Kline, a sleep doctor and chief of the American Sleep Association, told The Huffington Post: 'A considerable lot of the drugs and OTC items utilized for a sleeping disorder and stream slack can cause daytime sleepiness and lead to impaired daytime execution.

Therapeutically alluded to as 'desynchronises' and delegated a circadian beat sleep issue, stream slack is an integral part of long haul flights. Momentary issues from fly slack incorporate fatigue, loss of fixation, touchiness and loss of hunger. All the more worryingly, an examination distributed in The Lancet in 2007 found that steady disruption of body rhythms could prompt intellectual decay, insane and state of mind issue and potentially coronary illness and malignant growth.

Beside the stressing sleep insights, the examination found that practically 50% of those included said they had worked in any event one day while debilitated. A significant explanation was to maintain a strategic distance from the organization's disciplinary procedure (39.4 percent) and 28.6 percent said that they felt their sickness wasn't not kidding enough to warrant a free day work. Also, more than 80 percent said they hadn't had the open door for a supper break while working, and said this had occurred, by and large, multiple occasions during the 28 days that the study was directed.

Effect aide general secretary Michael Landers said on the association's blog: 'During the overview time frame a vast lion's share worked flight obligation times of over nine hours, while just about a third had worked at any rate one flight obligation time of over 13 hours. 'Most experienced flight delays, troubles in taking supper breaks and obligation swaps were likewise hard to accomplish. 'Most lodge crew reported acquiring the base rest time frame (12 hours off between shifts under flight time impediment rules) in any event once in the period.'

The association state the investigation will be utilized to help guarantee the airline is consenting to wellbeing and security aviation laws. Aer Lingus stated: 'Aer Lingus and every single other airline work in one of the most exceptionally directed businesses in the world and give specific consideration and regard for guarantee the wellbeing and prosperity of our representatives. 'The in-flight working condition is profoundly directed at national, European and worldwide levels and Aer Lingus agree to all the applicable codes and gauges. The creators of the report charged by the Impact worker's guild have not counselled nor looked for any contribution from Aer Lingus in the incorporating of their archive.'



Impacts of Fatigue on Aviation Performance

Pilot fatigue has long been a security issue (Caldwell and Caldwell, 2003). Flight crews are incessantly tested by schedules that are unusual, obligation periods that frequently stretch past 10 or 12 hours; work periods that call for evening time sharpness and delays in new time zones that spot sleep openings at wrong occasions. The exhibition of aviation staff, similar to that of modern move labourers, is incessantly compromised by fatigue brought about by schedule-driven sleep misfortune. Be that as it may, in aviation, the stakes are regularly higher on the grounds that they include multimillion-dollar airframes and the lives of up to 555 passengers.

Ongoing occasions have featured fatigue-related security issues in civil aviation. In 2004, Corporate Airlines Flight 5966 smashed on way to deal with Kirksville Regional Airport after its fatigued pilots, who were on their 6th flight of the day, had been on obligation for 14 hours. Since they were drained, these pilots disregarded distributed methodology, neglected to react to cautions that the aircraft was excessively near the ground, and collided with trees subsequent to losing attention to the area of their aircraft concerning the moving toward airport area and its environment. In February 2008, the Honolulu-based pilots of Go! Airline Flight 1002 overshot their goal by in excess of 30 miles since they nodded off on the flight deck during an excursion that was just 50 minutes long. In October 2009, a comparable occasion happened when the pilots of Northwest Airlines Flight 188 stayed lethargic to interchanges from air traffic control for just about an hour and a half and overflew their goal by 150 miles since they clearly had napped off at the controls.

Such episodes are not astonishing, given that pilot fatigue has been on the U.S. National Transportation Safety Board's (NTSB) Most Wanted List of wellbeing related needs since 1990. The Federal Aviation Administration (FAA) tried to refresh constraints on flight times and obligation hours a couple of times over the previous decades, however the 2009 accident of Continental Connection Flight 3407, in which 50 individuals were killed, revived the office's source of inspiration. Crash specialists verified that before that portentous flight, one of the two pilots had been conscious throughout the night, and the other had reported for obligation following an extensive drive and a nonrestorative sleep period. The NTSB reasoned that "the pilots' exhibition was likely impaired in view of fatigue" (National

Transportation Safety Board, 2010, p. 153), which drove the FAA to contract an Aviation Rulemaking Committee (ARC) to refresh flight guidelines for pilots. An essential charge of the ARC was to give science based proposals to new flight-obligation guidelines; at present, in any case, the guidelines keep on concentrating more on work-hour limits than on the sleep and circadian elements that are at the foundation of the issue of pilot fatigue

Sleep and fatigue checking

One inconvenience of inspecting obligation schedules independent from anyone else is that the sleep expected to be picked up by work force must be assessed as opposed to really estimated—and, obviously, the exactness of these estimations legitimately impacts the precision of fatigue-hazard counts. Nonetheless, immediate, experimental estimations of sleep and sleep/wake timing can be acquired utilizing wrist ACTi graphs (Morgenthaler et al., 2007; Sadeh and Acebo, 2002, for example, the Fatigue Science (Honolulu, HI) ReadiBand (see Fig. 1). The exactness of ReadiBand sleep/wake orders was checked in an investigation of 50 patients experiencing polysomnographic assessment (Russell et al., 2010); results showed 92% weighted precision of the understanding between ReadiBand ACTi graphic age by-age sleep/wake figuring's contrasted and highest quality level polysomno realistic conclusions of sleep/wake status. In spite of the fact that actigraphy isn't safeguard since it can't precisely recognize loose (development free) wakefulness or micro sleeps (i.e., slips into sleep that keep going for 30 seconds or less), it is obviously better at following sleep times, wake-up times, and sleep times than are emotional sleep logs. ACTi graphically estimated sleep accounts can give a strong sign of hazard levels for operational fatigue inferable from sleep misfortune and disturbed sleep/wake cycles.

Truth be told, actigraphs could be utilized to build up a preservationist qualification for-obligation program even without presenting the recorded later sleep-history information to a model examination. Since it is notable that the normal grown-up needs at least 8 hours of sleep so as to be completely refreshed (Van Dongen, Maislin, Mullington, and Dinges, 2003), the actigraphy record of pilots reporting to obligation could be inspected, and pilots appeared to have had under 8 hours of sleep in the first 24-hour time frame could be prohibited from up and coming flights (or possibly cautioned about their latent capacity level of impairment)

In-flight fatigue alleviation

Different methods can be executed either previously or during the obligation time frame to address remaining fatigue issues. Crew members ought to be taught about appropriate sleep cleanliness so they can upgrade the helpful idea of sleep before obligation or during delays (Caldwell, Caldwell, and Schmidt, 2008). Locally available cockpit snoozing ought to be approved to enable pilots to briefly make up for any current sleep obligation and in this manner constrict in-flight passes in watchfulness (Rosekind et al., 1994). The utilization of short-acting hypnotics for the advancement of value sleep ought to be permitted and even supported when the pre-duty or delay sleep period falls outside of the ideal circadian stage. Caffeine gum (which is by and by being remembered for the Army's First Strike Rations) could be utilized to briefly support in-flight readiness compromised by sleep obligation or circadian desynchronise (Committee on Military Nutrition Research, 2001). Controlled in-flight rest breaks (right now not approved under FAA guidelines) ought to be given to moderate cockpit crews' fatigue and weariness (Neri et al., 2002)

Instruction about logically legitimate fatigue countermeasures, along with administrative arrangements for their utilization, will enlarge the fatigue-relieving advantages of schedule advancement and fatigue following. In spite of the fact that there is no single enchantment slug, a blend of accessible methodologies will upgrade sharpness and improve aviation security

CHAPTER 4 RESEARCH METHODOLOGY

4.1 Introduction

Research methodology is that part of the research work that comprise of taking a systematic approach in solving a problem it is a science that concerns about how the research will be carried out. Researchers have mentioned methodology as "the procedure by which researchers go about their work of describing, explaining and predicting phenomena are called research methodology (Emory, 2010)." It is a process of studying different methods by which knowledge may be accumulated. The aim of the research methodology is to give the work plan of project.

There are different types of method which are applied in the process to collect data for conducting the study and meet with the objectives set in the first chapter. Methods according to Vander Stoep and Johnson (2009) help in creating the basic outline structure of the methods that should be employed in the study

Research technique is a way to deal with purposely deal with the investigation issue. In this envision, we find out about various steps that are generally grasped by the expert in focusing on his examination to know the investigation procedures and frameworks just as the methodology.

Experts furthermore need to understand the assumptions crucial procedures and they need to know the criteria by which they can pick that particular frameworks and techniques will be appropriate to explicit issues and others won't. This suggests it is central for the researcher to layout his framework for his issues as the equivalent may differentiate from issue to issue

4.2 Research Design

The research design is selected by the researcher strictly by evaluating the aim and objectives identified in the proposal. It is the apt design of the research that enables the researcher to complete the study in a systematic manner. There are three types of research designs specifically used in dissertation or applied for conducting academic research. These ate explanatory, exploratory and descriptive (Yin, 2003).

