THE WORKLOAD OF FLIGHT ATTENDANTS DURING SHORT-HAUL FLIGHT OPERATIONS: A SYSTEM ANALYSIS.

BY

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THESIS

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ABSTRACT

Background and aim: Flight attendants forms a significant part in 24-hour aviation industry. Flight attendant fatigue is a significant problem in the aviation industry as it continues to jeopardize the ability to fulfil important safety and security roles which is critical in performance duty of a flight attendant. However, little attention has been accomplished to the workload, working conditions and fatigue of flight attendants crew in transport aircraft. In addition, there is currently less research that have also embraced the problematic of smaller regional/commercial operation (short-haul flight operations) inducing fatigue among short-haul flight attendants as the nature of this operation are often characterised with high productivity expectations in a demanding environment with high time pressures resulting in high workloads and fatigue. Thus, flight attendant fatigue and workload is a worldwide challenge in this operational environment and less attention has been given to the determining factors.Therefore, the aim of the study was to determine the workload factors contributing to flight attendant fatigue during short-haul flight operations. **Methods (System analysis):** To achieve the research aim, the work system analysis, based on the Smith and Carayon-Sainfort model was chosen as the main research approach which was conducted in two ways; based on existing literature and secondly based on expert interviews. This method provided a systemic aspect to understand the whole work system of flight attendants work during short-haul operations in order to identify all the contributing factors to flight attendant fatigue and workload. **Results:** The literature analysis and the data from the expert interviews highlighted significant findings to flight attendant fatigue and workload. The reasons for flight attendant fatigue operating short-haul flights can be found at organizational, task, individual, environmental levels and tools and technologies and due to the interaction of the factors. The main factors of flight attendants' fatigue are thought primarily as a function of scheduling due to irregular, mixed schedules with early starts and late finishes, extended duty days (long working hours), as well as high workload, due to the short turnaround flights, the number of sectors flown in a single duty period and duty length and high jobs demands. In addition, flight duty and rest regulations, confined work space in the cabin, vibrations, noise and lighting, sleeping in an unfamiliar environment, family responsibilities all add to additional stress placed on the body which can influence workload and sleep and consequently influencing fatigue. **Conclusion:** Overall the study determined that flight attendant fatigue is a significant problem in modern industry of short-haul operations. Using this systematic approach (work system analysis based on the framework of the work system model developed by Smith and Carayon-Sainfort (1989) allowed for an accurate representation of the complexity of flight attendant work environment in short-haul aviation industries, thus contributed to an increased understanding of fatigue and risk factors that span the entire work system and aid in identifying the patterns in combination of work system variables that are associated with increased risk to flight attendant fatigue. Overall flight attendant fatigue is a product of interactions with the short-haul environment. It can have a negative impact on safety, performance and well-being. Therefore, it needs to be managed and dealt with in the near future.

Keywords: Flight attendants, fatigue, workload, short-haul, system analysis

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ACRONYMS/ABBREVIATIONS

FA	Flight attendant
FDP	Flight duty period
DP	Duty period
MMR	Mixed Method Research
SARA	South African Regional Aircraft
SACAA	South African Civil Aviation Authority
FAA	Federal Aviation Authority
CAA	Civil Aviation Authority
NASA	National Aeronautics and Space Administration
SD	Standard deviation
SHF	Short-Haul Flight
LHF	Long-Haul Flight
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFALPA	International Federation of Air Line Pilots' Associations
ALPA-SA	Airline Pilot Association of South Africa
AASA	Airline Association of Southern Africa
SEIPS	System Engineering Initiative for patient Safety
MEAD	Macroergonomics analysis and design
RCA	Root cause analysis
FTA	Fault tree analysis
FMEA	Failure modes effect analysis
OEM	Original equipment manufacturer
E/HF	Ergonomics and human factors
ASRS	Aviation Safety Reporting System
NTSB	National Transportation and Safety Board
TLX	Task Load Index
NASA-TLX	NASA Task Load Index
SP	Samn-Perelli

DEFINITIONS

Sectors defined as any flight which has a take-off and landing at different airports which are not less than 50 nautical miles apart in the last 24 consecutive hours (Civil Aviation Regulation, 2011).

Flight time is considered as the total elapsed time from the moment the aircraft first moved under its own power for takeoff, until the time it comes to rest at the end of the flight (Dinges *et al*., 1996; Civil Aviation Regulation, 2011).

Duty period Any continuous period which starts when a flight or cabin crew member is required by an operator to report for or to commence a duty whether on the ground or in the air and ends when that person is free from all duties (Dinges *et al*., 1996; Civil Aviation Regulation, 2011; Flight Time Limits, nd).

Duty Any task that flight or cabin crew members are required by the operator to perform, including, for example, flight duty, administrative work, training, positioning and standby when it is likely to induce fatigue (Dinges *et al*.,1996; Civil Aviation Regulation, 2011; Flight Time Limits, nd).

Flight duty period A period which commences when a flight or cabin crew member is required to report for duty that includes a flight or a series of flights and which finishes when the aeroplane finally comes to rest and the engines are shut down at the end of the last flight on which he is a crew member (Dinges *et al*., 1996; Civil Aviation Regulation, 2011; Flight Time Limits, nd).

Rest period A continuous and defined period of time that is uninterrupted, subsequent to and/or prior to duty, during which crew members are free of all duties and airport standby (Dinges *et al*., 1996; Civil Aviation Regulation, 2011; Flight Time Limits, nd).

Fatigue. A physiological state of reduced mental or physical performance capability resulting from sleep loss, extended wakefulness, circadian phase, and/or workload (mental and/or physical activity) that can impair a person's alertness and ability to perform safety related operational duties (Civil Aviation Regulation, 2011).

Flight crew/ aircrew members Both cockpit and cabin crew (Dijkshoorn, 2008).

Cabin Crew Crew members that are not flight crew members and are designated to perform safety duties in the passenger cabin in accordance with requirements of the operator and the Authority; qualified to perform cabin functions in emergency situations and enact procedures to ensure a safe and orderly evacuation of passengers when necessary. Equivalent Terms: Flight Attendant, Cabin Attendant, Steward (Civil Aviation Regulation, 2011).

Crew Member A member of either the Flight Crew or the Cabin Crew; when used in the plural (i.e. Crew members), refers to flight and Cabin Crew collectively. A person assigned by an operator to a duty on an aircraft during a flight duty period (Dinges *et al*., 1996; Civil Aviation Regulation, 2011).

Off blocks time is the time at the start of the flight when the aircraft first moves out of the gate (from departure gate) (Dinges *et al*., 1996; Flight Time Limits, nd).

On blocks time is the time when the aircraft finally comes to rest at the end of the flight (arriving at destination gate) (Dinges *et al*., 1996; Flight Time Limits, nd).

Schedule also known as a roster, is a list of planned shifts or work periods within a defined period of time; assignment of individuals to a roster or pattern of work (Dinges *et al*., 1996).

Micro-sleep A short period of time (seconds) when the brain disengages from the environment (it stops processing visual information and sounds) and slips uncontrollably into light non-REM sleep. Micro-sleeps are a sign of extreme physiological sleepiness (Blaivas *et al*., 2007).

Sleep dept Sleep loss accumulated when sleep is insufficient for multiple nights (or 24-hour days) in a row. It is also known as a period of extended wakefulness (Barkoukis *et al*., 2011; West and Egger, 2017).

Circadian rhythm is a daily alteration in a person’s behavior and physiology controlled by an internal biological clock located in the brain. Examples of circadian rhythms include body temperature, melatonin levels, cognitive performance, alertness levels, and sleep patterns (Barkoukis *et al*., 2011; Rosekind *et al*., 1996; Caldwell, 2005; Edery, 2000).

Shift Work is understood as a rotating or changing work hours. It also refers to any work pattern that requires an individual to be awake at a time in the circadian body clock cycle that they would normally be asleep (Barkoukis *et al*., 2011; Åkerstedt and Wright, 2009; Mellor, 1986; Maddox,1998).

Jet Lag Desynchronization between the circadian body clock and the day/night cycle caused by transmeridian flight (experienced as a sudden shift in the day/night cycle). Also results in internal desynchronization between rhythms in different body functions. Resolves when sufficient time is spent in the new time zone for the circadian body clock to become fully adapted to local time (Dijkshoorn, 2008; Samel *et al.,* 1995).

Window of Circadian Low (WOCL) Individuals living on a regular 24-hour routine with sleep at night have two periods of maximum sleepiness, also known as "WOCLs." One occurs at night, roughly from 3 a.m. to 5 a.m., a time when physiological sleepiness is greatest and performance capabilities are lowest. The other is in the afternoon, roughly from 3 p.m. to 5 p.m (Dinges *et al*.,1996; Flight Time Limits, nd).

Standby is a defined period of time at the airport, at the hotel or at home, during which a crewmember is required by the operator to be available to receive an assignment for a specific duty without an intervening rest period (Dinges *et al*., 1996; Civil Aviation Regulation, 2011; Flight Time Limits, nd).

Local night A period of eight hours falling between 2200 hours and 0800 hours local time (Flight Time Limits, nd).

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CHAPTER I

INTRODUCTION

1.1 Background/overview of the research

Fatigue is defined as a physiological state of reduced physical and mental performance capability because of sleep loss and workload, both mentally and physically (ICAO *et al*., 2015). Fatigue and associated risks and its management are very important topics for ergonomics in the transportation field (Horrey *et al*., 2011). Aviation by itself has been one of the fields where issues of fatigue showed greater impact, amongst other transportation means (Williamson *et al*., 2011).

The aviation industry heavily relies on 24-hour operations which resulted in an increase in demand for air transportation (Mikkelsen, 1998; Avers *et al*., 2011). This creates a great challenge to aircrew members as their duties have changed dramatically to support the 24-hour operation (Mikkelsen, 1998; Avers *et al*., 2011). There is an increase utilization rates of commercial aircrew members, with more hours of work and crew service and the consequence of less time off and sleep issues (Tritschler and Bond, 2010; Rosekind *et al*., 2000). Thus, the aviation industry recognizes workload as a significant prominent issue, as the nature of aircrew members job demands are often characterised with high productivity expectations in a demanding environment with high time pressures (Tritschler and Bond, 2010). Due to this aircrew members often experience high levels of fatigue (Tritschler and Bond, 2010). Workload is known to have a direct correlation to fatigue, thus poses a threat to aircrew and passenger safety as it might contribute to the risk of accidents (Tritschler and Bond, 2010). Hence, the concept of fatigue resumes a significant hazard in the aviation industry (Avers *et al*., 2009b; Vidotti *et al*., 2016). Studies have supported these concerns, with pilots and cabin crewmembers fatigue levels increasing significantly to unacceptable levels (Powell *et al.,* 2007; Powell *et al*., 2011). Fatigue has been cited as a cause in many aviation accidents and is a continuing problem facing aircrew member (both pilots and flight attendants) operating aircraft of all sizes (Printup, 2005; Caldwell, 2005), as it can impair individual's alertness and ability to safely operate an aircraft or perform safety-related duties, which in their performance is critical to both safety and security (Williamson *et al*., 2011; Caldwell, 2005; Stokes and Kite, 1994). In the aviation industry, fatigue has been identified as a risk factor for occupational safety, performance effectiveness and personnel well-being (Avers *et al*., 2011; Caldwell, 2005).

Flight attendants also known as stewards, cabin crew forms a significant part in transport aircraft as they provide service to passengers and ensure the safety and comfort of passengers during a flight. However little attention has been accomplished to the workload, working conditions and mental and physical fatigue of cabin crew as potential consequences of flight attendant job in transport aircraft. Flight attendant fatigue is a significant problem in the aviation industry as it continues to jeopardize their ability to fulfil important safety and security roles which is critical in performance duty of a flight attendant (Nesthus *et al*., 2007). Important safety and security roles of a flight attendant include; to ensure that no passengers in the aircraft gets injured for example, ensuring all passengers are seated with seatbelts fastened during turbulence phase of the flight, all hand on luggage are securely stored away and the galleys are secure prior to take-off. In addition, cabin crew are responsible for informing passenger of the aircraft safety procedures, control first aid, medical and emergency equipments. They also ensure that no foreign objects are onboard, and no activities occur that may interfere with normal progress of the flight (Holcomb *et al*., 2009). A fatigued flight attendant might pose a safety risk to passengers because fatigue can have detrimental effects on human performance capabilities (Avers *et al*., 2009a). It can cause flight attendants to forget performing simple safety and security related tasks such as to disarm or engage emergency doors, informing passengers safety procedures (putting on seat belts before take-off), giving passengers safety demonstration such as indicating emergency exits as well as failing to properly stow hand-on luggage and service items (Nesthus *et al*., 2007). It can also affect their alertness levels to respond to an emergency which can be an endangerment to passengers which could lead to incidences of accidents (Nesthus *et al*., 2007).

Studies into the causes of flight attendant fatigue have revealed that, independent of the type of operations (short-haul, long-haul or ultra-long range), they are all faced with its own unique fatigue issues (Bourgeois-Bougrine *et al*., 2003a). However, studies have shown that short-haul is perceived more fatigue inducing than long-haul flights due to the nature of job demands with tight schedules, high number of take-off and landing, multiple segments and short turnaround times between flights (Co *et al*., 1999). Therefore, sleep deprivation and high workload are known factors inducing fatigue during this occupation.

High workload is known to have a direct correlation to fatigue and has been shown to significantly influence fatigue among flight attendants operating short-haul flights, due to job/ task demands, which may put them at higher risk of fatigue and burnout (Caldwell *et al*., 2009; Avers *et al*., 2009b; Chen and Chen, 2014). This may have negative consequences on flight attendant performance and in-turn may impact passenger safety. However, it is not clear which factors contribute mostly to flight attendant fatigue during short-haul flights operation and where the workload lies in this profession as flight attendant fatigue operating short-haul operations are not well developed.

1.2 Statement of the problem/ research aim

There is currently less research that have embraced the problematic of smaller regional/commercial operation (short-haul flight operations) inducing fatigue among short-haul flight attendants as many of the research conducted have been associated with long-haul flight operations (international/ trans meridian operations). This is where tours of duty involve long sectors and travel across several time zones. Flight attendants are understudied occupational group, despite undergoing a wide and unique range of adverse job-related exposure. For example, they are often exposed to poor cabin air quality, sleep loss, heavy physical and mental job demands, verbal harassment, irregular work schedules, occupational noise and vibrations (Rayman, 2002; Grajewski *et al*., 2016; Griffiths and Powell, 2012; Ballard *et al*., 2006; Sharma, 2007). Therefore, flight attendant fatigue and workload is a worldwide challenge, less attention has been given to the determining factors. Understanding these factors is important and could help provide suitable working environment and manage the adverse outcomes of flight attendant fatigue and workload. Therefore, the aim of the study is to determine the workload factors contributing to flight attendant fatigue during short-haul flight operations.

Factors to consider are, dealing with small regional airports and airfields in South Africa having limited facilities that may be lacking embarkation and disembarkation infrastructure, increasing the responsibility and workload of single flight attendant. Fatigue from stress and workload due to the short turnaround flights, the number of sectors flown in a single duty period and duty length. The high frequency of take-off and landings to be performed per daily flight attendant schedule and number of passenger's movements in and out of the aircraft consequently implied per day, which would further compound workload and stress.

1.3 Project framing of the thesis

The research conducted forms part of the Denel SARA (South African Regional Aircraft) human capital development project, in a projected 24 passenger turboprop regional airliner, with the main focus on the fatigue and workload of flight attendants accommodated by SARA. Denel is a South African state-owned aerospace and defense technology firm, that has been designing, modifying as well as manufacturing aircrafts for more than 50 years (Campbell, 2016; Mogoba, 2018). Denel started developing aircrafts for pre-democracy South Africa. Thereafter, during the sanction's era, Denel developed Africa's first indigenous attack helicopter called the Rooivalk (Red falcon) (Mogoba, 2018; Denel, n.d.). Denel also developed the Oryx medium transport helicopter as well as the Cheetah fighter aircraft to mention a few (Martin, 2018; Mogoba, 2018; Denel, n.d.). In addition, Denel also focused on commercial aviation. Denel is well-known for being one of the airbus best contractors. Overall Denel has world leading aerospace competencies and capabilities for example, engineering, advanced manufacturing, design and airworthiness and systems integration (Mogoba, 2018). It also has original equipment manufacturer (OEM) accreditations for repair, maintenance and overhaul globally (defenceWeb, 2017; Denel, n.d.).