The design of the research venture famously known as the "Research design" decision with respect to what, where, when, how much, by what means concerning an inquiry or a research study constitutes research design. The research has concentrated each and every step of research design to design the project. The researcher wants to study the various security concerns and effect of sleeplessness of airline crew members. Also the researcher wanted to determine the opinions of people working in aviation. The researcher wanted to study the sleeplessness of airline crew members. The researcher design is based on objective of research.

4.3 Source of Data

Both secondary and primary data will be used in this study. Primary data was collected directly from the airline crew members, using questionnaire specially prepared for this purpose. Secondary data was collected from various related books, magazines, reports prepared by entrepreneurs, research scholars, various websites, etc.

4.4 Data Collection

There are two types of methods used for data collection which are

Primary Data

I collected primary data using methods such as interviews and questionnaires. The key point here is that the data that collected is unique to research. I have tried to collect the data using a questionnaire method.

Secondary Data

Secondary data was collected through the internet, company website, office records, etc.

4.5 Research Tool

The research tool used by the researcher is questionnaire. The questionnaires have questions of various dimensions related to the security concerns and effect of sleeplessness of airline crew members

Questionnaire

I was using the questionnaire for collecting data. At first, a work in progress was readied remembering the goal of the research. A pilot concentrate was done so as to know the precision of the questionnaire. The last questionnaire was arrived simply after certain significant changes were finished.

4.6 Sample Size

The sample size is 50 and main focus in this study is on security concerns and effect of sleeplessness of airline crew members. Simple random sampling is used for this research. The questionnaire has been distributed to airline crew members.

4.7 Statistical Tool

The data collected and classified, tabulated, analysed and interpreted in percentage to carry out the objectives of the study. The simplified data is then portrayed in the forms of tables and charts

4.8 Interpretation

I have use interpretation on the base of the analysed data and also some recommendations are given to fill the loopholes of the actual scenario

4.9 Likert scale

I have used Likert scale for data analysis. These comprise of various articulations which express either a favourable or unfavourable attitude towards the given object to which the respondents are asked to react. The respondent responds to in terms of several degrees of dissatisfaction or satisfaction.

4.10 Limitations

This study experience the following limitations

- This study is limited to airline crew members only.
- The result of the study is based on the views of the participants. Hence the data collected from them may be biased.
- The time allotted for the study is limited

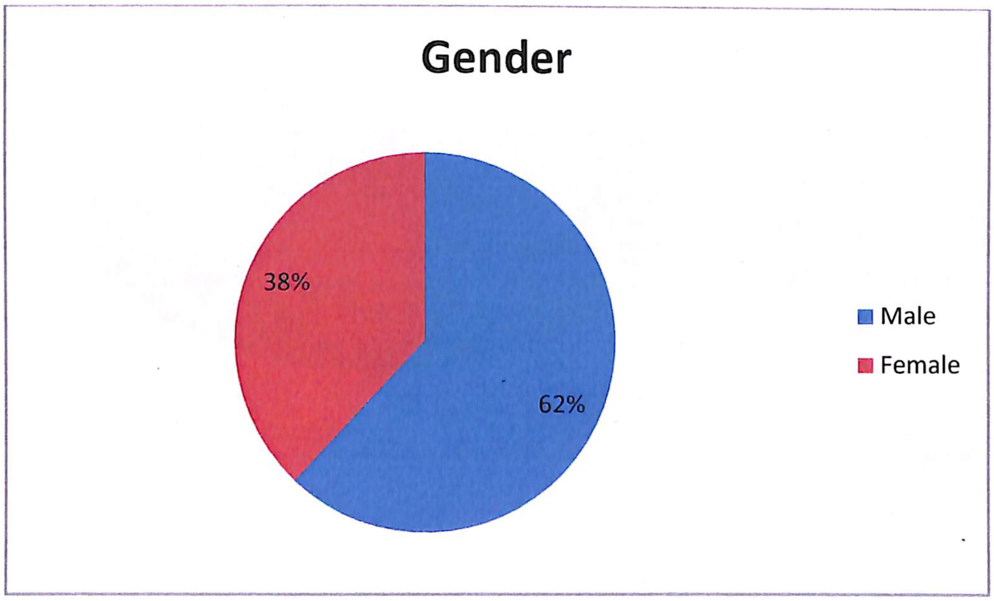
CHAPTER 5 DATA ANALYSIS

1. What is your gender?

Table 5.1 your gender

Option	No of Respondents	% of Respondents
Male	31	62%
Female	19	38%
Total	50	100%

Chart 5.1 your gender



Interpretation

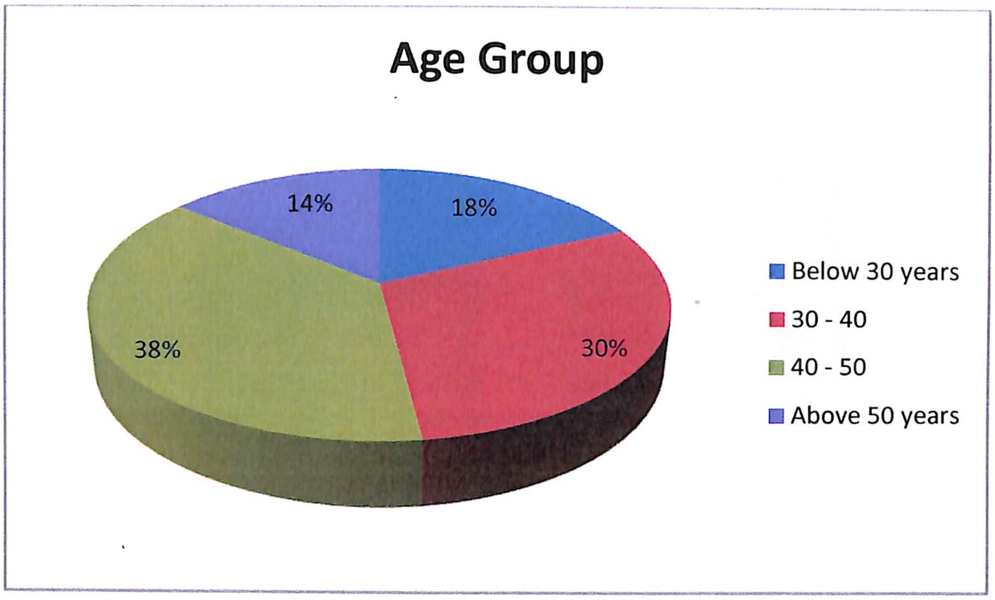
38% of respondents are Female while 62% of respondents are Male which is participated in this survey.

2. What is your age group?

Table 5.2 your age group

Option	No of Respondents	% of Respondents
Below 30 years	9	18%
30 - 40	15	30%
40 - 50	19	38%
Above 50 years	7	14%
Total	50	100%

Chart 5.2 your age group



Interpretation

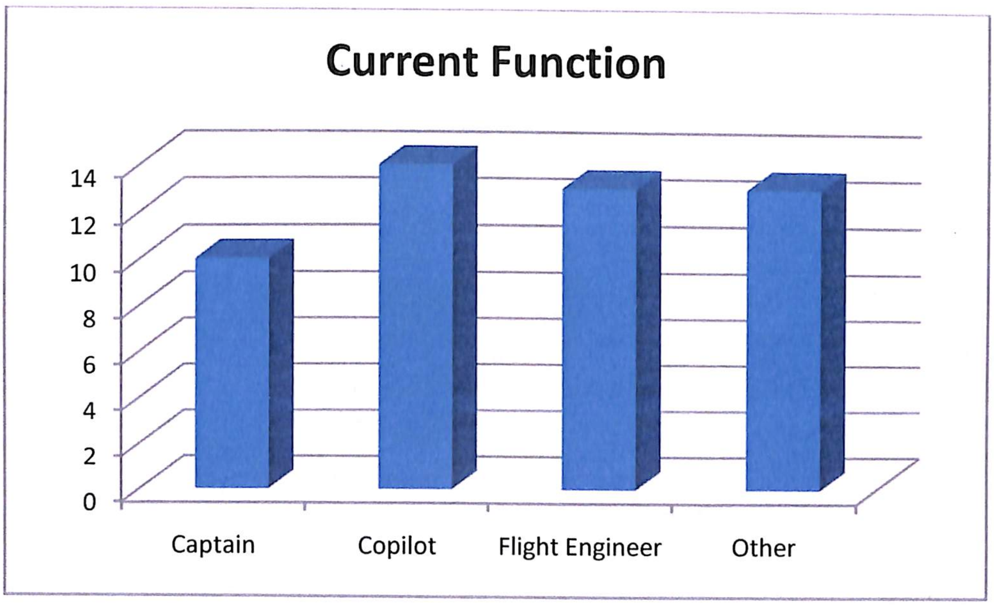
18% of respondents are Below 30 years, 30% of respondents are 30 - 40, and 38% of respondents are 40 - 50 while 14% of respondents are fell in Above 50 year's age groups.

3. As a crew member which one is your current function?

Table 5.3 your current function

Option	No of Respondents	% of Respondents
Captain	10	20%
Co-pilot	14	28%
Flight Engineer	13	26%
Other	13	26%
Total	50	100%

Chart 5.3 your current function



Interpretation

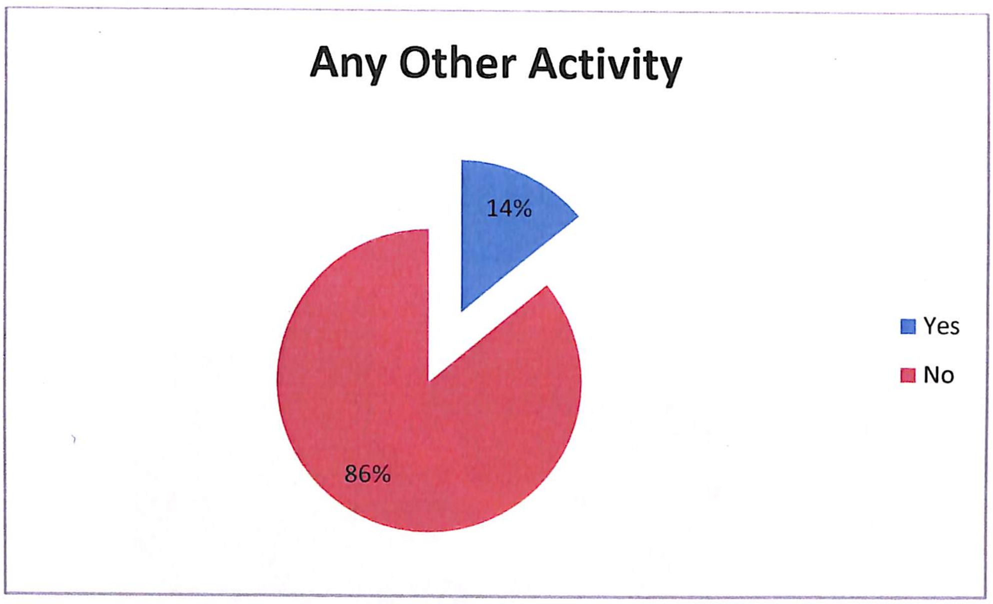
20% of respondents say Captain, 28% of respondents say Co-pilot, and 26% of respondents say Flight Engineer while 26% of respondents say other is their current function as a crew member.

4. Besides working as airline crew member, do you have any other activity?

Table 5.4 any other activity

Option	No of Respondents	% of Respondents
Yes	7	14%
No	43	86%
Total	50	100%

Chart 5.4 any other activity



Interpretation

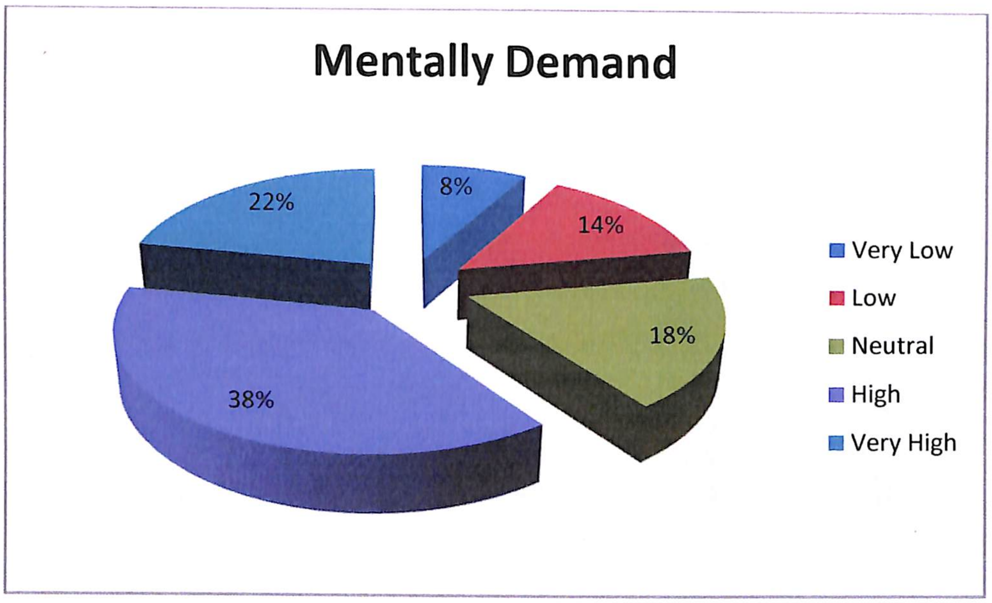
14% of respondents say Yes while 86% of respondents say No, they are working as airline crew member, and they have any other activity other than airline crew.

5. How mentally demanding was the flight?

Table 5.5 mentally demanding

Option	No of Respondents	% of Respondents
Very Low	4	8%
Low	7	14%
Neutral	9	18%
High	19	38%
Very High	11	22%
Total	50	100%

Chart 5.5 mentally demanding



Interpretation

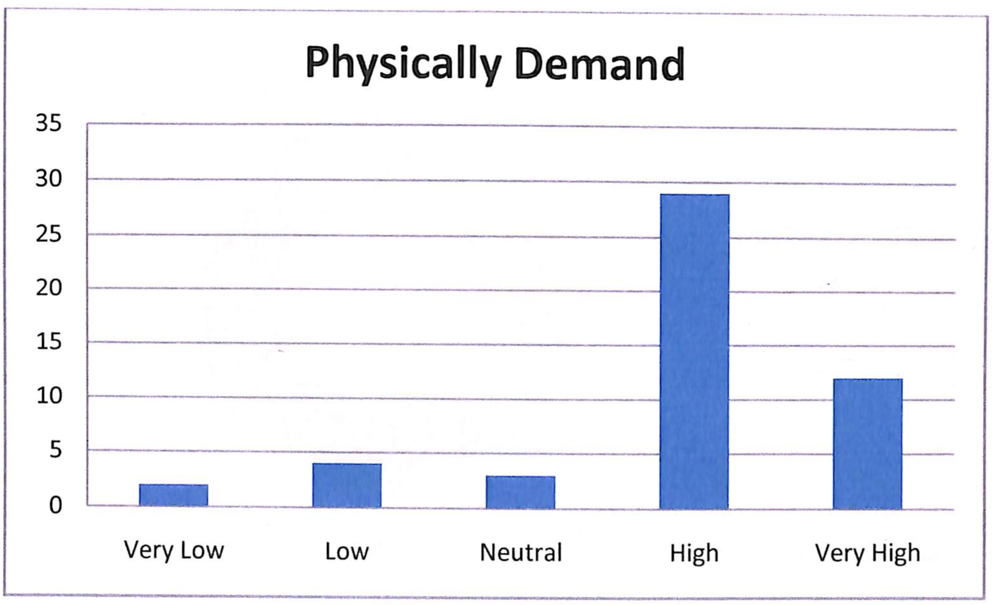
8% of respondents say Very Low, 14% of respondents say Low, 18% of respondents are Neutral, and 38% of respondents say High, while 22% of respondents say Very High for mentally demand workload during the flight.

6. How physically demanding was the flight?

Table 5.6 physically demanding

Option	No of Respondents	% of Respondents
Very Low	2	4%
Low	4	8%
Neutral	3	6%
High	29	58%
Very High	12	24%
Total	50	100%

Chart 5.6 physically demanding



Interpretation

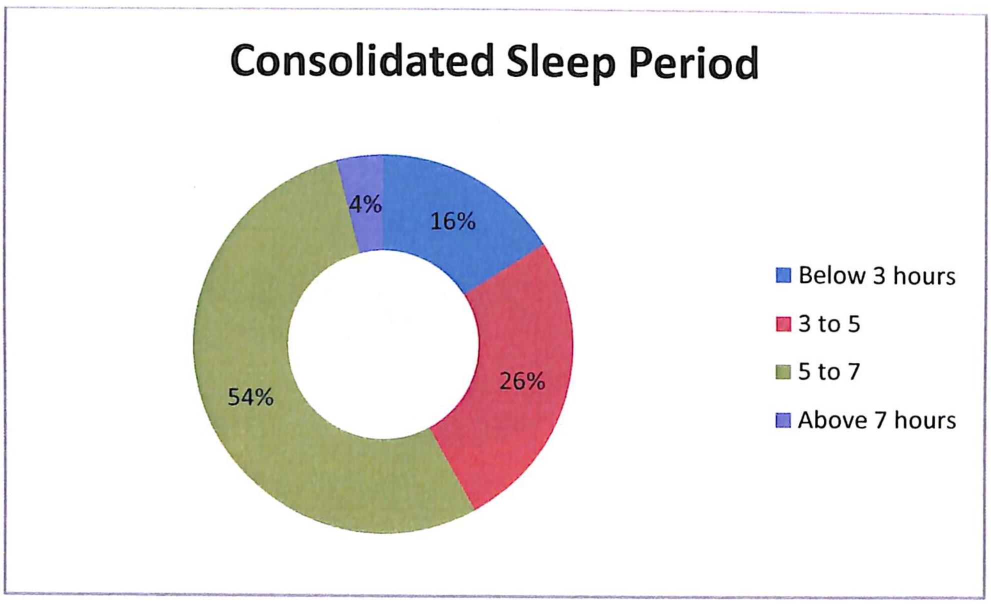
4% of respondents say Very Low, 8% of respondents say Low, 6% of respondents are Neutral, and 58% of respondents say High, while 24% of respondents say Very High for physically demand workload during the flight.