In the year 2012 Denel began to develop the concept of a regional aircraft, the Denel SARA (South Africa regional aircraft) project (Martin, 2018; Campbell, 2016). The SARA project forms part of the future aerospace development of South Africa with the main aim to promote aviation growth in particular growth in the development for regional air transport in Africa as well as in South Africa (Martin, 2018). It was also developed to enable future travelers that have the desire to commute on smaller aircrafts to avoid congestion on major routes (Martin, 2018). In addition, the objective of this project is to enable small outlying communities to connect with larger cities, thus connect with global economy.

Some characteristics and features of DENEL SARA aircraft include, a four-abreast seating layout, it is built with a pressurized cabin and will have a maximum take-off and landings (Martin, 2018; Mogoba, 2018). The short-haul duty cycle of SARA consists of completing 4 to 5 fairly short flight sectors (legs) per day, on rough field capabilities (low density routes). Their flight time per sectors ranges from approximately 45 min to 105 minutes, but with majority of sectors in the 45 minutes to 75-minute range. The daily route for each sector is characterize by local (operate in one region of the country), small regional airports and airfields as well as larger airfields. The departing airport of the initial sector and the destination airport on the final sector are the same.

1.4 Significance of research

Workload and fatigue in flight attendants operating short-haul flights is a current issue in the aviation industry. Research has proven that fatigue leads to degradation in performance, poor decision making, slowed reaction time, reduced vigilance, poor communication and much more (Rosekind *et al*., 1996). Fatigue is a factor that has been linked to performance declines in aircrew members. Due to the nature of the profession, flight attendants are extremely susceptible to fatigue, which may affect their ability to perform their duties safely. Workload and fatigue occur from a variety of interrelated factors, it is important that all factors present in a workplace are understood in understanding and determining the underlying fatigue risk factors. Therefore, understanding the contributing factors to fatigue and workload among short-haul flight attendants requires not only an assessment of specific aspects of work system, but more importantly a deep understanding of work system interaction (Wilson, 2000). As interrelationships among causal factors, increase high workload and fatigue and as an outcome, there is a decrease in safety, well-being and productivity. Knowledge and awareness of the contributing factors to flight attendant workload and fatigue during short-haul operations and how these factors impact and influence performance duty of flight attendant will help to predict, prevent and mitigate the occurrence of fatigue experienced among short-haul flight attendants, thus providing a suitable working environment for them.

1.5 Thesis outline

The following chapters are structured as follows:

Chapter 2 (Literature review) covers the background to understanding systems ergonomics, aviation ergonomics, the concepts of fatigue, aviation fatigue and flight attendant fatigue. In addition, it highlights different system analysis theory methods.

Chapter 3 (Methods) focusses on the concept, design and methodological procedure that has been chosen for the current study.

Chapter 4 (Results) highlights the results gathered from the system analysis based on the method chosen (Literature data and expert interview data).

Chapter 5 (Discussion) discusses the findings of the study, it discusses issues and insights that have been identified in this work, along with the limitations of the study as well as paths for future research.

Chapter 6 (Conclusion) concludes the thesis with a summary of the work presented in previous chapters.

CHAPTER II

REVIEW OF LITERATURE

2.1 Overview of the chapter

This chapter summarises the literature related to the current study. It aims to provide the necessary background for understanding systems ergonomics, aviation ergonomics, the concepts of fatigue, aviation fatigue, flight attendant fatigue and workload and examines the factors that are known to contribute to flight attendant fatigue and highlights different system analysis theory methods.

The first section (section 2.2) examines the basic concepts of systems ergonomics which include an overview of systems, systems theory and human factors/ergonomics. Section 2.3 outlines the concept of aviation ergonomics including a historic overview of human factors in aviation. Section 2.4 outlines the basic concepts of fatigue, which includes the dimensions of fatigue, causes and consequences of fatigue and how it applies within the aviation context. Section 2.5 outlines the concept of circadian rhythm, and sleep which are known factors affecting aircrew member fatigue. Section 2.6 outlines the concept of workload. Section 2.7 focusses on flight attendant fatigue. This section outlines the general duty of the flight attendant, what are the known causes of flight attendant fatigue in general and how it affects performance duty of a flight attendant. In addition, it highlights incidences and accidents associated with flight attendant fatigue. Section 2.8 outlines the various system analysis theories and methods available when understanding either failure of systems, errors and accidents as well as outcomes such as fatigue. The chapter ends with the summary of the chapter (section 2.9).

2.2 Systems ergonomics

A system is an interacting set of distinct parts within a boundary which function to reach a common goal (Wilson, 2014). They are often linked with other larger or smaller systems (Wilson, 2014). Each element has an effect on the functioning of the whole. Each element is affected by at least one other element in the system. All possible subgroups of elements also have the first two properties (Wilson, 2000). Chapanis (1996) defines a system as equipment systems. This implies an interaction between different level of complexity such as interactions of materials, software, people, tools, machines, facilities and procedures (Chapanis,1996). He also defines system as an organized whole (Chapanis, 1996). Singleton (1974) defines systems that change over time, having similar objects. He also defines systems as a human-made system as well as a system having a purpose (Singleton, 1974). Systems can be simple, complex, open or close (Cordon, 2013).

Systems theory suggests that when there is a problem with one component in the system that we cannot isolate that component but takes a holistic approach and view the whole system to understand what the problem could be and considering every system element as much as possible including both the input and output (Wilson, 2000; Wilson, 2014). Systems theory brings a holistic viewpoint to the organization and removes the individualistic mind-set or island mentality that everyone operates independently of each other (Mele *et al*., 2010). It also takes into consideration all possible sources of the problem and examines each individually and what role they play in the system (Mele *et al*., 2010). Holism concept refers to systems as seen as a whole (Wilson, 2014). For example, it examines and understands the cognitive, social, emotional and physical characteristics of individuals/people to improve and understand the connections they have with different parts of the system such as other people, environment, information and artefacts (Wilson, 2014). The main objective of the concept of holism is to produce safety benefits and enhance system efficiency and reliability (Wilson, 2014). System theory is also a way of understanding the interaction among systems (Wilson, 2014). Distress in a system pushes other elements causing reciprocity. One bad thing can lead to another however, it can work in both ways, therefore when understanding systems, it is not that simple we must acknowledge the complexity. Humans plays an essential role in a system, because it is not only to be part of the system but also shape the system (Hollnagel, 2014).

Ergonomics also known as human factors is the study of ways in which working conditions can influence the effectiveness of a task being done, looks at both organizational and human aspects that could contribute to job performance (Salvendy, 2012). In other words, human factors refer to the study of man in his working environment. It highlights the interaction between individual and other components in a complex system (the work environment) (Salvendy, 2012). Ergonomics/ human factor focuses on systems in which humans interact with their environment (Dul *et al*., 2012). According to IEA (2018) "Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theoretical principles, data and methods to design in order to optimize well-being and overall performance". Human factors is concerned with the human component of the system, the performance of the workforce and the effect other system components have on human's ability to perform his/her job/work effectively (Dul *et al*., 2012). It plays apart in the design of a variety of different systems with people for example; product/service systems (where the human is a product user or person who receives a service and the environment is the environment where the product is used or where the service is received) and work systems (where the human is a worker and the environment is the work environment) (Dul *et al*., 2012). This thesis will mainly focus on the work system, in particularly analyse short-haul flight attendants work system.

Ergonomics/human factors is characterized of having three fundamental characteristics which include, being design driven, it focusses on performance and well-being (two closely related outcomes) and it takes a systems approach which means that it is system focused (Dul *et al*., 2012; Norros, 2014; Hollnagel, 2014). Design refers a process or activity of designing instead of the design as a product or outcome. In addition, design refers to organizing or shaping something in a specific way in order to do things easier (Dul *et al*., 2012). Human factors/ergonomics is design driven which implies that through a systems design, performance and well-being can be improved (Dul *et al*., 2012; Hollnagel, 2014). In addition, E/HF can be associated with/concerned with all stages of design, evaluation, redesign, planning, maintenance and improvement of systems (Dul *et al*., 2012). System focus implies that it focuses on systems and human integrating within the system, rather than the main emphasis on the human itself (Wilson, 2014; Hollnagel, 2014). It also examines the design of natural systems.

Systems discipline is an important concept of ergonomics/ human factors as it states that good ergonomics is systems ergonomics (Wilson, 2014). System ergonomics also known as system human factors looks at the interactions of humans within the design of system (Wilson, 2014). It also accounts for and enhances the design of systems. Therefore, it does not examine an individual within a system in isolation (Wilson, 2014). These systems can be a work site, environment, artefact, society, buildings, community, organization or a group (Wilson, 2014). System ergonomics understands the context and settings of systems where human perform their work, to better understand how humans interact with each other and how they interact with their environment (Moray, 1994; Cordon, 2013). Sheridan (2014), states that system ergonomics is defined as a theory and application of human biomechanical and analyse people and machines within a complex technical system. She further defines system ergonomics as a method of system analysis (Sheridan, 2014).

The understanding of system ergonomics/human factors is a key to the ergonomics/human factors profession such as aviation. The discipline of human factors emphasizes interactions between people and their environment that contribute to performance, safety and health, and quality of working life, and the goods or services produced (Wilson, 2014). Ergonomics/ human factors in the aviation industry is important for the safety, efficiency and well-being of commercial airlines, aircrew members and passengers (Dumitru and Boşcoianu, 2015; Stanton *et al*., 2017).

Understanding human factors from a systems perspective and its knowledge of human capability and limitations is essential to optimize human performance. The knowledge about human abilities, behavioral patterns, limitations and characteristics to the design of person-machine systems (which is a system that involves an interaction between people and other system components such as work structure, tasks, environment and hardware) are the main focus of human factors (Salvendy, 2012). Human performance in complex work systems can only be understood as human interaction within the broader context of work which includes the physical environment, work procedures and practices, technology and psychosocial elements and the environment (Carayon *et al*., 2015). Therefore, human factors concepts and processes can be essential in understanding the causes of fatigue and workload. In addition, understanding interactions between physical, cognitive and many more sub-systems could also highlight how these interactions could further the understanding of fatigue and workload (Marras and Hancock, 2014). Therefore it is essential that performance examines both levels, the individual worker and at the systems level of organizational factors (the design, policies and procedures) including the task (looking at type of task performed by an individual and how they affect worker performance/ what task do individuals perform in their daily work routine?), facilities and equipment (looks at the tools, equipment and facilities used and how they work), and the environment (understanding the physical environment people work in) (Dul *et al*., 2012).

System approach is an important concept, because it helps in understanding overall effectiveness and efficiency as it identifies and understands interrelated processes as a collective system (Wilson, 2014). For example, it looks at current working conditions and living environments which contributes to increases in complexity of systems. Due to this it may cause significant changes within a system (Norros, 2014). As a result, this may cause unexpected situations such as human errors, fatigue, workload, injuries, performance decreases and accidents (Norros, 2014). According to Zink (2014), it is important to look at a broader perspective when examining working conditions in a whole and systems of systems analyzing to understand an organization (Zink, 2014). Therefore, system ergonomics approach played a vital part in this research to identify factors that contribute to flight attendant fatigue during short-haul flight operations, because as stated by Techera *et al*. (2016), fatigue is a product of complex interactions.

2.3 Aviation ergonomics

Air transport is considered one of the world's most important industries, as it plays a vital role as a mode of transport for short and long-distance travel (Daley, 2016). It provides the fastest mode of transport between cities locally and on an international scale (Daley, 2016). It provides an avenue for people to travel for business and tourism, thus generating economic growth (Daley, 2016).

Aviation is a complex system characterized with environment, people and technology (Chialastri, 2011). In complex and dynamic systems such as the aviation system, human factors and ergonomics is considered an important concept/aspect (Shorrock and Williams, 2016). This is because, human describes all aspects of human performance which interact with the environment (aviation environment) to influence the outcomes of events (Shorrock and Williams, 2016). Thus, human performance is seen as an efficiency or productivity and safety-critical activity. In the aviation context, human performance is equated with operational safety (Shorrock and Williams, 2016; Lauber, 1989).

According to Perezgonzalez (2009)**,** ergonomics plays an essential role in aviation particularly in aviation safety, because it reduces human error due to stressful working conditions or poorly designed equipment. In addition, ergonomics also helps to enhance aviation safety by maximizing human performance in different conditions (either abnormal or normal conditions) (Perezgonzalez, 2009). Human factors in the commercial aviation industry has become a common topic, this is because human error is a principle cause to most aviation accidents and incidents rather than mechanical failure (Shappell *et al*., 2007). Human factors are considered as a human condition such as fatigue, stress and many more (Yeow *et al*., 2014). In the aviation industry human factors research main objective is to identify and optimize factors that affect human performance (Salvendy, 2012). Therefore, it is concerned with the study of behaviors, human capabilities as well as limitations of operators in the system in order to enhance human performance, safety and well-being (Hopkin *et al*., 2016).

Ergonomics and human factors (E/HF) in the aviation industry have been seen to have long history, methodology, theory and application (Stanton *et al*., 2017). It has developed from the investigation of individual pilots' activities to crew resource management and considers research in entire aviation systems (Stanton *et al*., 2017). It has moved from focusing from individual task to examining the entire system. In addition, it focusses on factors that create constraints in behavior and in the culture of organizations (Stanton *et al*., 2017). According to Harris and Stanton (2010), aviation is considered a system of systems, in particular a sociotechnical system of systems that is characterized by human factors such as workload, fatigue, design, safety, maintenance, communication as well as automation (Harris and Stanton, 2010). Therefore, ergonomics in aviation should address all aspects of the aviation system and examines issues from a sociotechnical system perspective or takes a macro-ergonomics approach to address issues related to safe operations of aircraft or related to human performance (Harris and Stanton, 2010).

In order to understand human factors in aviation, this section will unpack on the historical overview of human factors in aviation. In the premature days of aviation, the role of human factors in aviation examined the well-being and safety of aircrew members (Hopkin *et al*., 2016). This is because there was a rapid development in the expansion of vehicles (aircrafts), thus responding to the vehicle and the environment to control it effectively in order to ensure safety of flights, resulted in the aircraft exceeding the human capability (Hopkin *et al*., 2016). This has resulted in major problems to well-being and safety of operators (Hopkin, *et al*., 2016). Thus, aviation ergonomics accepted its place in the human factors research field with its main focus on improving safety in aviation.

Aviation ergonomics research were predominately concerned with the design of aviation systems such as cabin and cockpit technology design (Maurino and Salas, 2010). Pre-world war I, the main objective of aviation was concerned with adventure and discovery, focusing on learning how aeroplanes fly (the mechanics and engineering of the aircraft) (Hopkin, *et al*., 2016). Thus, human factors were not seen as a common concept and scientific discipline at that time, however, there were problems associated to human factor in the early stages of flight (Hopkin, *et al*., 2016). These problems include strength and stability of airframe which have resulted in fatal accidents because of the structural element of airplane failure as well as engine failure (Hopkin, *et al*., 2016). During World War I, aeroplanes played a significant role to the war, as the aircrafts were used as battle field observation platforms (Monga, 2017). However, problems associated with human factors emerged among pilots during this era as pilots had to have special abilities to operate in a variety of climate conditions and the effect altitude would have on pilot performance (Hopkin, *et al*., 2016). Other problems were concerned with the design of equipment to ensure effectiveness and safety of mission as well as physiological stresses placed on pilots (Hopkin, *et al*., 2016).