7. How long was last consolidated sleep period?

Table 5.7 consolidated sleep period

Option	No of Respondents	% of Respondents
Below 3 hours	8	16%
3 to 5	13	26%
5 to 7	27	54%
Above 7 hours	2	4%
Total	50	100%

Chart 5.7 consolidated sleep period



Interpretation

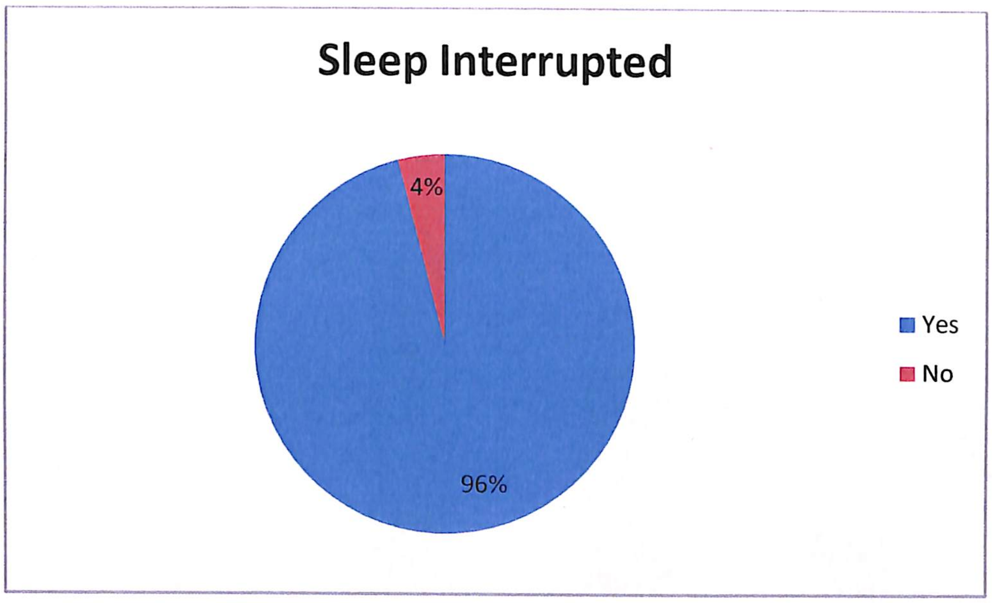
4% of respondents say Above 7 hours, 26% of respondents say 3 to 5, and 16% of respondents say Below 3 hours while 54% of respondents say 5 to 7 hours of last long consolidated sleep period.

8. Was your sleep interrupted?

Table 5.8 sleep interrupted

Option	No of Respondents	% of Respondents
Yes	48	96%
No	2	4%
Total	50	100%

Chart 5.8 sleep interrupted



Interpretation

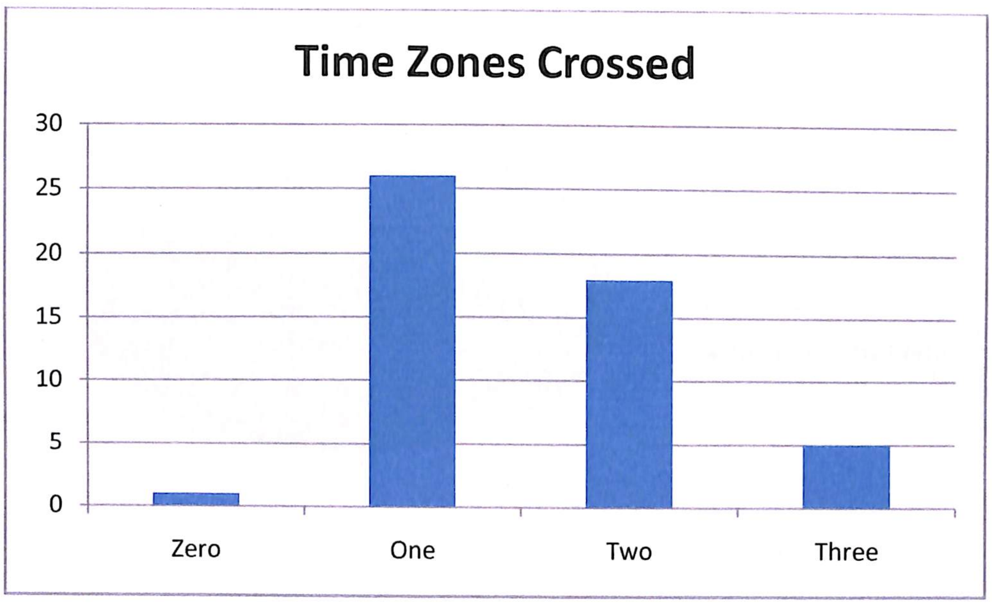
4% of respondents say No, while 96% of respondents say Yes, their sleep was interrupted during long-haul flight.

9. Number of time zones crossed?

Table 5.9 time zones crossed

Option	No of Respondents	% of Respondents
Zero	1	2%
One	26	52%
Two	18	36%
Three	5	10%
Total	50	100%

Chart 5.9 time zones crossed



Interpretation

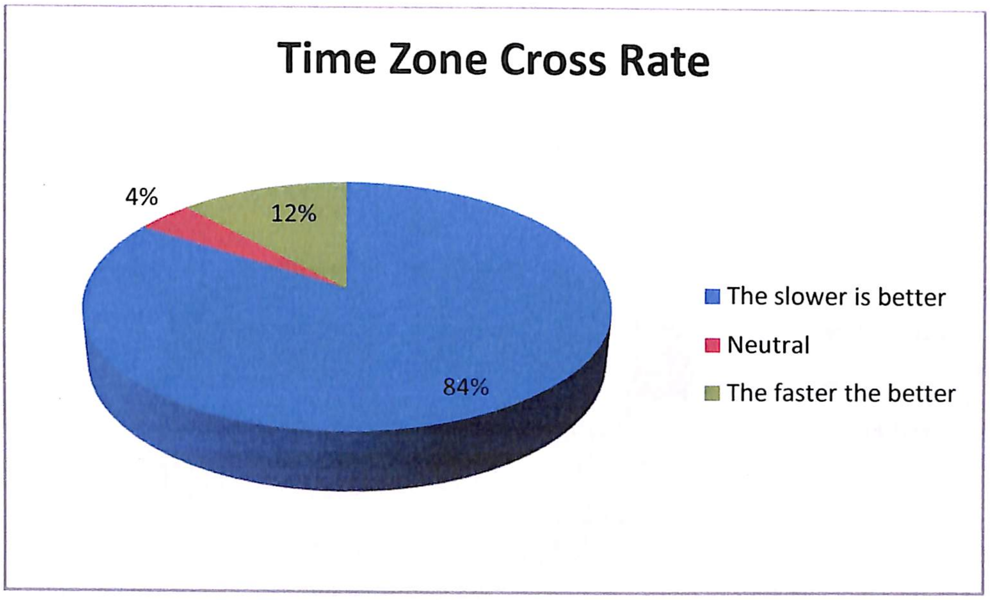
2% of respondents say Zero, 52% of respondents say One, 36% of respondents say Two and 5% of respondents say Three time zones crossed in single flight.

10. If more than one, at what rate were they crossed?

Table 5.10 rate were they crossed

Option	No of Respondents	% of Respondents
The slower is better	42	84%
Neutral	2	4%
The faster the better	6	12%
Total	50	100%

Chart 5.10 rate were they crossed



Interpretation

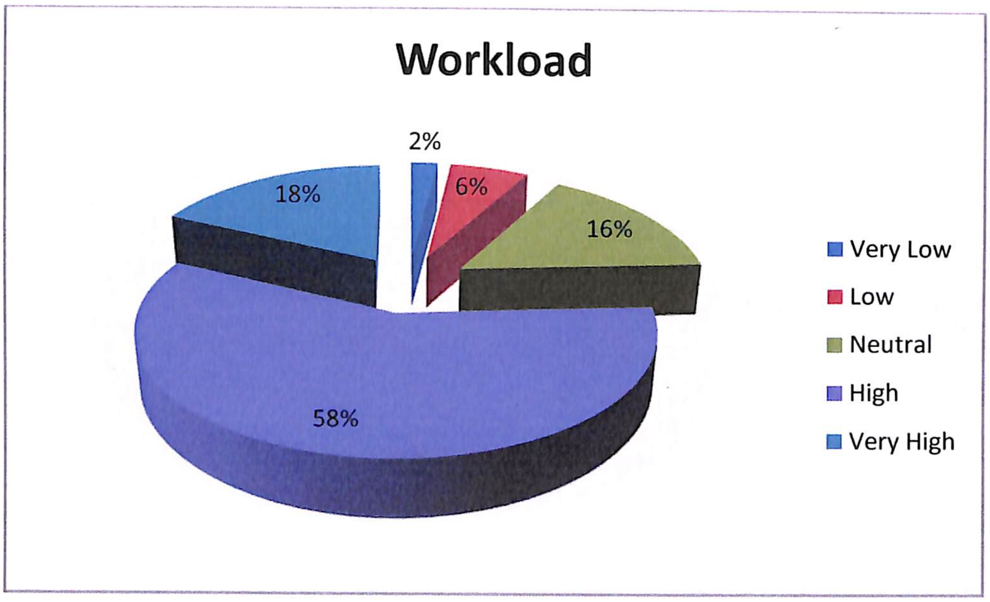
84% of respondents say the slower is better, 4% of respondents are Neutral and 12% of respondents say the faster the better, if more than one time zone crossed in single flight.