During, World War II, in the late 40s and early 50s ergonomics/human factors became a major field of study (Monga, 2017). This is because there was a rapid expansion of technologies for the development of airplanes (Advancement in engine and airframe technologies after world war I aircrafts) (Hopkin *et al*., 2016). In addition, WWII commercial aviation became widespread, as the aircrafts during this era were characterized of being heavily weaponized in order to partake in the war (Monga, 2017). Due to this, it created even more problems placed on the operators/individuals, as operators often found it difficult to adapt to the designs of the aircraft (Monga, 2017). Thus, led to crashes and accidents (Monga, 2017). Environmental factors such as extreme high altitudes, cold and heat also became major challenges to the design for safety and performance of aircrew members (Hopkin *et al*., 2016). Human capabilities and skill also exceeded their abilities to operate the newly designed aircrafts. In addition, the aircrafts during this era were also noisy which made speech communication more difficult (Hopkin *et al*., 2016). There was also a great deal of aircraft vibrations. These contributed to the onset of pilot fatigue. In general, WWI and

WWII aircrafts lacked an understanding of the characteristics and limitations of people who were responsible for operating the aircraft (Monga, 2017).

Post war, jet aircrafts became a major factor for military airplanes (Hopkin *et al*., 2016). During civil and military aviation activity, human technological climatic interface was an important issue as day and night seasonal extremes can impact on human performance (Hopkin *et al*., 2016). In addition, past war until the 1970s aviation research focused on pilot's mental ability to perform tasks under fatigue. Thus fatigue, pilot information processing abilities and spatial disorientation became common topics in research (Monga, 2017).

By early 1990s and early 2000s modern aircrafts, cockpit organization, crew interaction, automation as well as crew fitness (cabin crew and pilots) slowly established its place in human factors research field (Maurino and Salas, 2010; Monga, 2017). Researchers started to examine all aspects of the aviation industry such as organizational structure, maintenance, air traffic, pilot and cabin crew performance and instrument design and many more, all of which the main focus was to improve safety (organizational safety), efficiency and cost savings in the aviation industry (Maurino and Salas, 2010; Monga, 2017). Today with the improvements in safety and efficiency of operation been successful the aviation industry began to expand (Maurino and Salas, 2010). Thus, there were vast advances in technology, organizational structure and operations. This led to the expansion of additional demands/extra demands in the aviation industry such as greater demand for flights and operational adjustments (Maurino and Salas, 2010). As a consequence, changes occurred within the aviation such as changes in pilot and other aircrew members (flight attendants) roles in the aviation system, which had an impact on human performance and led to human factors implications (Maurino and Salas, 2010). One such implication is high workload and aircrew fatigue (Maurino and Salas, 2010). Therefore, understanding human factors related issues such as fatigue and workload became a specific concern to the aviation community.

2.4 Defining fatigue

2.4.1 Dimensions of fatigue

The term fatigue is widely used in many occupation and industries and in general refers to a state of tiredness that leads to mental and physical exhaustion that prevents people from functioning within normal boundaries (Techera *et al*., 2016). The condition of fatigue is experienced by every human being either during work or leisure time (Williamson *et al*., 2011). Fatigue can be classified as acute and chronic fatigue (Techera *et al*., 2016). Acute fatigue refers to a consequence of bodily or mental labour, insufficient recovery or emotional stress (Techera *et al*., 2016). It is a result from short-term sleep loss or short periods of heavy physical work or mental work (Techera *et al*., 2016). The effects of acute fatigue are of short duration and can be reversed by sleep and relaxation (Techera *et al*., 2016). Conversely chronic fatigue refers to long-continued fatigue, severe state of tiredness (Techera *et al*., 2016). The symptoms are similar to those produced by acute fatigue; however, it is experienced constantly and cannot be reversed by rest alone (Jason *et al*., 2010). Fatigue can also be classified as physical or mental fatigue (Brown, 1994). Mental fatigue is defined as psychobiological state caused by prolong periods of demanding cognitive activity characterised by feeling of lack of energy and tiredness (Boksem and Tops, 2008). Mental fatigue further decreases the ability to process and respond to information, causing a decrease in productivity and competency (Lorist *et al*., 2000; van der Linden *et al*., 2003). Muscular (physical) fatigue refers to a decrease in physical ability to exert a force or perform a task as a result from extended physical activity and high-intensity work (Jason *et al.,* 2010). Both types of fatigue can result in decrements in task performance (Davies and Parasuraman, 1982). This multidimensionality construct of fatigue itself, makes it difficult to assess or describe fatigue and thus has been critiqued as ‘vague’ (Åkerstedt *et al*., 2004; Dodge, 1982; Winget *et al*., 1984). However, despite the difficulty in assessing and describing fatigue due to the multiple factors and dimensions involved, it still occurs and therefore deserves to be studied.

Fatigue has been associated with stress, safety, and performance declines and is recognized as one of the major contributing factors to injuries, accidents and deaths in numerous work environments which often results in people less likely to produce safe performance and actions (Williamson *et al*., 2011). The numerous work environments that may be affected by fatigue include, many occupational settings such as emergency operation, hospitals, teaching as well as in many transport operations such as road, rail, aviation and many more (Williamson *et al*., 2011). The aviation industry is greatly dependent on 24-hour operations; thus, operational capabilities and technology have advanced in such a way that allows continuous activity to support 24-hour demands (Dinges *et al*., 1996; Co *et al*., 1999). Due to this, the industry has undergone a significant change to the internal structure of work (Dinges *et al.,*1996; Co *et al*., 1999). For example, irregular work hours and the concept of shift work have been established, as a result many people work early morning shifts, night shifts, and extended duty hours (Dinges *et al.,*1996; Co *et al*., 1999). However regardless of the economic benefits affiliated with these scheduling changes, they can have a detrimental effect on individual performance (Co *et al*., 1999), as humans are not designed to operate 24/7 schedules that describes todays aviation operations (Caldwell, 2012). Therefore, one of the major complaints of this occupation among aircrew members is fatigue, thus fatigue remains a significant problem in modern aviation operations (Dinges *et al.,*1996*;* Co *et al*., 1999).

In the aviation industry, fatigue has been addressed by several studies and documents' proving it is a major concern with the need to identify hazards associated with fatigue as risks to flight and crew safety (Dinges *et al.,*1996; Williamson *et al*., 2011; Caldwell, 1997). Fatigue in the aviation environments is defined as a physiological state of reduced physical and mental performance capability as a result of sleep loss, sleep deprivation and workload, both mentally and physically (ICAO *et al*., 2015). This is the most contemporary and commonly used and accepted definition of fatigue by aircrew members' worldwide (ICAO *et al*., 2015). Fatigue has been noted as a common cause in many aviation accidents and commonly affects aircrew member (both pilots and flight attendants) operating aircraft of all sizes (Printup, 2005; Caldwell, 2005). Significant evidence has shown that cabin crew/flight attendants and pilot fatigue has been the primary factor in several air incidents and accidents around the world (Neville *et al*., 1994; Samel *et al*., 1995; Caldwell, 2001).

2.4.2 Causes of fatigue

Fatigue is a major risk in the aviation, thus an understanding of the causes of fatigue is important, which may help reduce the risk of fatigue in the aviation industry.

In general fatigue in a variety of workplaces can be manifested from a variety of factors, these include work-related factors such as roster patterns, length of shifts, poor work scheduling, length of time worked, insufficient recovery time, long periods of time awake and inadequate rest breaks (Williamson and Friswell, 2013; Techera *et al*., 2016). In addition, fatigue is defined as a person not just characterised by symptoms of feeling drowsy or sleepy but consist of elements of workload relating to how hard and how long one has been working. Thus, workload has been shown to be one of the main work-related factors contributing to fatigue. Workload is closely related to the job/task demands required to perform a specific work task (MacDonald, 2003a). These tasks demand can be mentally or physically demanding work, which can often put a strain on the body and mind of individuals, especially tasks that requires a lot of attention, memory or pushing, pulling and lifting heavy objects (Techera *et al*., 2016). However repetitive or monotonous tasks which are seen as low workload can result in boredom, which ultimately contributes to fatigue (Williamson *et al*., 2011). This is because, the tasks produce low arousal and lack stimulation making it difficult to maintain alertness and attention, which facilitates sleepiness (Carskadon and Dement, 1987). Excessive exposure to physical environmental factors of a workplace such as excessive temperature, humidity, vibrations, low light and noise can significantly affect individual's vulnerability to fatigue (Sadeghniiat-Haghighi and Yazdi, 2015). Fatigue can also be caused by factors outside work such a poor sleep quality, sleep loss, social life, family needs or from combination of all and may accumulate over time (Williamson and Friswell, 2013; Techera *et al*., 2016). Overall fatigue can be described as a product of complex interactions. The causes of fatigue are multifaceted. The complex interaction of different factors contributing to fatigue and the effects of fatigue can be seen in Figure 1 which highlights the complexity of the relationship of the causes of fatigue as well as the consequences of fatigue (Techera *et al*., 2016). Thus, fatigue is difficult to define because it is so multifaced.

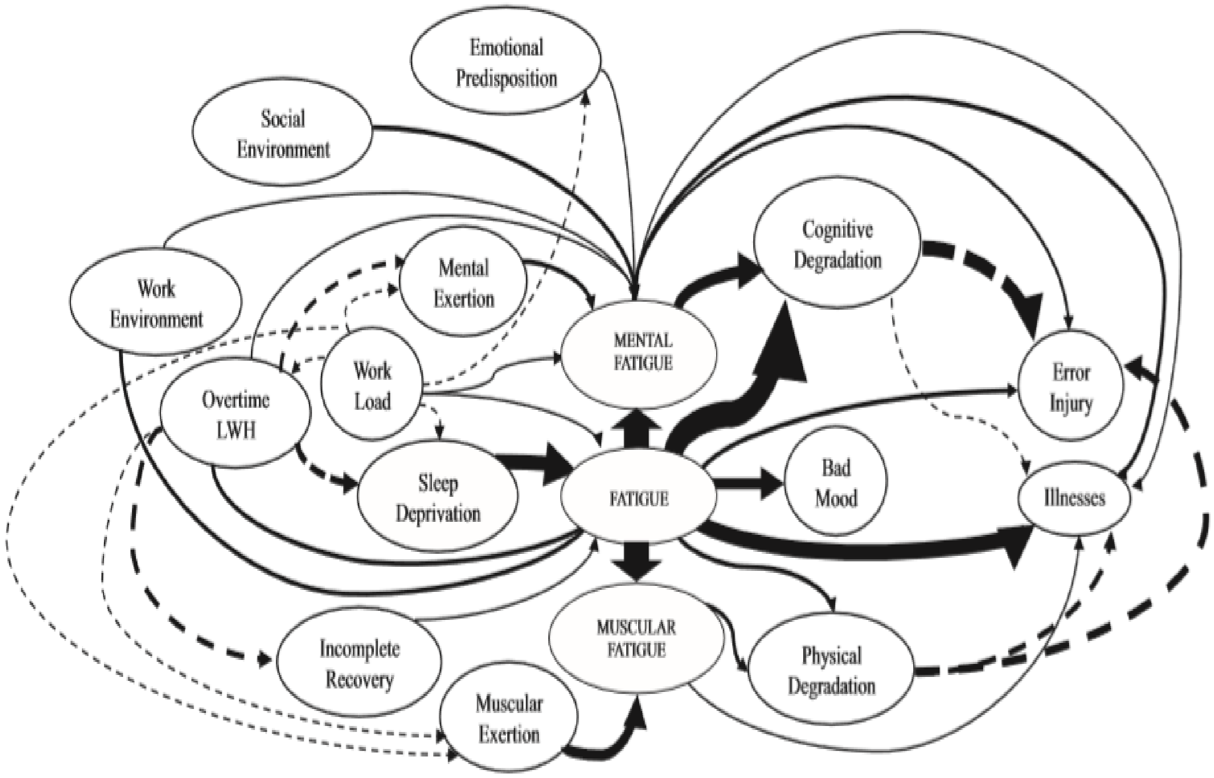

Figure 1: The system model highlighting the relationship between the causes and the effects of fatigue (taken from Techera *et al*., 2016, pp. 8).

Fatigue in aviation is a complex phenomenon that has a range of causal factors (Akerstedt, 2000). The interrelationships among causal factors can increase workload and fatigue and as an outcome there is a decrease in safety, well-being and productivity. Sleepiness and tiredness are considered the largest identifiable cause of accidents in transport operations (Akerstedt, 2000). Travelling over multiple time zones in a single day poses significant challenges to sleep and circadian physiology, which results in aircrew fatigue (Bourgeois-Bougrine *et al.,* 2003a), however operational demands largely due to unpredictable working hours (extended work days, long duty hours and early report times), limited time off, rotating and non-standard work shifts, jet lag, reduced sleep opportunities, circadian disruptions and increase workload levels continue to pose significant challenges among aircrew members and fatigue-related concerns to air safety (Bourgeois-Bougrine *et al*., 2003a; Neville *et al*., 1994; Samel *et al*., 1995). Factors such as stress, anxiety and poor health have also been identified as a cause inducing fatigue in the aviation environment (Maymand *et* *al*., 2012; Stokes and Kite, 1994). In addition, contributing aircraft environmental factors such as noise, low light levels, vibrations, movement restriction, and altitude (poor air quality) have been shown to induce fatigue levels among aircrew members (Dijkshoorn, 2008).

Studies into the causes of fatigue in aviation among aircrew members have also revealed that, independent of the type of operations (short-haul, long-haul or ultra-long range), they are all faced with its own unique fatigue issues (Bourgeois-Bougrine *et al*., 2003a). International operations also known as long-haul operations are characterised of having one or two long segments and travel long distances (Rosekind *et al*., 1994). The flight lengths typically require more than 6 hours and are often non-stop flights (Roach *et al*., 2012). Regional operations are quite different from medium and long-haul operations. Regional airline operations also known as short-haul operations, is a growing segment of commercial air travel industry, however it poses significant challenges regarding human fatigue (Co *et al*., 1999). Regional operations generally operate in one region of the country, it is characterised by short distance travel (flight length ranges between 30 mins to 3 hours), smaller aircrafts, short turnaround times and multiple flight segments (Co *et al*., 1999).

Fatigue during international flights is mainly due to time zone differences and flight duration (long duty times) (Bourgeois-Bougrine *et al*., 2003a). The short-distance nature of regional operations results in multiple flight segments, high frequency of take-off and landing, relatively high workload such as, high frequency of on-board services (serving beverages or meals) and short turnaround times between multiple flights ranging from 15 to 35 minutes, are all potential fatigue inducing factors for reginal operators (Nesthus *et al.,* 2007; Co *et al*., 1999). However, both short-haul and long-haul aircrew members report fatigue as a result from multiple flight legs, early wake times, consecutive duty days, insufficient recovery sleep periods, time demands and high workloads (Bourgeois-Bougrine *et al*., 2003a).

Long-haul scheduled flights involve multiple duty days including one or more days of layover, followed by several days off (van Drongelen *et al*., 2013; Samn and Perelli, 1982). Conversely short-haul schedules involve 3 to 4 successive days, followed by 1 or 2 days off (van Drongelen *et al*., 2013). Due to this, the days off in between may not be sufficient to recover from the days on duty, thereby may induce a cumulative fatiguing effect and increasing the risk of accidents over successive duty days (van Drongelen *et al*., 2013; Samn and Perelli, 1982; Folkard and Åkerstedt, 2004). According to Gander *et al*. (1994), time constraints, high number of legs per day, consecutive work days seemed to increase fatigue in short-haul flights among air crewmembers. Several studies have shown that short-haul operations are perceived more fatigue inducing than long-haul operations (Bourgeois-Bougrine *et al*., 2003a). Therefore, the aspect of short-haul flight operations inducing fatigue will be the main focus of the study.

2.4.3 Consequences of fatigue

Fatigue has a very real detrimental impact on safety in many occupations and industries (Caldwell, 1997). It significantly affects a person’s ability to function and the effects of fatigue include poor performance and productivity, and an increased risk of injuries and stress-related diseases (Caldwell, 1997). Fatigue directly affects individuals physical and mental abilities needed to carry out simple tasks and decision making (Techera *et al*., 2016). It reduces vigilance, impairs concentration, affects reaction time, decreases alertness, causes cognitive degradation and results in poor communication, increasing organizational risks and creates a direct link with incidents and accidents (Akerstedt, 1995; Rosekind *et al.,* 1996; Techera *et al*., 2016).

Fatigue in aviation, is a big scourge to flight safety and flight operations (Griffiths and Powell, 2012), as it can impair individual’s alertness and ability to safely operate an aircraft or perform safety-related duties, which in their performance is critical to both safety and security to passengers (Williamson *et al*., 2011; Caldwell, 2005; Stokes and Kite, 1994). In addition, it often reduces a person’s ability to focus and hold attention on the task being performed. Crew members’ fatigue might threaten passenger safety and personal health as it can affect their ability to react to or assess safety threats to passengers and crew, crew members may forget to inform safety procedures to passengers, they may forget to engage or disarm doors during emergency and stow luggage in the galleys properly and many more (Griffiths and Powell, 2012). Fatigue can affect human performance in various ways. It reduces most aspects of performance such as decision making, reaction time, communication, concentration and attention, which are critical in their performance (Akerstedt, 1995; Techera *et al*., 2016; Brown and Niehaus, 2009). Causal factors such as long-duty cycles, sleep loss and many more, can cause aircrew members (pilots and flight attendants) to become inattentive, careless as well as inefficient (Akerstedt, 2000). In addition, fatigue can affect mood of individuals as a result of lack of sleep. Consequently, this can jeopardize the quality of communication and social interaction with pilots or passengers which is essential throughout any flight (Holcomb *et al*., 2009; Brown and Niehaus, 2009). Fatigue can also cause aircrew members showing up late for work and results in high numbers of sick-leave (Dijkshoorn, 2008).

2.5 Circadian rhythm and sleep

In order to understand how circadian disruptions and sleep disruptions which are considered to be known factors significantly contributing to fatigue in the aviation industry, due to the increasingly complex operations that continue around-the-clock, a clear understanding of circadian rhythm and sleep are necessary.

2.5.1 Circadian rhythm

The circadian rhythm refers to the bodies' 24-hour internal clock that regulates bodily function such as hormone secretion, body temperature, mood, digestion and performance capabilities (Rosekind *et al*., 1996). The circadian rhythm controls sleep, and wakefulness based on light-dark cycle in the environment in which humans are programmed to respond to these cues (Caldwell, 2005; Edery, 2000). For example, the body is trained to be asleep at night and awake during the day (Caldwell, 2005; Avers *et al*., 2009a). If this system gets distorted (circadian desynchrony) which occurs when the timing of sleep and wake periods become misaligned or out of sync with the timing of your internal clock, fatigue level in an individual will increase as sleep will consistently be initiated at the wrong time, creating a decrease in individual's performance (Dijk and Czeisler, 1995; Caldwell, 2005; Samel *et al*., 1997). Circadian rhythm is commonly affected by scheduling and sleep disruptions and results in changes in alertness and performance (Nesthus *et al*., 2007; Avers *et al*., 2009a). According to Caldwell (2005), work schedules in conflict with the circadian rhythm can result in cognitive and psychomotor performance decrements.

The two main causes of circadian rhythm disruptions include jet lag which is associated with long-haul flight operations and shift lag (shift work) which are associated with both short and long-haul flight operations. Jet lag is a physical response due to an abrupt change in time zones or is associated with travelling across multiple time zones (Dijkshoorn, 2008; Samel *et al.,* 1995). This results in a misalignment between internal circadian clock and the external light-dark and sleep-wake cycle (Dijkshoorn, 2008; Samel *et al.,* 1995). It causes individuals circadian clock to be out of sync with its local day and night cycle, causing a conflict in time cues (Dijkshoorn, 2008; Samel *et al.,* 1995; Thomas *et al*., 2015). Jet lag results in overall decrease in performance and attention in daytime function such as lack of concentration, slowed reflexes, irritability, decreased decision making, judgement and memory (Dijkshoorn, 2008; Samel *et al.,* 1995). Individuals also experience feelings of disorientation, light headedness and have lack of energy (Dijkshoorn, 2008; Samel *et al.,* 1995). Studies have shown that jet lag increases fatigue, sleepiness and decreases performance in flight crews (flight attendants and pilots) (Samel and Wegmann, 1989; Graeber, 1988).

Shift lag (shift work) refers to when individuals have to sleep at times when you are supposed to be awake (during the day) and when ones is awake and should be sleeping (at night) (Åkerstedt and Wright, 2009). In other words, its means, a distortion in working hour's which requires sleep to be displaced from its normal night time period (Dijkshoorn, 2008; Åkerstedt and Wright, 2009). This is common among aircrew members that work in shift-rotation schedules in a 24-hour operation (Dijkshoorn, 2008). Night shifts and early report times to duty are strongly associated with shift lag (Dijkshoorn, 2008). Consistent change in sleep rhythm will affect performance due to the irregularities of sleep cycle from the disturbances of the internal biological clock (Dijkshoorn, 2008). Thus, it inevitably affects aircrew performance increasing their fatigue levels (Dijkshoorn, 2008). Studies have shown that flight attendant working during a night flight was a major cause of fatigue (Nesthus *et al*., 2007; Avers *et al*., 2009a).

2.5.2 Sleep

Sleep is defined as a reversible condition of reduced responsiveness usually associated with immobility (Caldwell, 2006). Sleep is a vital physiological need (Siengsukon *et al*., 2013). Most individuals require about 8-hours of sleep each day (Siengsukon *et al*., 2013). Obtaining adequate sleep is important to prevent or resolve fatigue (Mallis *et al*., 2010). Sleep provides the body with a period of rest and recuperations (Mallis *et al*., 2010). It is also essential to maintain health, well-being, positive mood, alertness and performance (Mallis *et al*., 2010). Studies have shown that obtaining less than the required amount of sleep may cause individuals to have significant cumulative effects on wakeful function (Dinges *et al*., 1997; Carskadon and Roth, 1991). Today, job demand and commitments, family demands, and social life combined all limit the opportunities for night-time sleep for individuals. A shortage of sleep is known as one of the most important factors that contributes to a decrease in human function and increase in fatigue (Carskadon and Roth, 1991). Studies have shown that losing about one to two hours of sleep a night can impair alertness and performance (Rosekind *et al*., 2000; Caldwell and Caldwell, 2003; Carskadon and Roth, 1991). Insufficient sleep will result in physical and psychological problems (Rosekind *et al*., 2000). Disruptions to sleep or limited sleep can lead to high levels of subjective fatigue and in turn impair performance (Petrilli *et al*., 2006). Individuals that sleep less than the recommended hours can result in functioning difficulties, including alertness, reduced reaction time, performance, and mood (Davy, 2014; Krueger, 1989). Sleep loss has been shown in numerous studies to produce neurobehavioral deficits such as degrade perceptual and cognitive processes, vigilance and increases subjective sleepiness (Nesthus *et al*., 2007; Krueger, 1989). It has also shown to decrease judgement, physical coordination, communication, decision making and other parameters (Techera *et al.,* 2016; Rosekind *et al*., 2000).

In the aviation industry sleep loss is known as the one of the main contributing factors to aircrew fatigue and is directly associated with a variety of scheduling factors (Caldwell, 2012). These scheduling factors are independent on the type of flight operations (long-haul and short-haul) (Samel *et al*., 1995). Common scheduling factors that affect aircrew member fatigue includes, time awake prior to duty, early start times, late finishes, variable work periods, insufficient recovery time, consecutive work periods and shift work, jet lag and crossing different time zones (Samel *et al*., 1995). Caldwell (2012) points out that, fatigue among aircrew members increases when the pre-duty sleep is less than 6 hours, the work period occurs during usual sleep hours and when individuals are awake for more than 16 hours. Thus, sleep debt which refers to the accumulation of fatigue due to prior inadequate rest periods either through inappropriate timing or length of rest is common among aircrew members (Dijkshoorn, 2008). In addition, an individual who does not get adequate amount of sleep and is sleep deprived may also be susceptible to episodes of microsleep

(Mikkelsen, 1998; Dijkshoorn, 2008). Microsleep refers to when an individual begins falling asleep uncontrollably for brief periods during their work. (Mikkelsen, 1998; Dijkshoorn, 2008). Apart from the scheduling factors, noise, light and age are also known factors that can affect the quality of one's sleep (Dijkshoorn, 2008).

2.6 Workload

Workload similarly to fatigue can be known as a multifactorial, complex and multidimensional construct (Ahsberg *et al*., 1997; Hart and Staveland, 1988; Annett, 2002). Workload can be described as the amount of effort or resources induced by an individual while performing a task with specific demands (Hart and Staveland, 1988; Stramler, 1992). According to Lysaght *et al*. (1989), workload can be defined as the 'relative capacity to respond'. It consists of several components, there is an operator using his or her resources to respond to an external physical or cognitive demand in order to perform a task (Lysaght *et al.,* 1989). In other words, workload has been described as an indicator of the level of total mental and/or physical effort required to carry out one or more tasks at a specific performance level (Stramler, 1992). According to Weingner *et al*. (2004) states that workload is very wide term and there are a lot of factors that can affect it, such as tasks demands, organizational, environmental and individual factors (Carayon *et al*., 2006b).

The relationship between fatigue and workload has been described as a complex phenomenon, due to both overload and underload been identified as contributing factors to fatigue (Hancock and Verwey, 1997; Tritschler and Bond, 2010). The causes and consequences of workload vary in different operational contexts. In the aviation industry workload is known as a common factor contributing to crewmember fatigue (Hancock and Verwey, 1997; Tritschler and Bond, 2010). When workload is too high or too low, it can significantly increase the productivity of all types of errors and incidences of accidents (Petrilli, 2007). High levels of workload and fatigue have been identified as a common problem that can adversely affect productivity and performance of individuals (Chen, 2010; Hancock and Verwey, 1997). This is because task demand exceeds the resources and capabilities of an individual (Rubio *et al*., 2004). It may cause individuals to become incapable to deal with environmental demands and may exceed the capability of a fatigued individual, thus has a negative impact on performance (Kantowitz and Casper, 1988; Wickens *et al*., 2004). High workload has also been shown to have consequences for sleep, as a result of the time required to relax after demanding work. While low workload may cause work-underload and as a result individual may become bored and easily distracted which increases the likelihood of errors (Hancock and Verwey, 1997; Rubio *et al*., 2004). Low workload can be characterised as a monotonous continuous task that requires high vigilance with low input (Desmond and Hancock, 2001). For example, in the aviation industry particularly short-haul operations, aircrew members working repetitive flights on the same day and repetitive flights to the same destination can be characterised by boredom and lack of concern about maintaining precision. This has been shown to enhance fatigue levels and performance decrements (Bourgeois-Bougrine *et al*., 2003b; Gander *et al*., 1994). Low workload may also unmask physiological sleepiness (Carskadon and Dement, 1987).

2.7 Flight Attendant fatigue

Flight attendants forms an important part in the aviation industry. Flight attendants are administered staff on board the aircraft responsible for offering customer service to passengers, ensuring cabin safety and comfort of passengers (Henning, 2015). They also deal with security and emergency situations and administer first aid to passengers (Henning, 2015; Bergman and Gillberg, 2015). Flight attendants must be flexible and adaptable as airlines operate 24-hours a day, 7 days a week and 365 days a year. Work of a flight attendant are often characterised of being long, demanding and are required to remain professional and friendly throughout their assigned duty period. They are also often exposed to unpleasant situations; however, they are required to maintain composed and well-behaved in a professional manner. Flight attendants plays an important role in in-flight safety and services of overall performance of airlines and reduce passenger concern (Vidotti *et al.,* 2016).

Flight attendant fatigue is a significant problem in the aviation industry due to the nature of 24-hour operations, as it continues to jeopardize the ability to fulfil important safety and security roles which is critical in performance duty of a flight attendant (Nesthus *et al*., 2007). Fatigue is an important influence on flight attendant (cabin crewmembers) performance both in long-haul (international flights) and short-haul (domestic flight) operations (Caldwell *et al*., 2009; Avers *et al*., 2009b). It has been shown that the fatigue levels of cabin crew tend to be much higher than those of cockpit crew, mainly due to the nature of their job/task demands, which may put them at higher risk of fatigue and burnout (Caldwell *et al*., 2009; Avers *et al*., 2009b). For example, since the 9/11 terrorist attack, tasks, duties and responsibility of flight attendants has expanded significantly resulting in it becoming more complex which consequently increases the work of cabin crew and this may impact their fatigue levels (Vidotti *et al.,* 2016; Nesthus *et al*., 2007; Dijkshoorn, 2008). Fatigue has emerged as an important safety issue among cabin crewmembers. According to Avers *et al*. (2011) flight attendants have experienced fatigue while at work and agree that it is both a common experience and safety risk or threat to aviation safety as flight attendants have been shown to nod-off (fall asleep unintentionally) during a flight (Avers *et al*., 2011). Therefore, it is critical that the extent and impact of fatigue in this occupation be understood.

Existing literature on flight attendant fatigue have identified that the main contributing factors associated with flight attendant fatigue consist of circadian disruptions and sleep loss, because of time zone changes and shift work (Rosekind *et al*., 1996). Circadian disruption is known as a common factor inducing fatigue among flight attendants (Caldwell, 2012). For majority of individuals, the circadian system is in harmony with their work schedule, they work during the day and sleep at night. However, for many individuals such as flight attendants, their work schedule may be in conflict with their circadian system. Flight attendants work schedules are often characterised with shift work, jet lag, early report times to work, late finishes which are known factors inducing circadian rhythm and sleep disruptions (Arendt, 2010). This is because they operate domestic and international sectors under different condition such as day and night time, short, long or ultra-long-range flights, periods of circadian rhythm, time zone differences and different number of sectors. According to Caldwell (2012), the aviation schedules exert a powerful influence on circadian factors and sleep. Hawkins (1993) points out that circadian disruptions also known as circadian desynchronization (disturbed pattern of biological rhythms) has a major impact on individual performance and on safety. Circadian disruptions can lead to significant decrements in alertness and performance (Neri *et al*., 2002). For example, some of the human performance decrements include, decision making, vigilance, ability to multi-task, loss of mental agility and alertness, which are all essential for flight attendants to perform their duties effectively (Neri *et al*., 2002).

Sleep loss appears to be a key factor of fatigue among flight attendants. Insufficient sleep aggravates the existence of fatigue among flight attendants which may in turn have an impact on flight safety (Stokes and Kite, 1994). According to Williamson *et al*. (2011) sleep loss leads to impaired performance and accidents. An individual who is sleep deprived may result in them not being able to perform as well as they normally would after a sufficient rest period and may even doze off on the job (Stokes and Kite, 1994). Sleep disturbances is a common issue in the aviation industry and one of the main problems associated with jet lag, shift lag (shift work) and travel fatigue in long distance as well as short distance travel among aircrew (pilots and flight attendants) (Hume and Watson, 2003).

During short-haul flights, due to the nature of this profession, fatigue is generally caused by tight schedules, multiple flight segments and short-turnarounds time flights which contribute to an increase in perception of high workload (Bourgeois-Bougrine *et al*., 2003a, Gander *et al*., 1994). Thus, short-haul aircrew members commonly identify high workload and sleep deprivation as the main factors contributing to fatigue (Bourgeois-Bougrine *et al*., 2003a). However, flight attendant fatigue operating short-haul operations are not well developed as there are limited studies on short-haul operations inducing fatigue among flight attendants. Therefore, this section will be the main focus of the current study.