11. Do you feel significant workload during flight operation?

Table 5.11 workload

Option	No of Respondents	% of Respondents
Very Low	1	2%
Low	3	6%
Neutral	8	16%
High	29	58%
Very High	9	18%
Total	50	100%

Chart 5.11 workload



Interpretation

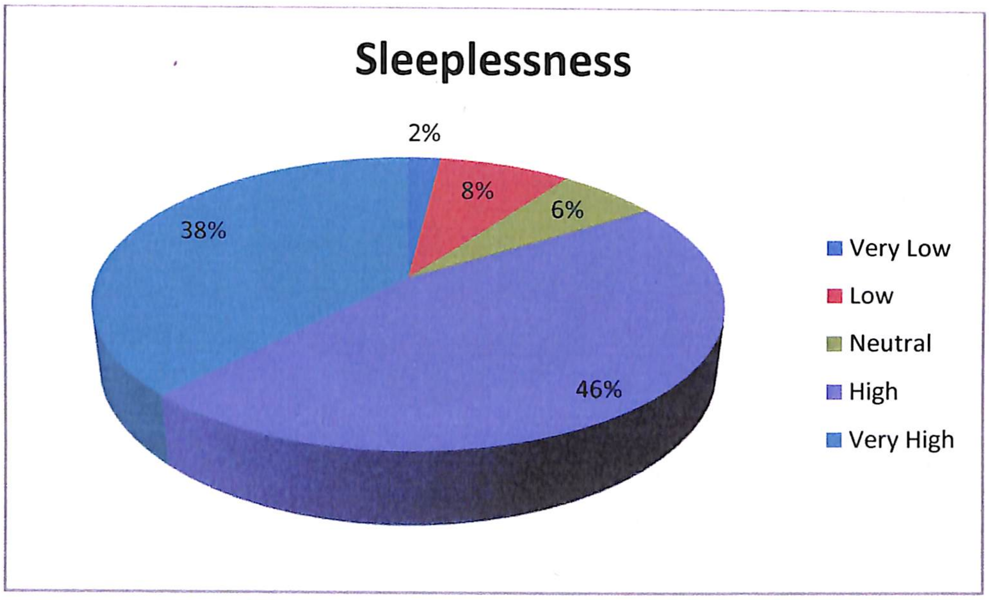
2% of respondents say Very Low, 6% of respondents say Low, 16% of respondents are Neutral, and 58% of respondents say High, while 18% of respondents say Very High workload during flight operation.

12. In your opinion, to what extent sleeplessness is a concern in-flight operation?

Table 5.12 sleeplessness is a concern in-flight operation

Option	No of Respondents	% of Respondents
Very Low	1	2%
Low	4	8%
Neutral	3	6%
High	23	46%
Very High	19	38%
Total	50	100%

Chart 5.12 sleeplessness is a concern in-flight operation



Interpretation

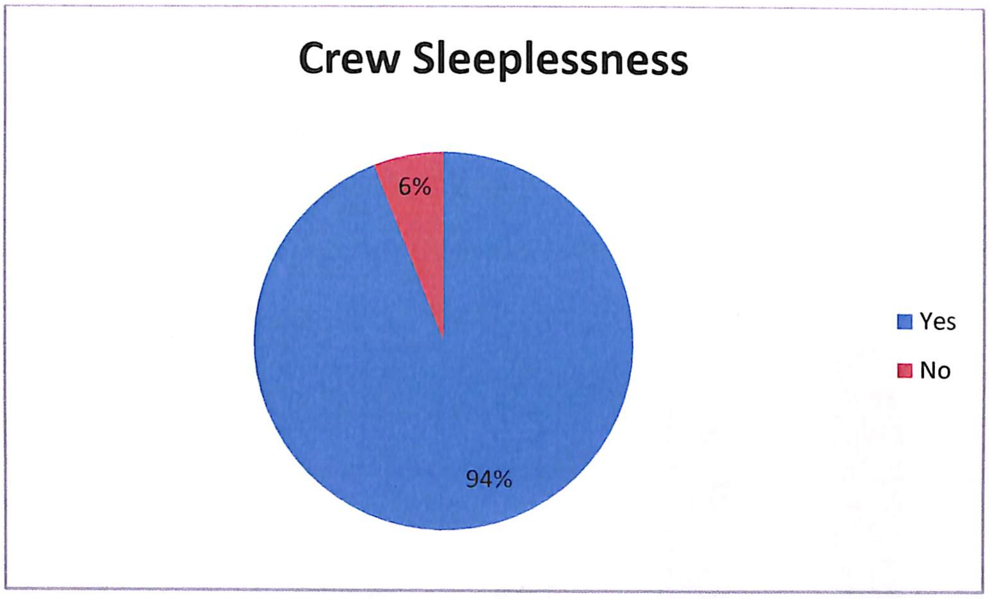
2% of respondents say Very Low, 8% of respondents say Low, 6% of respondents are Neutral, and 46% of respondents say High, while 38% of respondents say Very High in their opinion, to sleeplessness is a concern in-flight operation.

13. Is crew sleeplessness is a common occurrence in long haul flight operation?

Table 5.13 crew sleeplessness

Option	No of Respondents	% of Respondents
Yes	47	94%
No	3	6%
Total	50	100%

Chart 5.13 crew sleeplessness



Interpretation

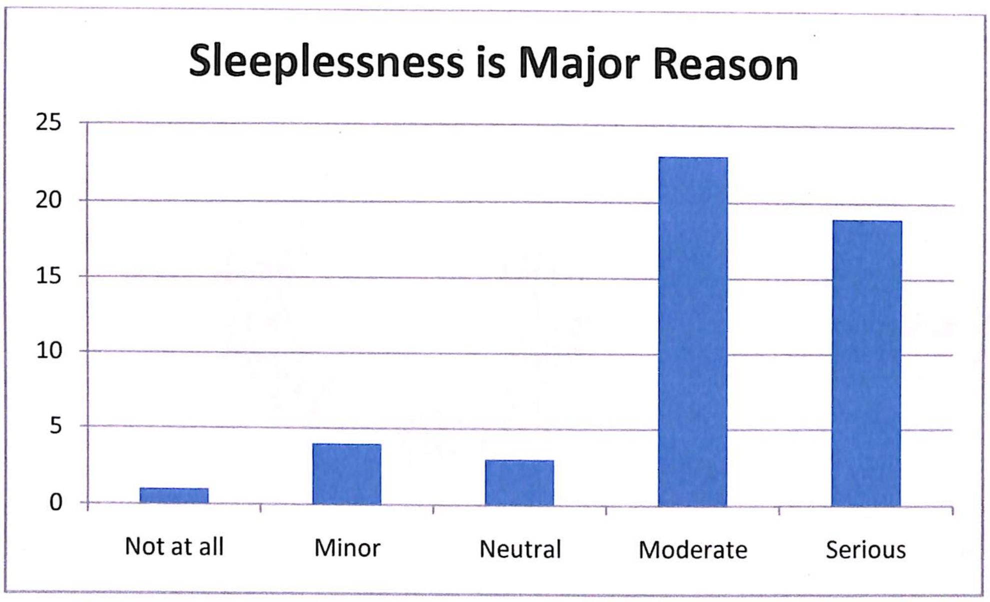
6% of respondents say No, while 94% of respondents say Yes; crew sleeplessness is a common occurrence in long haul flight operation.