Due fatigue having the potential to adversely affect safety, in-turn contribute to accidents or incidences, it is important to recognize the safety-related issues. Thus, this section will highlight the incidences/or accidents of flight attendant fatigue. Fatigue among flight attendants is similar to fatigue experienced by pilots, however flight attendant fatigue does not cause direct accidents such as aeroplane crashes or equipment failure, but a fatigued flight attendant performing a specific task can have safety ramifications such as decrease in performance of safety related duties (Nesthus *et al*., 2007). A flight attendant that is unfit for duty (individuals that suffer from fatigue or feel unfit) can to an extent affect the safety of flight and safety of passenger. Some incidences and accidents of a fatigued flight attendants include;

- Forgetting easiest tasks such as arming doors for take-off and giving safety briefing to passengers.

- Reported being too fatigued to look for suspicious behaviour required for security purposes.

The following incidents are case study reports that have been reported from the Aviation Safety Reporting System (ASRS) and National Transportation and Safety Board (NTSB) accident databases regarding flight attendants:

ACN: 736520 Synopsis: Beset with fatigue due to long duty days and five consecutive days of flying, flight attendants fail to disconnect slide girt bar on B737-300 prior to cracking door to signify it was safe to be opened (Brown and Niehaus, 2009).

B757 flight crew both fell a sleep during night flight (Brown and Niehaus, 2009).

NTSB ID NO. CHI95IA215 in an ATR-72 aircraft where flight attendants did not close the aft entry door. This incident was due to fatigue as the flight attendant had been on duty for more than 14 hours with only a maximum of 5 hours of sleep the previous night (Nesthus *et al*., 2007).

2.8 Models of system analysis

System analysis refers to a problem-solving method with the main objective to examine the broader system, taking all aspects of the situation into account by breaking and understanding apart the parts within a system and figuring out how it works and interact with each other in order to achieve a goal (Beimborn, 2003; Kendall and Kendall, 2005). To understand system analysis, it is important to understand what a system is. A system is a set of parts, steps or components that are connected to form a more complex whole (Dul *et al*., 2012; Cordon, 2013). Systems concept implies that human performance must be evaluated in terms of the context of systems and that the efficiency of a system is determined by optimizing the performance of the human/ person and components of the system (Salvendy, 2012). This is because human performance involves a complex interaction of several factors (Wiegmann and Shappell, 2003). To identify a problem within a system, it is important to analyse the system, this involves breaking down parts or elements within a system that makes up a system and evaluate how the factors/ elements interact with each other (Kendall and Kendall, 2005). Thereby, system analysis is the process of identifying problems and organizing facts or details of a system (Karsh and Alper, 2005). It is important because various aspects of analysis provide avenues to reduce the occurrence of errors in the system (Karsh and Alper, 2005). Thus, eliminate the problem that occurs in order to make relevant changes and improvements within the system (Karsh and Alper, 2005).

There are a variety of system analysis methods and models that have been used to conduct a system analysis in different workplace environments. These include System Engineering Initiative for patient Safety (SEIPS) model of work system, Reason/Vincent model of accidents and adverse event, Donabedian's model of quality, Macroergonomics analysis and design (MEAD), Root cause analysis (RCA), Fault tree analysis (FTA), Failure modes effect analysis (FMEA), Work system analysis model by Smith and Carayon-Sainfort and many more. These models and methods are used to analyse and determine the weaknesses and failures of systems and facilitate its redesign, some focus on causes of accidents and adverse events, while others are used to provide a framework for understanding the structures, processes and outcomes (patient safety, employee outcomes such as stress, fatigue, burnout, safety and organizational outcomes such as injuries, accidents and illnesses) (Carayon *et al.,* 2006b). An overview of these methods and models will be discussed in the following sections:

2.8.1 Systems Engineering Initiative for Patient Safety (SEIPS) Model

Systems Engineering Initiative for Patient Safety (SEIPS) model is known as a conceptual model to identify problems within a work system of any industry (Steele *et al.,* 2018; Carayon *et al*., 2006b). However, it is the most widely used healthcare human factor systems model (Carayon and Wood, 2010; Carayon *et al*., 2014). In addition it is also known as model of work system and patient safety (Carayon *et al*., 2003; Carayon *et al*., 2006b).The SEIPS model was developed as a main objective to address and improve patient safety and other organizational, employee and patient outcomes for healthcare work systems with the basis for investigating the healthcare work system to gain an understanding and carry out interventions (Carayon *et al*., 2014; Carayon *et al*., 2003).

The SEIPS model is an integration between work system model developed by Smith and Carayon, Donabedians model of quality and improvement (structure-process-outcome model) and the balance theory model, which looks at relationships between components of the system and importance of considering the entire system when evaluating healthcare processes and outcomes (Carayon *et al*., 2014; Carayon and

Wood, 2010; Smith and Carayon-Sainfort, 1989; Donabedian,1988; Carayon *et al*., 2003). This model highlights and analyses the structure of an organization (the work system) which is characterized by five components (tools and technology, task, organization, environment and the person) affecting the extent to which safe care is provided (the process) (Carayon *et al*., 2006b; Carayon *et al*., 2014; Steele *et al*., 2018). In other words, this model describes the work system of caring for and managing the patient, affects the likelihood the patient completes his or her experiences without harm (outcome) (Carayon *et al*., 2003).

2.8.2 Reasons Model

The Reasons Model is known as a useful framework for adverse events analysis (Reason,1990). It has become a common model where complex accidents can be understood; thus, it is the most frequently cited accident causation model (Reason,1990). This model is widely used in healthcare systems (Perneger, 2005). Reasons Model mainly focusses on the environment or on the system where the event happens, instead of focusing on the individual/person causing the event (Reason, 2000). Accidents and incidents are due to conditions or situations in which the person is trying to perform (Reason,1990). In other words, the causes of accidents and incidents moves away from human error to the environment in which humans work (Reason, 1997). Reasons Model states that the main contributing factors to accidents are, unsafe acts, organizational/systems and local workplace (Reason, 1995; Reason, 1997).

2.8.3 Donabedian's Model

The Donabedian's model was developed in 1980 (Donabedian, 1980a). It is considered one of the most well-known conceptual frameworks in performance measurements and improvement in healthcare specifically quality of care in healthcare industry (Donabedian, 1980a). This model has been widely accepted and used in the literature associated with the development of quality standards (Ibn El Haj *et al*., 2013; Ayanian and Markel, 2016). The main goal of the Donabedian model is to assess the quality of health (Donabedian, 1980a; Donabedian, 1980b).

There are three components that characterizes the Donabedian model these include Structure, Process and Outcomes which are essential for examining health services and evaluating quality of healthcare (Donabedian, 1988; Donabedian, 1980b; Carayon *et al*., 2006b). Thus, this model is also known as a structure-process-outcome model (Ibn El Haj *et al*., 2013). Structure describes the context in which care is delivered (population to be saved, economy and buildings) (Donabedian, 2005; McDonald *et al.,* 2007). Process denotes the transaction between patients and providers throughout delivery of healthcare (Ibn El Haj *et al*., 2013; McDonald *et al*., 2007). For example, how the organization is working (organizational processes) and interaction with the patient (clinical processes) (Donabedian, 1988; McDonald *et al*., 2007). Outcomes refers to the effects of healthcare on health status of populations and patients (level of functioning, patient satisfaction and experiences and quality of life) (Donabedian, 2005).

2.8.4 Macroergonomics Analysis and Design (MEAD)

Firstly, macroergonomics is a sub-discipline of ergonomics and human factors, which focusses on the sociotechnical system, the investigations of relationships between person, technology, organizational design, environmental and their interactions as well as knowledge about work systems and work system design (Hendrick and Kleiner, 2001; Kleiner, 2008; Hendrick, 1986). Macroergonomics analysis and design (MEAD) was developed to achieve systemic improvements in performance and has been applied in industrial environments (Kleiner,1999). Macroergonomics method consist of ten stages used for assessing and improving the work system (Kleiner, 2008). This method of analysis investigates ergonomics problems within a holistic system context (Kleiner, 2006). For example, it can be used as a framework to analyse and design a safe and productive work system and help to determine the risks and causal factors to problems (Hendrick and Kleiner, 2001; Kleiner, 2008).

2.8.5 Fault Tree Analysis (FTA)

Fault tree analysis (FTA) is a systematic method of system analysis, that examines systems from a top-down process where an undesired event is logically broken down into possible causes or combinations of causes of an event (Suresh *et al*.,1996; Patil *et al*., 2009; Ericson, 2015). This process is represented with the use of graphical symbols for ease of understanding (Suresh *et al*., 1996; Patil *et al*., 2009; Ericson, 2015). FTA is known as one of the most widely used methods in system reliability, maintainability as well as safety analysis (Patil *et* al., 2009; Ericson, 2015). The main purpose of FTA is used to investigate potential faults, its modes and causes and then quantifies their contribution to the system unreliability in the course of product design (Bertsche, 2008b; Ericson, 2015). FTA is used to establish human errors, hardware and software failures that can lead to undesired events at the system level (Patil *et al*., 2009). In addition, FTA helps identify potential causes of system failure before their failures actually occurs (Patil *et al*., 2009). For example, in order to establish all possible failure causes, fault tree analysis considers understanding functional relationships between subsystems and components and identify top-level fault events of a system (Patil *et al*., 2009; Ericson, 2015). It also considers interactions between any system and neighbors including human interfaces (Ericson, 2015).

2.8.6 Failure Modes Effect Analysis (FMEA)

Failure modes effect analysis (FMEA) also known as a general approach is a systematic, proactive method of analyzing and investigating a process prospectively for possible ways in which failure can occur (Stamatis, 2003). FMEA can redesign the process to eliminate the possibility of failures, stop the failure before it harms an individual or minimize the consequences of failures (Bertsche, 2008a; Stamatis, 2003). In other words, it is a method used for evaluating a process to identify where and how it might fail and to assess the relative impact of different failures in order to identify the parts of the process that is in most need of change (Stamatis, 2003).

FMEA was developed outside of the health care as it was previously used in military, used by NASA as well as automotive industries (Bertsche, 2008a). However today FMEA is been widely and primarily used in healthcare systems (Spath, 2003). It has also been used in other high-risk industries. This analysis is a step by step approach for identifying all possible failures in a manufacturing, assembly process, a design, a product as well as a service (Stamatis, 2003).

The main objective and benefit of this method are, it can identify error prone situations or failure modes in a specific process of care and can anticipate and eliminate failure modes before they occur (it can help establish potential failure modes of an item, establish effects on the item, elements and the system itself in order to prevent possible failures by correcting the processes) (Stamatis, 2003). Thus, will reduce risk of harm (Stamatis, 2003). Other benefits include, it is multidisciplinary in nature, it seeks input from frontline workers, and it provides a systematic method for improvement (Stamatis, 2003).

2.8.7 Root Cause Analysis (RCA)

Root cause refers to fundamental failure or breakdown of a process which when resolved prevents a recurrence of the problem (Ammerman, 1998; Wilson,1993). Root Cause Analysis (RCA) is a systematic process (systematic approach) for ascertaining and analyzing root cause of events or problems to determine how these problems can be solved or be prevented from occurring (Ammerman, 1998; Wilson,1993). It also refers to a collective term that describes a wide range of tools, approaches and techniques used to discover causes of problems or faults (Ammerman, 1998).

The main goal of this analysis is to identify root causes, problem-solving techniques. In other words, this approach is used to analyse the events or problems that occur in order to determine what happened? how it happened? why it happened? and actions for preventing reoccurrences (What can be done to prevent the problem from happening again?) (Ammerman, 1998; Wilson,1993). In addition, this analysis offer support for the core activity or root cause analysis (Wilson,1993). RCA was developed mainly to analyse activities such as quality control, accident analysis, occupational safety and health, engineering and maintenance failure analysis as well as various system-based processes such as change in management and risk management (Ammerman, 1998; Wilson,1993). Examples where root analysis are applied to solve problems and preventable actions include, major accidents, human error, medical mistakes, maintenance problems and productivity issues (Ammerman, 1998). The analysis is also used in high risk industries such as nuclear power, airlines, the military and increasingly in healthcare (Wilson,1993). The analysis focusses on systems and not people (Ammerman, 1998).

2.8.8 Work System Model

Work refers to a task or an activity to be undertaken by any individual/ person. System mentioned previously refers to a set of parts/elements or activities that are joined, with the purpose to understand the link between different elements (hardware, software, people, spaces and buildings) (Wilson, 2014). Work system analysis is defined as dissection (analysis/examination) of a work system where humans interacts and performs their work with the utilization of technologies, information and resources which are essential to produce services for internal or external customers (Karsh and Alper, 2005; Alter, 2013).

Work system refers to people interacting with the internal and external environment (internal been the physical and psychosocial factors and external been the cultural, economic and political factors), thus, it examines the work environment, including organization, cultural and the technical environment within which the work system operates (Salvendy, 2012). It refers to people interacting with hardware (machine and tools), thereby work system examines the technologies that people use while doing their work (Hendrick and Kleiner, 2001; Salvendy, 2012). It also refers to people interacting with organizational design (work systems process and structure), thus, work system examines the processes and activities which include everything that take place or happens within the work system (Hendrick and Kleiner, 2001). Lastly it refers to people interacting with job design (tasks, skill requirements, knowledge and work modules) (Hendrick and Kleiner, 2001). It examines the people who perform the work (Hendrick and Kleiner, 2001). In addition, work system examines the knowledge about work from various/different bodies of literature such as job stress, human factors/ergonomics and job/organizational design (Salvendy, 2012).

Work system analysis provides a framework for identifying basic factors for understanding and evaluating the structure of work system (Carayon, 2009). System analysis also provides a holistic view and insight of how a system works and examines how the elements within the system interact with each other (Karsh and Alper, 2005; Carayon, 2011). For example, from a systems perspective, human performance exists in the context of a dynamic (and often messy) system. For complex systems such as aviation, everything connects with something. When there are changes in one part, there are adjustments elsewhere. All of these aspects of the system interact in various ways, over time and in different situations.

The work system analysis method has been widely used in research in healthcare industry and can be applied in research in other high-risk industries such as the aviation industry (Carayon, 2009). In addition, this method also highlights a complete understanding of a work system of a person in comparison to the other system analysis research methods. This method utilizes the work system model developed by Smith and Carayon-Sainfort (1989) as a framework to understand the critical components of a work system and the interactions among them. Thus, the model provides a way of describing all of the factors of work that affect a worker. According to Carayon (2009), the work system model highlights a systemic aspect of work. The work system model includes factors such as the individual (person), tool and technologies, environment, organization as well as tasks (refer to Figure 2) (Smith and Carayon-Sainfort, 1989). According to the work system model, tasks are performed by an individual that utilizes technologies and tools (Smith and Carayon-Sainfort, 1989; Carayon, 2006a). The tasks are also performed under various organizational conditions in a physical environment (Carayon, 2006a). These five elements within the work system (task, tools and technology, organizational, environmental and individual factors) can interact and influence each other (Carayon *et al*., 2006b; Carayon, 2009). Thus, when there is an adjustment to any of the component within the work system, this can directly affect the other components and as a result can bring about different outcomes that can either have a positive or negative impact on the worker (employee), for example in terms of performance and safety, affect the work as well as organizational outcomes (Carayon *et al*., 2006b; Carayon, 2009).

The individual (person) in the work system is the person who performs the work (Alter, 2013). The individual factors include demographic characteristics (gender, education and age), work experience, psychosocial, physical and cognitive characteristics as well as cultural characteristics (Carayon, 2009). The environmental factors in the work system include, layout of workstation, noise, lighting and vibrations (Carayon, 2009). The tools and technology factor in the work system includes the tool and technologies that participants use and workstation design (Carayon, 2009; Alter 2013). The organizational factors look at how organization is designed in the work system, these includes work scheduling, teamwork, organizational culture and climate, social and organizational support and participation (Carayon, 2009). The task refers to how the work is performed. The task-related factors in the work system include workload, job content and challenge, repetitiveness, job autonomy and task significance (Carayon, 2009).

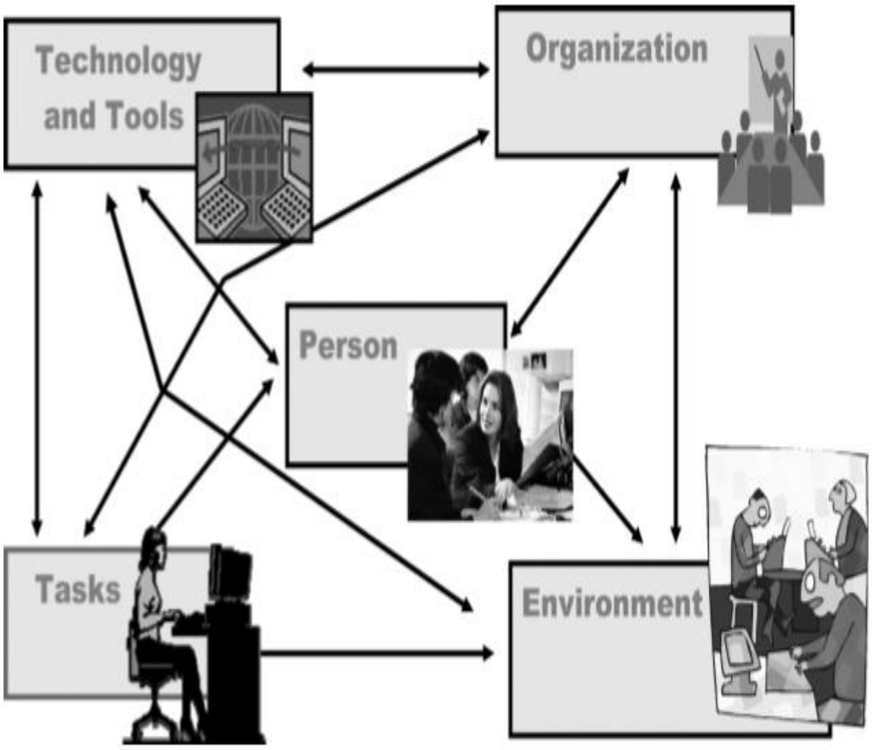

Figure 2: Model of the work system developed by Smith and Carayon-Sainfort (taken from Smith and Carayon-Sainfort, 1989).

2.9 Summary of Chapter

Overall this chapter highlighted an overview of the knowledge and the main information in the subject area being investigated. It presented general theories, to the application of these theories, issues to flight attendants and their work environment. For example, it started off with an overview of systems ergonomics, then moved onto aviation ergonomics, then to the background of understanding fatigue, circadian rhythm and sleep as well as workload and flight attendant fatigue. This chapter ends with an overview of different models and methods of system analysis. Due to the knowledge of the various theories and themes that was presented in the study relating to the research topic, the current study adopted a systems perspective in order to identify the main contributing factors to flight attendant fatigue during short-haul flights.

CHAPTER III

METHODS (SYSTEM ANALYSIS)

3.1 Introduction and aim

In this chapter, the methodological approach (the process and rationalisation regarding methods procedure) that has been chosen to be used in the current study are discussed. This section provides details of the research concept, purpose and methodology.

3.2 Research concept and methodological framing

A research design is defined as a design that includes the methodology and procedure that is used to guide the research process (Creswell, 2014). The key consideration when designing a research project is establishing which method is appropriate for the aim of the study. This research project aims to determine the workload factors contributing to flight attendant fatigue during short-haul flight operations defined in chapter 1. The breadth of fatigue sources/ risk factors identified in the previous studies on fatigue points to the need for macroergonomics approach to better understand and address factors contributing to/ or preventing fatigue among short-haul flight attendants work systems. In other words, achieving the aim required a system approach which relied a comprehensive understanding of all components of the work system structure of flight attendants. Therefore, for this study the work system analysis method (which is a macroergonomics approach/system approach) based on work system model developed by Smith and Carayon-Sainfort (1989) which was used as a framework, was chosen for this study, as it was found to be the most accurate method to address the research aim (defined in chapter 2). This method was chosen as it provided a systemic aspect of whole work system of flight attendants work, describing all of the factors of work that affect a worker (flight attendants operating short-haul flights), for example, it includes factors such as the individual (person), tool and technologies, environment, organization as well as tasks that will help identify the main workload factors contributing to fatigue among flight attendants operating short-haul flights. Thus, it evaluated all the components and possible interactions with components of the work system structure and dimensions of fatigue. In addition, work systems model incorporates balance theory which describes how negative factors (such as fatigue) in work system can be offset or minimized by improving other components of the work system (Carayon *et al*., 2006b). Overall, a work system analysis contributes to an increased understanding of fatigue and workload, allowing for a representation of flight attendant work system.

For this study a work system analysis (Smith and Carayon-Sainfort, 1989; Hendrick and Kleiner, 2001) was undertaken in three phases, however the Empirical analysis (quantitative component) of the work system analysis could not be executed as part of the thesis, as permission could not be obtained from the airlines in time to conduct this section. Therefore, only the literature analysis and expert interview procedures were discussed in detail.

I. Literature based (based on the existing literature to collect, identify information about the work elements and work structure of short-haul flight attendants and identify main factors contributing to short-haul flight attendant fatigue and workload;

II. Expert Input (qualitative component of the study), where individual interviews were conducted with experts to gather more information about fatigue and workload, the impact of fatigue and aircrew fatigue and short-haul flight attendants work and

III. Empirical analysis (quantitative component of the study) was implied to analyse and quantify the effects of the key factors identified in the literature and expert interviews. According to Johnson and Christensen (2008), quantitative method quantifies problems by way of generating numerical data that can be transformed into statistics, thus making the findings more generalizable to the population. This method is also considered structured as opposed to qualitative methods (Bergman, 2011). In addition, quantitative research is used to investigate relationships between variables (Willig, 2012). The quantitative data would have been collected using a variety of questionnaires/surveys. These included: A general questionnaire, Subjective NASA TLX scale (assessing workload levels), Subjective Samn-perelli (SP) 7-point scale (assessing fatigue levels), Subjective stress scale (assessing perception of severity of stress), Self-report duty and sleep diaries/logs and 5-point Likert scale (assessing sleep quality). Objective performance measure of sleep/wakeful behavior would have been assessed using an actigraphy. Overall these measures were suggested to verify the key factors identified objectively and subjectively.

Overall the methods were chosen because it provided a greater understanding of the topic being examined and it is known to be valid, reliable and generalizable as opposed to using one method (Bergman, 2011; Johnson and Christensen, 2008). The results from each analysis have been combined in order to produce the results of this study.

3.3 Literature based analysis

A scoping literature research was conducted in a systematic way; however, it does not take the form and process/approach of a standard and classical criterion of systematic review concept/method in terms of criterion-based selection of papers, reporting methodology, because the study included qualitative information (Jahan *et al*. 2016; Rother, 2007). Therefore, this study took the form of a narrative/descriptive literature review method but included aspects of systematic review in terms of databases used, and inclusion and exclusion criteria (Jahan *et al*., 2016). According to Rother (2007), narrative/descriptive literature review method are known as a critical, objective and comprehensive method of analysis that form, describe and discuss an evidence-based synthesis on current knowledge on a topic or theme. In addition, it helps to establish a theoretical and contextual point of view, that is essential part of research process. The literature analysis aimed to gain and assemble generalized knowledge and explanation from existing peer-reviewed paper, articles and scientific books that represented empirical evidence on the relationship between workload, fatigue and flight attendants based on the five components (organization, task, tools and technologies, individual/person and environment) of the work system model developed by Smith and Carayon-Sainfort, with the main aim to determine the contributing factors to flight attendant fatigue. In this study, we focused on literature at the interaction of human factors with workload, fatigue and performance in an aviation context (particularly flight attendants operating short-haul flights). Thus, this section aims to identify all factors contributing to short-haul flight attendant fatigue and workload. In addition, this section also aimed to describe and quantify the factors where possible. The literature analysis differed from that of literature review as it just focused on existing research that was necessary for the analysis relating to the objectives of the study and of relevant theoretical ideas which was the factors contributing to flight attendant fatigue during short-haul flight operations. Whereas the literature review focus on all the knowledge that was relevant to the area of study.

3.3.1 Search process and literature selection

To investigate the contributing factors to short-haul flight attendant fatigue and workload, it was necessary to consider research from several disciplines. The research study performed a comprehensive search for articles. The search strategy made use of seven online databases to locate and retrieve journal articles pertaining to the topic and aim of the study as well as scientific books/E-books. This was done using an array of keywords and phrases as shown in Table 1. The different databases included Science Direct, Scopus, PubMed, Research Gate, Google Books, E-books, Mendeley, Rhodes Library and Google Scholar. The multidisciplinary databases were searched from the February 2017 to Sep 2018, with no publication date restrictions to allow for a comprehensive search. In the case of the Science Direct and SCOPUS databases the 'advanced search' option was selected. In addition, the 'search all' option was also selected on the Rhodes University Library page with the 'advanced' option being made use of. The remaining databases were searched in their entirety for relevant open access journal articles. In addition, the references of all articles retrieved were also reviewed and checked for additional pertinent articles.

Table I: Keywords and phrases used to search each database

Fatigue Workload	Short-haul flights Flight attendants Cabin crewmembers Causes Contributing factors	System analysis Work system analysis Work system Model	Organization Task Environment Person/individual Tools and technology

The keyword search on the online databases resulted in a match of 4157 journal articles, from which 437 were retrieved based on keywords, title and abstract. The additional exclusion criteria once it met the keyword criteria that lead to an exclusion of many articles were, articles that related to related to comfort in airline cabins for flight attendants, health outcomes such as quality of life ozone toxicity symptoms among Flight attendants, or breast cancer among Flight attendants as well as examining indoor quality of cabin. Once these journal articles were obtained based on the title and abstracts screening, they were then screened using the inclusion/exclusion standards (Table 2). This resulted in a total of 97 journal articles being included. After full reading and assessment of inclusion/exclusion criteria, the final set of papers after the second screening process was approximately 89 articles which were included for analysis. Figure 3 shows the process of screening and details of the number of articles at each phase.

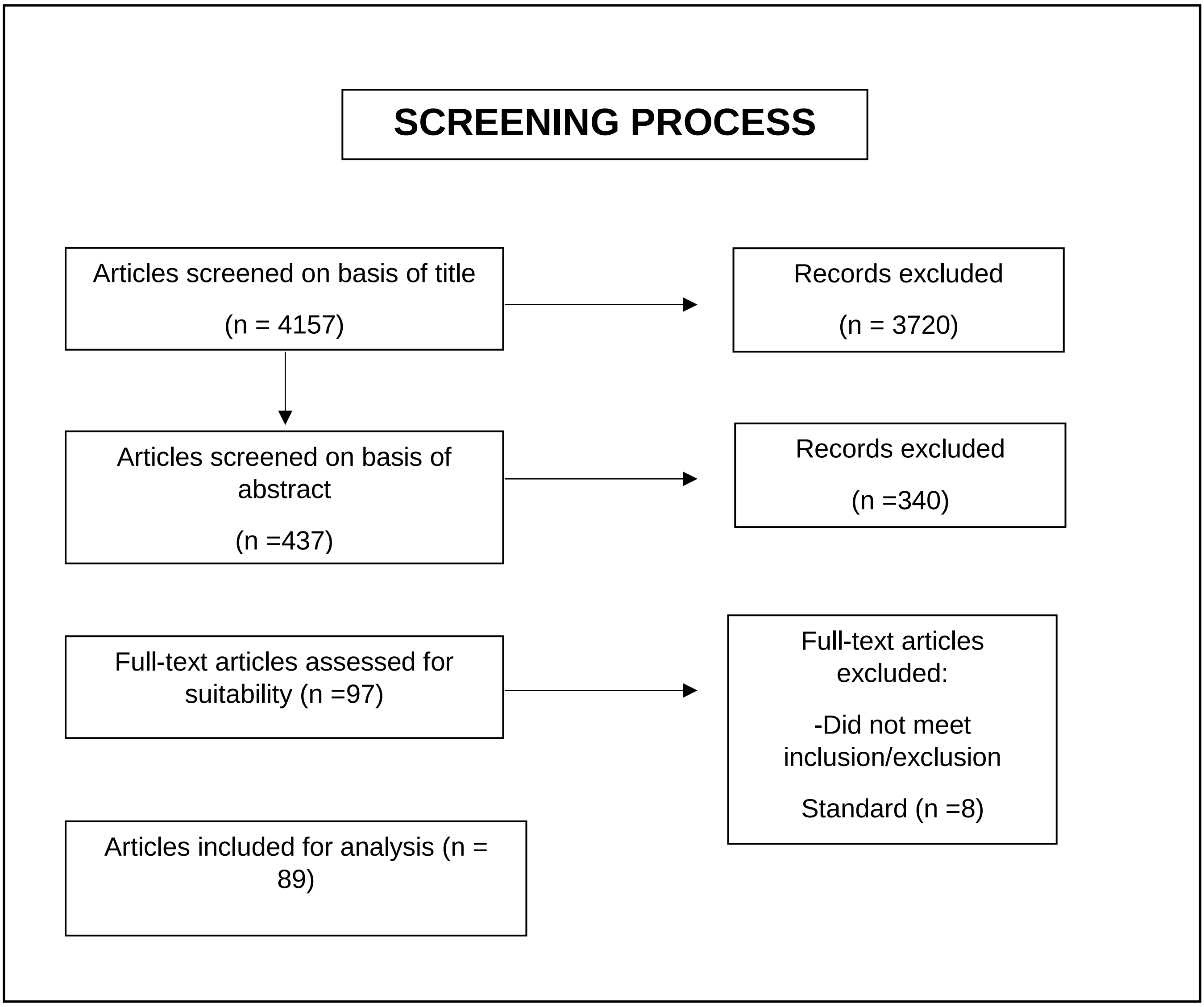

Figure 3: The screening process of journal articles for study selection

Table II: The inclusion and exclusion criteria used during the screening process

Inclusion criteria	**Exclusion criteria**
✓ Peer-reviewed publications/ published eBooks/books and reports. ✓ Includes key words "Fatigue" (physical and mental) and/or "Workload" (physical, cognitive and emotional) ✓ Regional/Commercial flight (short-haul flight) operations ✓ Short-haul flight attendants	➢ Long-haul flight attendants ➢ International flights (long-haul flight) operations

3.3.2 Procedure of Literature analysis

The steps for executing a literature analysis are provided below:

Step 1-To analyze work of flight attendants

During this step flight attendants work environment during short-haul operations was examined in detail based on the articles retrieved from the screening process. This was done in order to understand the setting and the context in which they perform their work.

Step 2-Identification of factors contributing to fatigue and workload

A work system map was produced to identify the factors contributing to flight attendants' fatigue and workload. This section was conducted based on work system model developed by Smith and Carayon-Sainfort which was used as a framework to identify all components of work system and the interaction of the components that contribute to flight attendant fatigue and workload.

Step 3- Quantify the key finding identified in previous step.

Based on the factors identified in the previous step. This section analyzed, quantified and explained the key factors identified contributing to flight attendant fatigue during short-haul operation in detail which produced the results for the thesis.

3.4 Expert interview

3.4.1 Research design

Individual interviews (formed part of the qualitative method) were conducted with sector or subject matter experts with the main purpose to determine and explore general information and opinions on the research topic (aviation fatigue, aircrew fatigue, and what factors experts perceive contribute the greatest to workload and fatigue in short-haul operations among flight attendants). In addition, the purpose was also to gain additional input and opinions on elements that the researcher was not sure about.