14. In your opinion, sleeplessness is one of the major reason which increases crew fatigue?

Table 5.14 Sleeplessness is Major Reason

Option	No of Respondents	% of Respondents
Not at all	1	2%
Minor	4	8%
Neutral	3	6%
Moderate	23	46%
Serious	19	38%
Total	50	100%

Chart 5.14 Sleeplessness is Major Reason



Interpretation

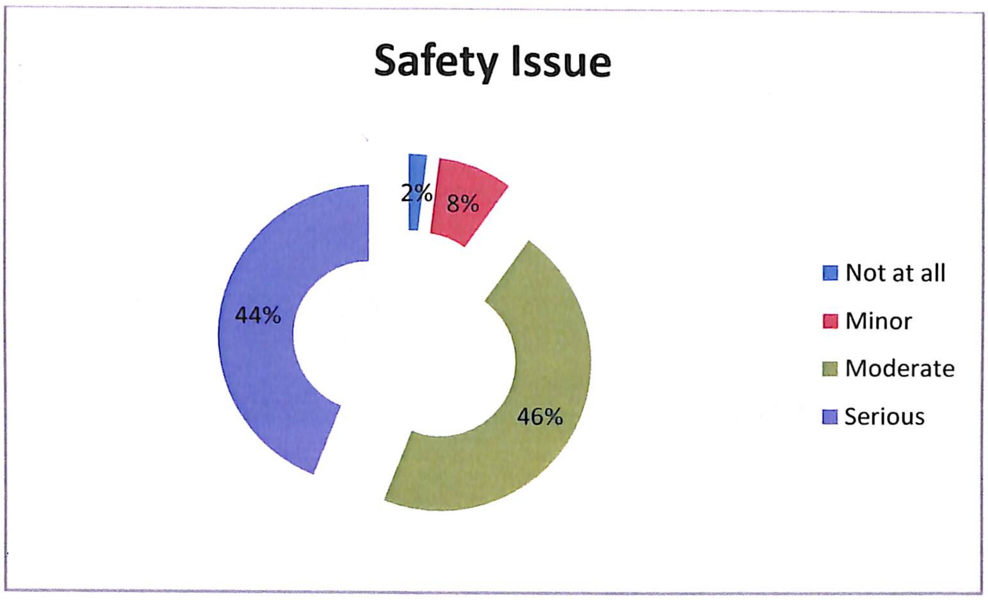
2% of respondents say Not at all, 8% of respondents say Minor, 6% of respondents are Neutral, 46% of respondents say Moderate, while 38% of respondents say Serious for sleeplessness is one of the major reason which increases crew fatigue.

15. When crew fatigue occurs, how significant a safety issue is it?

Table 5.15 safety issue

Option	No of Respondents	% of Respondents
Not at all	1	2%
Minor	4	8%
Moderate	23	46%
Serious	22	38%
Total	50	100%

Chart 5.15 safety issue



Interpretation

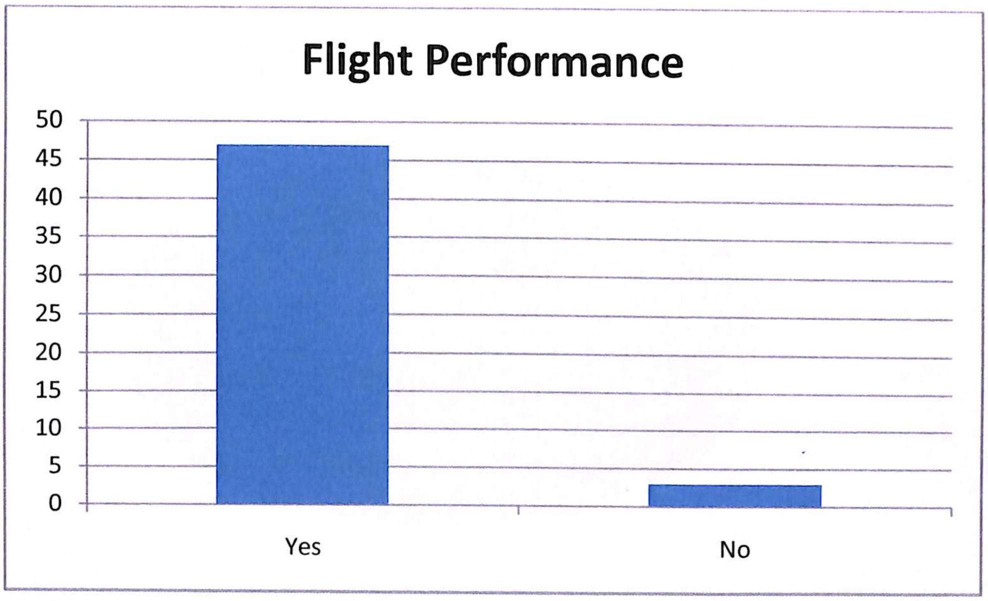
2% of respondents say Not at all, 8% of respondents say Minor, 46% of respondents say Moderate, while 38% of respondents say Serious for crew fatigue is a significant a safety issue.

16. Does sleeplessness affect your flight performance?

Table 5.16 flight performance

Option	No of Respondents	% of Respondents
Yes	47	94%
No	3	6%
Total	50	100%

Chart 5.16 flight performance



Interpretation

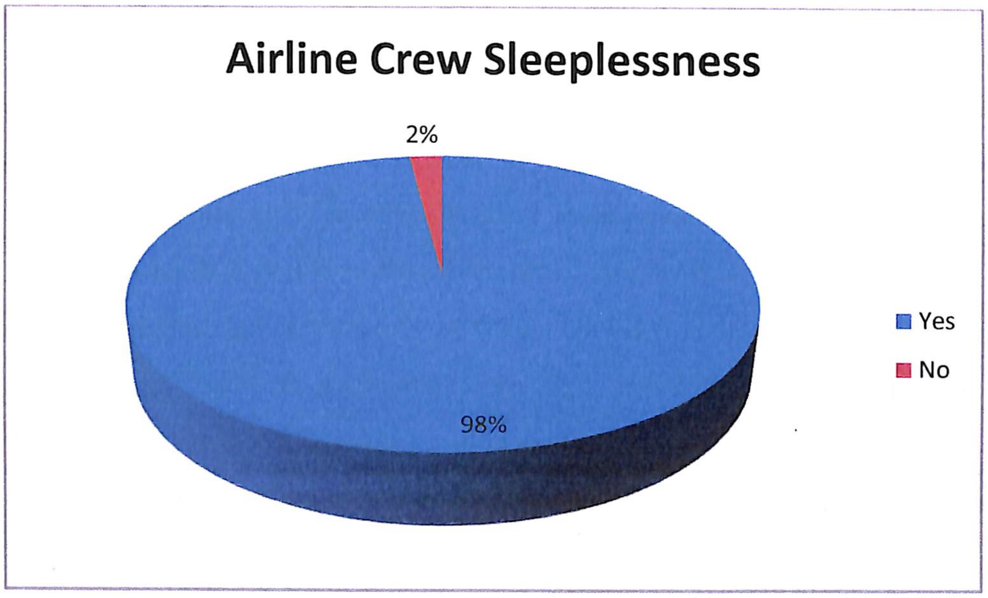
6% of respondents say No, while 94% of respondents say Yes, sleeplessness affect their flight performance.

17. Do you think, airline crew member sleeplessness is one of the major security concerns?

Table 5.17 Airline Crew Sleeplessness

Option	No of Respondents	% of Respondents
Yes	49	98%
No	1	2%
Total	50	100%

Chart 5.17 Airline Crew Sleeplessness



Interpretation

2% of respondents say No, while 98% of respondents say Yes they think, the airline crew members sleeplessness is one of the major security concerns.

CHAPTER 6 FINDINGS

Findings of the Study

- 38% of respondents are Female while 62% of respondents are Male which is participated in this survey.
- 18% of respondents are Below 30 years, 30% of respondents are 30 - 40, and 38% of respondents are 40 - 50 while 14% of respondents are fell in Above 50 year's age groups.
- 20% of respondents say Captain, 28% of respondents say Co-pilot, 26% of respondents say Flight Engineer while 26% of respondents say other is their current function as a crew member
- 14% of respondents say Yes while 86% of respondents say No, they are working as airline crew member, and they have any other activity other than airline crew.
- 8% of respondents say Very Low, 14% of respondents say Low, 18% of respondents are Neutral, and 38% of respondents say High, while 22% of respondents say Very High for mentally demand workload during the flight.
- 4% of respondents say Very Low, 8% of respondents say Low, 6% of respondents are Neutral, and 58% of respondents say High, while 24% of respondents say Very High for physically demand workload during the flight.
- 4% of respondents say Above 7 hours, 26% of respondents say 3 to 5, and 16% of respondents say Below 3 hours while 54% of respondents say 5 to 7 hours of last long consolidated sleep period.
- 4% of respondents say No, while 96% of respondents say Yes, their sleep was interrupted during long-haul flight.
- 2% of respondents say Zero, 52% of respondents say One, 36% of respondents say Two and 5% of respondents say Three time zones crossed in single flight.
- 84% of respondents say the slower is better, 4% of respondents are Neutral and 12% of respondents say the faster the better, if more than one time zone crossed in single flight.

- 2% of respondents say Very Low, 6% of respondents say Low, 16% of respondents are Neutral, and 58% of respondents say High, while 18% of respondents say Very High workload during flight operation.
- 2% of respondents say Very Low, 8% of respondents say Low, 6% of respondents are Neutral, and 46% of respondents say High, while 38% of respondents say Very High in their opinion, to sleeplessness is a concern in-flight operation.
- 6% of respondents say No, while 94% of respondents say Yes, crew sleeplessness is a common occurrence in long haul flight operation.
- 2% of respondents say Not at all, 8% of respondents say Minor, 6% of respondents are Neutral, 46% of respondents say Moderate, while 38% of respondents say Serious for sleeplessness is one of the major reason which increases crew fatigue.
- 2% of respondents say Not at all, 8% of respondents say Minor, 46% of respondents say Moderate, while 38% of respondents say Serious for crew fatigue is a significant a safety issue.
- 6% of respondents say No, while 94% of respondents say Yes, sleeplessness affect their flight performance.
- 2% of respondents say No, while 98% of respondents say Yes they think, the airline crew members sleeplessness is one of the major security concerns.