Interviews were considered the most appropriate method for collecting data, to gain insights into the views and experiences of individual experts. Interviews are considered the most widely used qualitative research method (DiCicco-Bloom and Crabtree, 2006). Interviews are considered a useful qualitative method to obtain detailed information about opinions, experiences and perceptions from individuals (Gaskell, 2000; Alshenqeeti, 2014). Qualitative research can also facilitate rich descriptions of the research participant that can offer valuable insights into the settings and situations in which flight attendant work (DiCicco-Bloom and Crabtree, 2006). Expert interviews refer to, an individual's special knowledge and experiences which result from the actions, responsibilities, obligations of the specific functional status within an organization/institution (Bogner *et al*., 2009). In addition, it is also known as an information gathering meetings used primarily for collecting facts and knowledge. Expert interviews are considered an efficient and concentrated method of gathering data in comparison to observation (Bogner *et al*., 2009). It is also considered a great way to obtain new knowledge, obtain additional unknown or reliable and valuable information and authoritative opinions of the research topic (Bogner *et al*., 2009). It is also a quick method to obtain specific information (Bogner *et al*., 2009). Hence, the current study conducted expert interviews to gain insights and local knowledge into fatigue and workload as a problem in South African short-haul operational context.

3.4.2 Sample and sampling strategy

Experts are known as individuals having high insight in aggregated and/or specific knowledge in a particular area or field (Bogner *et al.,* 2009). The experts for the study were selected experts with unique knowledge in the field of aviation and fatigue or on the research topic. The interviewees were classified as “experts” because they had high knowledge on the research topic, and they were chosen according to the qualifications in the field of aviation which met the criteria of being and expert. These included aviation experts from aviation industries (Managers, HR personnel’s, fatigue specialists, flight attendants) and fatigue experts’, individuals who specialize in fatigue research. The sample for the study was recruited via email and by snowball sampling.

3.4.3 Procedure of expert interviews

The individual interviews were conducted via face to face meetings with the participant, telephone (telephone interview) or using ZOOM which is known as a simple modern video/ web communications software, with an easy, reliable cloud platform designed for video and audio conferencing, chat, online meetings and webinars. An advantage of Zoom is that it does not require participants to share their contact information with each other or to create an account in comparison to programs such as Hangouts and Skype. Thus, the experts were an invitee in a meeting scheduled by the researcher with a Zoom Host license and did not require a Zoom account in order to join a meeting. The experts could join a meeting from their phone, desktop, mobile and tablet devices. The researcher scheduled a meeting using the Zoom app. Thereafter received an invitation link which was then sent via email to the expert who volunteered to participate in the interview. Once the expert received the invitational link, they were required to follow simple steps to join the zoom meeting with the researcher (refer to Appendix B3).

Before commencement of the interview, participants were required to complete an online pre-screening questionnaire in google forms using a link (see Appendix B1) which was sent to them via email. Participants were also required to sign and return the participant consent form which was either returned in the form of a hard copy or via email to the researcher. The pre-screening questionnaire included, demographics information (age, sex) and questions related to their current job (type of employment, work experience) (refer to Appendix B1). The researchers met up with volunteered expert who were interested in the study and explained the procedure and purpose of the study and interview, and answered issues related to the project. Thereafter discussion was set forth. Each interview lasted for approximately between 30 and 45 minutes and was conducted at a time and location that best suited the participants. Before commencement of the interview, permission was granted from each participant (expert) to record the interview. The interviews were audio-recorded via voice recorder on the researcher's mobile phone or via tape recorder and recorded in full writing. The interview was semi-structured and included a set of open-ended questions that allows for spontaneous and in-depth responses (refer to Appendix B2). The interview questions were developed based on the NASA study (Co et al., 1999 and Phillips, 2015). The question was adjusted to create discussion (open ended questions) with the interviewee to obtain detailed information about opinions, experiences and perceptions from the experts in the industry. Pilot testing was done to test the questions and to gain some practice in interviewing.

3.4.4 Interview data analysis

The interviews were recorded and transcribed verbatim by the researcher into text using Microsoft Word and was entered in NVivo software (a qualitative analysis software) to analyse the data. The researcher analysed the transcripts to determine the most important factors that emerged in each interview. The method of analysis chosen for the study was the qualitative approach of thematic analysis (Braun and Clarke, 2006). Thematic analysis is a considered the most widely used qualitative approach to analysing interviews (Braun and Clarke, 2006). Braun and Clark (2006) point out that the thematic analysis is a flexible approach which can provide rich and detailed yet complex account of data. This method is used to identify, analyse and captures the main themes within a data set (Alhojailan, 2012). The main themes recurring from the data was categorised and coded (Braun and Clarke, 2006).

The analysis of the interview text was conducted in a stepwise method based on the form of thematic analysis described by Braun and Clark (2006) using Nvivo version 12. The first phase was the process of familiarisation with the data (Rohleder and Lyons, 2014; Braun *et al*., 2014). This is where data was transcribed, read and re-read in great detail to be familiar with the depth and breadth of the content and to identify initial themes (Rohleder and Lyons, 2014; Braun *et al*., 2014). This process also allowed the written accounts to be checked and rechecked for accuracy of language against the audio recordings (Rohleder and Lyons, 2014; Braun *et al*., 2014). The researcher then generated initial codes using text system (second phase). The coding process was performed manually and categorised according to similar patterns (recurring words or phrases) or topics that occurred within the data for each question (Rohleder and Lyons, 2014; Braun *et al*., 2014). Once all data was coded, the researcher then searched for the common themes and then classified and categorised the main themes that emerged (Rohleder and Lyons, 2014; Braun *et al*., 2014; Aronson, 1995). The codes and the themes emerged from the data and the criteria for determining the most important factors for each interview was based on the work system model to identify the important factors from each interview. Following the coding, descriptions, and categorizing, the researcher then represented the findings by way of a narrative (direct citations of the experts) (Rohleder and Lyons, 2014; Braun *et al*., 2014)..The audio recording was uploaded onto the computer and saved as voice files on the computer hard-drive as well as the transcripts. These were only available to the researcher and academic supervisor.

3.4.5 Ethical consideration

Prior to recruitment of the experts for the expert interview, ethical clearance was obtained from the Human Kinetics and Ergonomics Ethics Committee (refer to Appendix A5). Full disclosure of the aim and methods procedure of the interview was provided to the ethics committee before ethical approval was granted. The letter of information to participant (expert) (refer to Appendix A1) and informed consent form (refer to Appendix A2) that the participants would receive prior to the interview session was also included upon which ethics was approved of which the data collection proceedings took place.

a. Sample permission

Permission letters and institution consent form via email was sent out to gain permission from Denel aviation management (refer to Appendix A3). In addition, RU gatekeeper permission from director of human resources at Rhodes University of consent for fatigue expert (lecturers and researchers) in the department of Human Kinetics and Ergonomics was also obtained (refer to Appendix A4). Once permission from Denel SARA management and RU gatekeeper have been granted, the experts were then recruited by means of email through existing contacts such as through project mentors (Denel SARA managers), individuals from aviation institutions such as Denel aviation and staff (lecturers and researchers) from the Department of Human Kinetics and Ergonomics (Rhodes University, South Africa) who conduct research in aviation and fatigue. An overview of the purpose and content of the research and interview was provided. Interested participants (experts) for the interview were asked to contact the researcher via email, WhatsApp messages, to set up the first date for the expert interview procedure at a place and location that best suited the expert.

b. Informed consent

Prior to the commencement of the expert interview, all recruited experts were familiarised with the research aim, requirements, procedures and potential benefits of the interview session, which were explained both verbally and in written form. The participants (experts) were then given the opportunity to sign an informed consent document. Throughout all the interaction that the researchers had with the experts, a constant reminder was made that they were free to withdraw from the study at any stage, with no prejudice against them. The experts agreeing to be part of the interview were assured that all of their personal information such as their names, their airline affiliation they work for, or university institution would be kept confidential and that their anonymity would be maintained.

c. Anonymity

All data and personal information recorded during the study was stored in either electronic or paper format. Experts' confidentiality and anonymity was preserved by allocating each a code. No information that could lead to identification of any individual was released, thus they remained anonymous with regards to their data and results. Only the primary researcher and academic supervisor kept the main lists of codes and names. Irrespective of the affiliation that the expert worked for, the airline or university was not mentioned anywhere in the thesis (it remained anonymous). The interviews were audio-recorded via voice recorder on the researcher's mobile phone, tape recorder and recorded in full writing but was only granted with their permission. The audio recordings were uploaded onto a secure password protected computer and saved as voice files on the computer hard-drive as well as the transcripts. These was only available to the researcher and academic supervisor.

3.5 Summary of chapter

For the current study it has been chosen to conduct a Work system analysis based on the Smith and Carayon-Sainfort model to determine the workload factors contributing to flight attendant fatigue operating short-haul flights. The work system analysis was conducted in two ways; based on existing literature which is a critical examination of existing research relating to the phenomena of research interest and of relevant theoretical ideas and secondly based on expert interview which was used as innovation process for gaining new local knowledge and expertise and to gain additional input on the research topic that the researcher was not sure about from various stakeholder in the aviation industry and fatigue experts.

CHAPTER IV

RESULTS

4.1 Overview of the chapter

This chapter reports the findings of this research. The results of the study are presented and discussed with reference to the aim of the study which is to, identify the workload factors contributing to flight attendant fatigue during short-haul flight operations. To address the research question, a work system analysis was conducted based on the work system model developed by Smith and Carayon-Sainfort (1989) stated in the previous chapter.

This section highlights the results which was based on literature and expert input data. Section 4.2 details the work system analysis of a short-haul flight attendant. This section identified, described and explained the factors. Overall noting the main workload factors contributing to flight attendant fatigue and workload during short-haul flight operations. Section 4.3 outlines the outcome of the literature analysis. Section 4.4 details the expert input results and section 4.5 summaries the chapter.

4.2 Literature analysis results

Based on the work system analysis, the findings of the study represented was structured according to the Smith and Carayon-Sainfort model, which highlighted a holistic aspect and used as a framework to define the variables that relate to the five components (tasks, organization, technology and tools, person and environment) of the work environment of short-haul flight attendants (refer to figure 2 in chapter 2). It was discovered in literature analysis (first phase of the study) that short-haul flight attendant workload and fatigue was induced from a variety of factors. These include the task-related factors (the tasks and responsibilities of short-haul flight attendant which are physical, cognitive and emotional demanding, single flight attendant duty and repetitiveness of task), organizational factors (work scheduling which includes multiple flight segments, short-turnaround times between flights, consecutive duty days, irregular working hours and high number of take-off and landing) and individual factors such as the stress, sleep, work experience and age. Other factors include the environmental factors such as confined work space, high noise levels, low light levels, vibrations and low air quality as well as the tools and technologies such as the service trolleys, and limited facilities. All of these factors in the work system plays a significant role in increasing cognitive, physical and/or psychosocial workloads placed on the individual worker and as an outcome contributes to flight attendant fatigue during short-haul flight operations. In addition, the factors within the work system also interact and influence each other, which further increases the cognitive, physical and/or psychosocial workloads placed on the individual worker, thus, induces flight attendant fatigue.

4.2.1 Task-related factors

Occupation specific work demands has a strong correlation to work-related fatigue. Job demands are characterized of all physical, organizational, psychological and social aspects of a job that contains cognitive, physical and emotional (psychological) efforts to perform specific work tasks (Gillet *et al*., 2015; Els *et al*., 2015; Schaufeli and Bakker, 2004). Task demands can be either cognitive demanding (relating to information processing), physically demanding (associated with physical aspects of behavior and musculoskeletal system) and emotionally demanding (which is primarily the effort that individuals deal with organizationally desired emotions during interpersonal interactions) (Hockey, 2000; Morris and Feldman, 1996; De Jonge and Dormann, 2003). Task demands can be affected by physical work environment, task requirement itself, organizational factors, work equipment and social factors (Gillet *et al*., 2015). Task demands may lead to positive outcomes; however, it may also lead to negative outcomes experienced by individuals which occurs when there is a mismatch between the human capabilities and task/system demands (Gillet *et al*., 2015; Karwowski, 2001). Some of the negative outcomes include fatigue, which is one of the main risks' factors, anxiety, stress, high workload or burnouts (Gillet *et al*., 2015; Karwowski, 2001). These negative outcomes can affect the safety and well-being of workers/individuals, decrease performance and productivity (Gillet *et al*., 2015; Karwowski, 2001).

Therefore, humans may feel fatigue due to the job demand that they must perform. This is because if there is a mismatch between work demands and fitness of an individual worker, for example depending on the type of job/work, individuals may feel fatigue pushing themselves to perform a certain task effectively, which may put a strain on the body and mind especially work that requires a lot of attention/memory and thought or physical exertion (MacDonald, 2003a). Consistently working with heavy workloads can induce the effects of fatigue, these include when work is characterized with excessive work hours or performs physically demanding or mentally stressful tasks (Gore, 2018; MacDonald, 2003a). It was found that one such occupation with these work-related characteristics are short-haul flight attendants in the aviation industry.

The main objective of flight attendant’s task/duty and responsibility are to ensure passenger safety and comfort and providing service on board the aircraft (Bergman and Gillberg, 2015; Vidotti *et al.,* 2016). Due to the changes in duties and responsibilities of flight attendants since “9/11” terrorist attack, the tasks carried out by flight attendants has shown to become more complex, and has resulted in work overload (Nesthus *et al.,* 2007; Vidotti *et al.,* 2016; Hoppe, 2018). High workload has been identified as a major concern in the aviation industry, particular in short-haul flight operations, thus can have negative consequences to flight attendant performance and in-turn impact passenger safety (Tritschler and Bond, 2010; Damos *et al*., 2013). The tasks, duties and responsibility of a flight attendants are physically, mentally and emotionally demanding (Nesthus *et al.,* 2007; Chen and Chen, 2014; Vidotti *et al.,* 2016). As a consequence, flight attendants have reported an increase in stress and high workload which further contributes to increases in fatigue levels experienced among flight attendants (Nesthus *et al.,* 2007). The increased stress and high workload among flight attendant is similar to those experienced by pilots although their duty/duties are varied and include more physical activity, with higher social involvement (Nesthus *et al*., 2007). In addition, short-haul flight operations are also carried out by one flight attendant, attending to approximately 9-50 passengers (Nesthus *et al*., 2007; Chen and Chen, 2012; Hoppe, 2018). Due to this, flight attendants often have no rest opportunities which increase the workload demands placed on an individual flight attendant and has been shown to result in higher fatigue levels (Nesthus *et al*., 2007).

Flight attendants perform many tasks during short-haul flights, for example they are involved in a number of pre-flight, in-flight (routine and non-routine tasks) and post flight tasks to ensure passenger safety (Avers *et al*., 2009a; Nesthus *et al*., 2007). However most of their tasks are performed on board an aircraft (in-flight), although they may assist station agents during boarding or assist passenger with embarking/disembarking on and off the aircraft (Nesthus *et al*., 2017). The different flight stages of flight attendant duty process of domestic/commercial and regional airlines are represented in Figure 4. Pre-flight duty of a flight attendant includes pre-flight briefing (where cabin crew are assigned their working positions for the upcoming flight), crew are also informed of flight details, the schedule and if there are passengers with any special requirements, such as diabetic passengers, passengers in wheelchairs or the number of infants on board, checking emergency as well as other equipment's (Avers *et al*., 2009a; Nesthus *et al*., 2007; Shao *et al*., 2008). They also check/observe passenger access, help passengers to their seats and help with their carry-on luggage (Avers *et al*., 2009a; Nesthus *et al*., 2007; Shao *et al*., 2008). In-flight (routine and non-routine) duty of flight attendants can be classified into three tasks; these include safety, security and passenger service (Damos *et al*., 2013). The safety duty of flight attendants (routine duty) is to make sure that no individual in the cabin during the flight gets injured (Vidotti *et al.,* 2016; Damos *et al.,* 2013). For example, flight attendants must make sure that all passengers in the cabin are seated with their seat belts fastened in order for individuals not to be thrown about in the cabin, thus resulting in them getting injured especially during turbulence phase of flight (a sudden, violent shift in the airflow) (Vidotti *et al.,* 2016; Damos *et al.,* 2013). In addition, flight attendants ensure that all hand on luggage are securely stored away, and galleys are secure prior to take-off and carry out safety rules (informing passengers of the aircraft safety procedures) (Avers *et al*., 2009a; Nesthus *et al*., 2007; Vidotti *et al.,* 2016).