CHAPTER 7 CONCLUSION

Conclusion

The results of this study highlight the need to implement preventive actions related to the organization of work, aiming at improving working conditions and health, especially in aspects related to the sleep of airline crew members. Airline crew member should be aware of the signs of sleeplessness which include a reduction in alertness and attention, lack of concentration, increased response times, small mistakes, a reduction of social communications, and poor comprehension. Airline crew member can use simple strategies such as developing a good sleep routine, only using the bedroom for sleep, not ingesting alcohol or caffeine and not worrying or working preceding resting to improve sleep and lessen fatigue

Sleep and circadian factors are the primary underpinnings of human fatigue, and aviation schedules exert a powerful influence on both. Unfortunately, the regulations designed to manage fatigue in operational environments have not sufficiently emphasized these factors. Thanks to technological advances such as computerized fatigue models and sleep-tracking autography, we are now able to better consider the impact of scheduling factors on aircrews. These advances, when used in combination with behavioural counter-fatigue strategies, can significantly mitigate fatigue and improve operational safety.

When analysing daytime sleepiness, where the main cause is usually irregular work hours influencing the biological clock and the homeostatic regulation of sleep and wakefulness, variables that were associated were encouraging starts, fatigue and sleep protests, albeit just the last two had a predictive value for sleepiness. Once again, the role of sleepiness and fatigue were highlighted.

The sleeplessness reported by airline crew member's reflected the effects of their work schedules: night flights, jet lag, and successive early wake-ups. For long-haul flights, time pressure, number of legs per day, and consecutive days on duty contributed to increased sleeplessness with fatigue. There is strong need to consider chronobiology in the development of aircrew scheduling rules, as well as flight and duty time limitations to allow for the additional fatigue effects of multi-leg flights and work constraints in long-haul flights. At long last, pilots ought to be made mindful that the impacts of fatigue incorporate not only the self-reported reduction of alertness and attention, and lack of concentration, but also produces in them the signs that they observed in other crewmembers, including increased response times, small mistakes, a reduction of social communications, and bad air traffic control message reception.

The idea of airline head out inclines pilots to disturbed sleep schedules, however he calls attention to a few methodologies that can both anticipate a genuinely impaired pilot and moderate the results of an absence of sleep. There are some fatigue expectation models that can help decide the effect of work/lay schedules on pilot execution. Crew members ought to be instructed on sleep cleanliness so they can catch some remedial rest before obligation or during delays. On-board cockpit resting ought to be approved with the goal that pilots will have the option to make up for an absence of sleep. Also, new wearable sleep-following advances ought to be used to really quantify the pre-obligation and delay sleep of flight crews with the goal that they can all the more likely oversee and enhance their own sleep.

REFERENCE

- Akerstedt T, Wright KP Jr. Sleep loss and fatigue in shift work and shift work disorder. Sleep Med Clin. 2009; 4(2):257-71. https://doi.org/10.1016/j.jsmc.2009.03.001
- Caldwell JA. Fatigue in aviation. Travel Med Infect Dis. 2005; 3(2):85-96. https://doi.org/10.1016/j.tmaid.2004.07.008
- Goode JH. Are pilots at risk of accidents due to fatigue? J Safety Res. 2003; 34(3):309-13. https://doi.org/10.1016/S0022-4375(03)00033-1
- Ingre M, Van Leeuwen W, Klemets T, Ullvetter C, Hough S, Kecklund G, et al. Validating and extending the three process model of alertness in airline operations. PLoS One. 2014; 9(10):e108679. https://doi.org/10.1371/journal.pone.0108679
- Itani A. Saúde e gestão na aviação: a experiência de pilotos e controladores de tráfego aéreo. Psicol Soc. 2009; 21(2):203-12. https://doi.org/10.1590/S0102-71822009000200007
- Powell DMC, Spencer MB, Holland D, Broadbent E, Petrie KJ. Pilot fatigue in short-haul operations: effects of number of sectors, duty length, and time of day. Aviat Space Environ Med. 2007;78(7):698-701
- Banks S, Dinges DF. 2007. Behavioural and physiological consequences of sleep restriction. J Clin Med. 3:519–528
- Scott JPR, McNaughton LR, Polman RCJ. 2006. Effects of sleep deprivation and exercise on cognitive, motor performance and mood. Physiol Behav. 87:396–408
- Waters F, Bucks RS. 2011. Neuropsychological effects of sleep loss: implication for neuropsychologists. J Int Neuropsychol Soc. 17:571–586.
- Lieberman HR, Tharion WJ, Shukitt-Hale B, Speckman KL, Tulley R. 2002.Effects of caffeine, sleep loss, and stress on cognitive performance and mood during U.S. Navy SEAL training. Sea-air-land. Psychopharmacology. 164:250–261
- Harrison Y, Horne JA. 2000. The impact of sleep deprivation on decision making: A review. J Exp Psychol Appl. 6:236–249

- Gander PH, Mangie J, Van Den Berg MJ, Smith AAT, Mulrine HM, Signal TL. 2014. Crew fatigue safety performance indicators for fatigue risk management systems. Aviat Space Environ Med. 8:139–147.
- Akerstedt T. 2003. Shift work and disturbed sleep/wakefulness. Occup Med. 53:89–94.
- Horne JA, Reyner LA. 1995. Sleep related vehicle accidents. Br Med J. 310:565–567
- Reason J. 1990. Human error. Cambridge (England): Cambridge University Press.
- Moore-Ede M.2003. (Writer). Sleep, alertness, and fatigue among military personnel in Iraq. Lexington (MA):In I. Circadian Technologies (Producer)
- Dinges DF, Powell LW. 1985. Microcomputer analyses of performance on a portable, simple visual RT task during sustained operations. Behav Res Methods Instrum Comput. 17:625–655
- Lim J, Dinges DF. 2008. Sleep deprivation and vigilant attention. Ann N Y Acad Sci. 1129:305–322
- Dinges DF, Pack F, Williams K, Gillen KA, Powell JW, Ott G,E, Aptowicz C, Pack AI. 1997. Cumulative sleepiness, mood disturbance, and psychomotor vigilance performance Decrements during a week of sleep restricted to 4–5 hours per night. Sleep. 20:267–277
- Russo M, Sing H, Kendall A, Johnson D, Santiago S, Escolas S, Holland D, Thorne D, Hall S, Redmond D, et al. (2005). Visual perception, flight performance, and reaction time impairments in military pilots during 26 hours of continuous wake: implications for automated workload control systems as fatigue management tools. In Strategies to maintain combat readiness during extended deployments –a human systems approach (pp. 27–1,7–16). Meeting Proceedings RTO-MP-HFM-124, Paper 27.
- McNair DM, Lorr M, Droppleman LF. 1971. Profile of mood states manual. San Diego: Education and Industrial Testing Service
- Terry PC, Lane AM, Fogarty GJ. 2003. Construct validity of the POMS-A for use with adults. Psychol Sport Exerc. 4:76–92.
- Previc FH, Lopez N, Ercoline WR, DaLuz CM, Workman AJ, Evans RH, Dillon NA. 2009. The effects of sleep deprivation on flight performance, instrument scanning and

physiological arousal in United States air force pilots. Int J Aviat Psychol. 19:326–346

- Harrington JM. Health effects of shift work and extended hours of work. Occup Environ Med 2001;58(1):68-72
- Costa G. Shift work and occupational medicine: an overview. Occup Med 2003; 53(2):83-8.
- Figueiro MG, White RD. Health consequences of shift work and implications for structural design. J Perinatol 2013; 33:S17-S23.
- Arendt J. Shift work: coping with the biological clock. Occup Med 2010; 60(1):10-20.
- Haus E, Smolensky M. Biological clocks and shift work: circadian dysregulation and potential long-term effects. Cancer Causes Control 2006; 17(4):489-500.
- Zee PC, Goldstein CA. Treatment of shift work disorder and jet lag. Curr Treat Options Neurol 2010; 12(5):396-411.
- Åkerstedt T. Shift work and disturbed sleep/wakefulness. Occup Med 2003; 53(2):89-94.
- Sallinen M, Kecklund G. Shift work, sleep, and sleepiness-differences between shift schedules and systems. Scand J Work Environ Health 2010; 36(2):121-33.
- van Dongen HPA, Maislin G, Mullington JM, Dinges DF. The cumulative cost of additional wakefulness: dose-response effects on neurobehavioral functions and sleep physiology from chronic sleep restriction and total sleep deprivation. Sleep 2003; 26(2):117-29.
- Folkard S, Lombardi DA, Tucker PT. Shiftwork: safety, sleepiness and sleep. Ind Health 2005; 43(1):20-3.
- Achermann, P. (2004). The two-process model of sleep regulation revisited. Aviation, Space, and Environmental Medicine, 75(Suppl. 3), A37–A43.
- Caldwell, J. A., & Caldwell, J. L. (2003). Fatigue in aviation: A guide to staying awake at the stick. Burlington, VT: Ashgate Publishing Company.
- Caldwell, J. A., Caldwell, J. L., Brown, D. L., & Smith, J. K. (2004). The effects of 37 hours without sleep on the performance of F-117 pilots. Military Psychology, 16, 163–181.
- Caldwell, J. A., Caldwell, J. L., & Schmidt, R. M. (2008). Alertness management strategies for operational contexts. Sleep Medicine Reviews, 12, 257–273.

- Caldwell, J. A., Mallis, M. M., Caldwell, J. L., Paul, M. A., Miller, J. C., & Neri, D. F. (2009). Fatigue countermeasures in aviation. Aviation, Space, and Environmental Medicine, 80, 29–59.
- Caldwell, J. A., Mu, Q., Smith, J. K., Mishory, A., George, M., Caldwell, J. L., Brown, D. L. (2005). Are individual differences in fatigue vulnerability related to baseline differences in cortical activation? Behavioural Neuroscience, 119, 694–707.
- Command Flight Surgeon. (2005). Fatigue in naval aviation. Retrieved from https://www.netc.navy.mil/nascweb/sas/files/fatigue_in_naval_aviation.pdf
- Committee on Military Nutrition Research. (2001). Caffeine for the sustainment of mental task performance: Formulations for military operations. Washington, DC: National Academies Press.
- Dijk, D. J., & Franken, P. (2005). Interaction of sleep homeostasis and circadian rhythmicity: Dependent or independent systems? In M. A.
- Kryger, T. Roth, & W. C. Dement (Eds.), Principles and practice of sleep medicine (pp. 418–434). Philadelphia, PA: Elsevier Saunders.
- Dinges, D. F. (1990). The nature of subtle fatigue effects in long-haul crews. Proceedings of the Flight Safety Foundation 43rd International Air Safety Seminar (pp. 258–267). Arlington, TX: Flight Safety Foundation.
- Folkard, S., & Åkerstedt, T. (1991). A three-process model of the regulation of alertness and sleepiness. In R. Ogilvie & R. Broughton (Eds.), Sleep, arousal and performance: Problems and promises (pp. 11–26). Boston, MA: Birkhauser
- Hursh, S. R., Raslear, T. G., Kaye. A. S., & Fanzone, J. F. (2006). Validation and calibration of a fatigue assessment tool for railroad work schedules, Summary Report (Technical Report No. DOT/FRA/ ORD-06/21). Washington, DC: U.S. Department of Transportation, Federal Railroad Administration, Office of Research and Development.
- Hursh, S. R., Redmond, D. P., Johnson, M. L., Thorne, D. R., Belenky, G., Balkin, T. J., Eddy, D. R. (2004). Fatigue models for applied research in warfighting. Aviation, Space, and Environmental Medicine. 75(Suppl. 3), A44–A53.
- Lyman, E. G., & Orlady, H. W. (1981). Fatigue and associated performance decrements in air transport operations (NASA Contractor Report No. 166167). Moffett Field, CA: NASA Ames Research Center.

- Monk, T. (1994). Shift work. In M. H. Kryger, T. Roth, & W. C. Dement (Eds.), Principles and practice of sleep medicine (pp. 471–476). Philadelphia, PA: Saunders.
- Morgenthaler, T., Alessi, C., Friedman, L., Owens, J., Kapur, V., Boehlecke, B., Swick, T. J. (2007). Practice parameters for the use of actigraphy in the assessment of sleep and sleep disorders: An update for 2007. Sleep, 30(4), 519–529.
- National Research Council. (2011). The effects of commuting on pilot fatigue. Washington, DC: National Academies Press. Retrieved from http://www.nap.edu/catalog.php?record_id=13201
- National Transportation Safety Board. (1994). A review of flight crew-involved, major accidents of U.S. air carriers, 1978 through 1990 (NTSB Safety Study No. SS-94–01). Washington, DC: Author.
- National Transportation Safety Board (2010). Aircraft accident report: Loss of control on approach, Colgan Air, Inc., operating as Continental Connection Flight 3407, Bombardier DHC-8-400, N200WQ. (NTSB Report number NTSB/AAR-10/01, PB2010-910401). Washington, DC: Author.
- Neri, D. F., Oyung, R. L., Colletti, L. M., Mallis, M. M., Tam, P. Y., & Dinges, D. F. (2002). Controlled activity as a fatigue counter measure on the flight deck. Aviation, Space, and Environmental Medicine, 73(7), 654–664.
- Åkerstedt, T., Fredlund, P., Gillberg, M., Jansson, B. (2002). A prospective study of fatal occupational accidents—Relationship to sleeping difficulties and occupational factors. Journal of Sleep Research, 11, 69-71. doi:10.1046/j.1365-2869.2002.00287.x
- Artazcoz, L., Borrell, C., Benach, J. (2001). Gender inequalities in health among workers: The relation with family demands. Journal of Epidemiology & Community Health, 55, 639-647. doi:10.1136/jech.55.9.639
- Aviation Safety Network. (1997). Retrieved from http://aviation-safety.net/database/record.php?id=19971219-0
- Aviation Safety Network. (1999). Retrieved from http://aviation-safety.net/database/record.php?id=19991031-0
- Baum, A., Newman, S., Weinman, J., West, R., McManus, C. (1997). Cambridge handbook of psychology, health & medicine. Cambridge, UK: Cambridge University Press.

- Belza, B. L. (1995). Comparison of self-reported fatigue in rheumatoid arthritis patients and controls. Journal of Rheumatology, 22, 639-643.
- Boisard, P., Gollac, M., Valeyre, A., Cartron, D. (2003). Time and work: Duration of work. Dublin, Ireland: European Foundation for the Improvement of Living and Working Conditions.
- Butcher, J. N. (2002). Assessing pilots with "the wrong stuff": A call for research on emotional health factors in commercial aviators. International Journal of Selection and Assessment, 10, 168-184. doi:10.1111/1468-2389.00204
- Danish Airline Pilots' Association. (2011). How do Danish pilots experience working under the current subpart-Q regulations contained in EU-OPS? Copenhagen, Denmark: JP/Politikens Hus.
- Dembe, A. E., Erickson, J. B., Delbos, R. G., Banks, S. M. (2005). The impact of overtime and long work hours on occupational injuries and illnesses: New evidence from the United States. Occupational & Environmental Medicine, 62, 588-597. doi:10.1136/oem.2004.016667
- Gjerdingen, D., McGovern, P., Bekker, M., Lundberg, U., Willemsen, T. (2001). Women's work roles and their impact on health, well-being, and career: Comparison between the United States, Sweden, and The Netherlands. Women & Health, 31(4), 1-20.
- Goode, J. H. (2003). Are pilots at risk of accidents due to fatigue? Journal of Safety Research, 34, 309-313. doi:10.1016/S0022-4375(03)00033-1
- Harrington, J. (2001). Health effects of shift work and extended hours of work. Occupational & Environmental Medicine, 58, 68-72. doi:10.1136/oem.58.1.68
- Health and Safety Executive. (2002). Occupational ill-health age statistics (Information Sheet 2/02/EMSU). Retrieved from www.hse.gov.uk/statistics
- Kim, Y. G., Yoon, D. Y., Kim, J. I., Chae, C. H., Hong, Y. S., Yang, . . . Kim, J. Y. (2002). Effects of health on shift-work: General and psychological health, sleep, stress, quality of life. Korean Journal of Occupational and Environmental Medicine, 14, 247-256.
- Maruyama, S., Morimoto, K. (1996). Effects of long workhours and life-style, stress and quality of life among intermediate Japanese managers. Scandinavian Journal of Work, Environment & Health, 22, 353-359. doi:10.5271/sjweh.153

- Matthews, S., Power, C. (2002). Socio-economic gradients in psychological distress: A focus on women, social roles and work-home characteristics. Social Science & Medicine, 54, 799-810. doi:10.1016/S0277-9536(01)00110-1
- Nolen-Hoeksema, S. (2001). Gender differences in depression. Current Directions in Psychological Science, 10, 173-176
- O'Hagan, A. D., Issartel, J., Fletcher, R., Warrington, G. (2016). Duty hours and incidents in flight among commercial airline pilots. International Journal of Occupational Safety and Ergonomics, 22, 165-172.
- Sirois, B., Trutschel, U., Edwards, D., Sommer, D., Golz, M. (2009, September). Predicting accident probability from frequency of micro sleep events. IFMBE Proceedings Volume 25/IV 11th International Congress of the IUPESM Medical, Physical and Biomedical Engineering World Congress 2009, Munich, Germany.
- Swedish Airline Pilots' Association . (2011). How do Swedish pilots experience working under the current subpart-Q regulations contained in EU-OPS? Stockholm, Sweden: Axand Consultancy Agency.
- Vandeputte, M., de Weerd, A. (2003). Sleep disorders and depressive feelings: A global survey with the Beck Depression Scale. Sleep Medicine, 4, 343–350.
- Virtanen, M., Ferrie, J. E., Singh-Manoux, A., Shipley, M. J., Stansfeld, S. A., Marmot, M. G., Kivimäki, M. (2011). Long working hours and symptoms of anxiety and depression: A 5-year follow-up of the Whitehall II study. Psychological Medicine, 41, 2485-2494. doi:10.1017/S0033291711000171