They also prepare and serve beverages and food, completing safety checklist, respond to passenger requests. These duties are known as passenger service duties of flight attendants (Avers *et al*., 2009a; Nesthus *et al*., 2007; Vidotti *et al.,* 2016; Shao *et al*., 2008; Damos *et al*., 2013).

Non-routine duty involves dealing with several emergencies such as cabin fires, ill or disruptive passengers or first aid situations. They also control first aid and medical equipment, control of emergency equipment, inform passengers on emergency landings and many more (Avers *et al*., 2009a; Nesthus *et al*., 2007). Post flight duty encompasses flight attendants disarming doors, deplaning passengers, checking as well as tidying cabin to prepare for the next flight. They also perform post flight briefing where they submit reports to the airline with flight details such as duty-free sales, food and drinks sales, any unusual incidents and customs (Avers *et al*., 2009a; Nesthus *et al*., 2007).

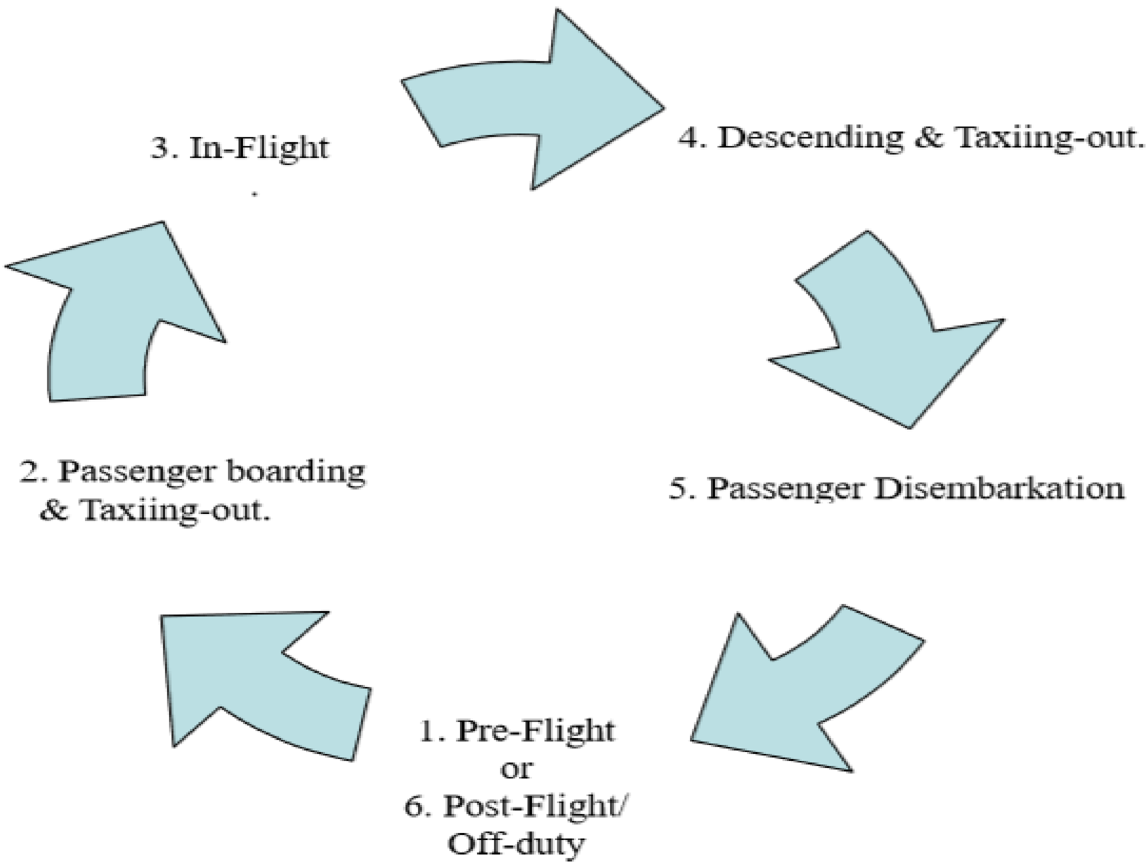

Figure 4: Flight Stages Correlated to Cabin Crew Duty (taken from Shao *et al*., 2008, pp. 3).

Flight attendants operate in an environment that requires the use of cognitive skills such as vigilance, accuracy and rapid decision making. The greatest challenges of flight attendants are related to ensuring safety and especially responding to a non-routine situation in the cabin (Nesthus *et al*., 2007). It is during these duties (routine and non-routine duties) that the abilities, skills, and training of the flight attendants are mostly challenged and where one would expect the effects of fatigue to have the greatest impact on performance (Nesthus *et al*., 2007). This is because during these tasks, flight attendants require high levels of cognitive performance for example sufficient high levels of alertness and vigilance to carry out their duties such as to ensure safety and adequate response to abnormal and emergency situations, in order to bear important aircraft cabin safety, comfort and service to passengers (Ng *et al.,* 2011). Constant high levels of cognitive performance due to the duties and responsibilities, increases the workers mental workload (which is the amount of mental processing capability or resources and the amount required by the task for optimal task performance) may contribute to exhaustion, worker stress and mental fatigue experienced by flight attendants (Nesthus *et al*., 2007; Cain, 2007; Ng *et al*., 2011). High levels of fatigue and lowered alertness in cabin crew may have negative effects on safety and have been shown to increase incidences of accidents and injury as a result of failing to remember to securely stow away the hand-on luggage during turbulence, informing passenger about safety procedures and nodding off during a flight (Nesthus *et al*., 2007). Hancock and Verwey (1997) demonstrated that fatigue is directly related to the workload of sustain attention.

In addition, there is also a shift towards an increasing emotional workload that can be observed among flight attendants during these tasks (routine and non-routine duties). The working environment of cabin crew has been described as highly stress-provoking due to general organizational environment of flight attendants, their responsibilities and duties that they bear during flight operations and because cabin crew are responsible for the safety of passengers (Nesthus *et al*., 2007; Boyd and Bain, 1998; Hajiyousefi *et al*., 2017; MacDonald *et al.,* 2003b; Boyd and Bain, 1998). Flight attendants also deals with aggressive, demanding passengers (Chen and Chen, 2014; Chen and Kao, 2012). In general stress refers to some undesirable condition, task, circumstance or other factors that have an affect (impinge) upon an individual (McCormick and Sanders, 1993). Stress is considered as an everyday reality in the aviation industry which occurs in the body's physical or mental response to situations (Hajiyousefi *et al.,* 2017). According to Campbell and Bagshaw (2008), stress is triggered by the reaction of stressors such as unfavorable environmental conditions which can occur during flying operation. He also states that stress is a resultant of demands placed on individuals that the body reacts to (Campbell and Bagshaw, 2008). It is commonly known as a threat to aviation safety as it can impair alertness and performance levels (Hajiyousefi *et al.,* 2017). Stress is one of the many causes of fatigue; however, fatigue may also induce stress. According to Suvanto and Ilmarinen (1989) high cognitive as well as physical job demands are common sources of stress among short-haul flight attendants. According to Nesthus *et al*. (2007), flight attendants have reported increased amount of stress due to their responsibilities and duties during flight operation in both international and domestic flights.

Flight attendants during short-haul flight are emotionally challenged by requirements to perform multiple tasks on tight schedules and for being front-line employee in service where passengers look to for information, help and support (Hajiyousefi *et al.,* 2017; MacDonald *et al.,* 2003b; Boyd and Bain, 1998). For example flight attendants have regular exposure to emotional stressors, this is due to the fact that the working environment of cabin crew include unobtrusive and highly disciplined responses to medical and other emergencies that can occur during a flight, assurance of passenger compliance with federal aviation regulations, vigilance for activities within the cabin environment that may deliberately or accidentally threaten the safety of passengers or flight crew (Hajiyousefi *et al.,* 2017; MacDonald *et al.,* 2003b; Boyd and Bain, 1998). Overall flight attendants are exposed to a variety of stressful situation in cabin and are also under pressure to complete tasks that may be challenging or difficult which may induce stress (Hajiyousefi *et al.,* 2017; MacDonald *et al.,* 2003b; Boyd and Bain, 1998; Chen and Chen, 2012).

Susceptible individuals may also experience exhaustion and stress due to excessive "emotion work" (Heuven and Bakker, 2003; Hochschild, 1983). For example, because their workload incorporates higher social involvement and may deal with demanding, violent and aggressive passengers, flight attendants are often emotionally challenged as they have to control their overt behaviour and provide emotions to maintain positive interaction (good humour, friendliness, and cheerfulness) with passengers throughout the flight which contradicts the expression of their own feelings (Kinman, 2009; Chang and Chiu, 2009; Chen and Chen, 2012; Chen and Kao, 2012). The emotional well-being of flight attendants in the airline workplace has been viewed as being important as a member of service delivery (Hochschild, 1983). This emotional control is influenced by job performance rules, so they have to adjust their emotions to the requirement of the job (Kinman, 2009; Chang and Chiu, 2009). Managing these expressions for long periods may lead to flight attendants becoming emotionally exhausted (Kinman, 2009; Chang and Chiu, 2009). Emotional exhaustion refers to feelings of energy depletion and describes mental and physical indifferent attitudes towards the receivers of one's services under a certain amount of emotional labour (Kinman, 2009; Chang and Chiu, 2009). Emotional exhaustion is considered a core dimension of burnout and fatigue (Kinman, 2009; Chang and Chiu, 2009). Dormann and Zapf (2004) demonstrated that flight attendants who perceive emotional dissonance between their internal true feelings and the displays of professional friendliness required in their work are more likely to experience stress (Dormann and Zapf, 2004). According to Williams (2003) flight attendants are also characterised as performing work that may lead to emotional exhaustion due to the duties that tend to allow restricted job autonomy and requires long working hours. Therefore, long term emotional suppression along with high emotional labour demands, are the causes of psychological (mental) fatigue (Shao *et al*., 2008).

Furthermore, as indicated by the responsibilities and duties of flight attendants (pre-flight, routine and post-flight duties) they are also involved in a number of physically demanding tasks. These include considerable bending over, walking, spending most of their time on their feet, continuous standing, pushing and pulling trolleys as well as lifting heavy objects from the floor to above shoulder-level heights (Nesthus *et al*., 2007). These physical stressors increase the physical workload (which is to the measurable portion of physical resources expended when performing a given task) of flight attendants, thus contributing to high levels of fatigue (Kantowitz and Casper, 1988; DiDomenico and Nussbaum, 2008). The increase in high physical workload which is associated with their work tasks also results in flight attendants experiencing high risk of fatigue-related symptoms or work-related muscle disorders such as low back pain (Schaub *et al.,* 2007; Khrisnapandit *et al.,* 2016; Glitsch *et al*., 2007;Vidotti *et al.,* 2016). Low back pain (LBP) is a common musculo-skeletal disorder where pain and discomfort appear in the lower back area below the costal margin but above the inferior gluteal folds (Manek and MacGregor, 2005). A study conducted by Sharma *et al*. (2013), stated that characteristics of short-haul flights such as ratio of flight attendant to passengers (single flight attendant attending to 9-50 passengers) and hour of in-flight service/duty (long working hours) increases the workload of flight attendants, thus leads to greater experience of lower back pain, severity of back pain and work day loss. In addition, 9 hours or more flight time and 4 sectors in the last 24-hours which are also associated with short-haul flights, increases risk of lower back pain (Khrisnapandit *et al.,* 2016). This is because more physical loading of work particularly manual material handling tasks (long standing and frequent bending) is done on short-haul and medium haul flights, as a consequence this induces end of duty fatigue (Logie *et al*., 1997; Khrisnapandit *et al.,* 2016).

Low back pain (LBP) often experienced by flight attendants could limit their duties and responsibilities (Schaub *et al.,* 2007; Khrisnapandit *et al.,* 2016; Glitsch *et al.,* 2007). For example, flight attendants performing their duty with acute pain, often find it difficult to be able to provide appropriate cabin services, but also their awareness of abnormal situations and response ability is often weakened, and this may render potential lethal risks to flight safety (Schaub *et al.,* 2007; Khrisnapandit *et al.,* 2016; Glitsch *et al.,* 2007). According to Khrisnapandit *et al.* (2016), lower back pain was found to be a leading cause of work absence, activity limitation which may result in a huge economic burden to the airline industry, families and individuals.

Overall high workload is important factor to consider in operations of cabin crewmembers as it is an important factor that modifies fatigue (Cain, 2007). It is defined as the physical and/or mental requirements associated with a task or combination of tasks (Kantowitz and Casper, 1988; DiDomenico and Nussbaum, 2008). In flight task, workload refers to work done by flight attendant in the aircraft. It can differ with the difficulty of task and the number of tasks being performed (Gawron *et al*., 1989). High workload is known to have a direct correlation to fatigue and has been shown to significantly influence fatigue among flight attendants operating short-haul flights, due to job demands with tight schedules, high number of take-off and landing and short turn-around times between flights (Co *et al*., 1999; Tritschler and Bond, 2010). High levels of mental, physical and emotional workload are important factors influencing performance of an individual (Xie and Salvendy, 2000; Moray, 1988). Studies have shown that workload increases fatigue and is associated with reduced performance abilities (Cain, 2007; Lee, 2010; Lysaght *et al*., 1989).

4.2.2 Organizational factors

Flight attendants perform their tasks under certain organisational conditions such as specific scheduling factors which may further influence workload levels and in-turn contributes to fatigue. Flight attendants working during short-haul flight operations are often rostered for irregular patterns of early starts and late finishes (duties that extend on either side of the standard working day) which can disrupt normal sleep routines and increase mental and physical fatigue (Thomas *et al*., 2015). However, extended overnight operations are less common (Thomas *et al*., 2015). The work pattern may also involve multiple take-offs and landings resulting in a more demanding workload across the workday (Thomas *et al*., 2015). Other factors identified include consecutive days worked, the number of sectors flown, long flight duty periods and short-turnaround times (Gander *et al*., 1994; Gander *et al*., 1998; Spencer and Robertson, 2000; Spencer and Robertson, 2002). Thus, studies have shown that work schedules of flight attendants are common cause to fatigue (Ono *et al*.,1991; Castro *et al*., 2015; Avers *et al*., 2009a)

Total duration

Based on the Federal Aviation Authority (FAA) and South Africa Civil Aviation regulations, flight duty period (the period that begins when a crew member is required to report for a duty period that includes one or more flights and ends at block-in time of the final flight segment.This period also includes pre-flight activities and flight time), should not exceed 35 hours during the preceding seven days and may not exceed 10 hours within 24-hour period (Dinges *et al*., 1996; SACAA CAR/CATS, 2016). Duty period (A continuous period of time during which tasks are performed for the operator, determined from report time until free from all required tasks), may not exceed 14 hours within 24-hour period (Dinges *et al.,*1996; SACAA CAR/CATS, 2016). However, a typical day for a flight attendant during short-haul flight operations consist of, on average four to six flight segments, with flights lasting anywhere from 30 minutes to 3 hours of flight time and duty days lasting approximately 10-16 hours (Nesthus *et al*., 2007; Dijkshoorn, 2008). Bennett (2003) noted that the most practical duty day in short-haul operation is characterized of 12 hours or more duration in any 24-hours. Therefore, long duty or extended duty periods plays a significant role contributing to fatigue among flight attendants. Substantial number of studies have demonstrated that extended duty periods, contributes to fatigue (Gander *et al.,* 1998; Samel *et al.,* 1997; Caldwell, 2005). According to Avers *et al*. (2011), on average flight attendants work days are +- 9.6 hours with average maximum of 12.9 hours and minimum of 6.4 hours. It has been noted that length of duty day of more than 10 hours is one of the most common factors contributing to fatigue in flight attendants (Avers *et al*., 2011; Caldwell, 2012). Duty days longer than 14 hours, was identified as the major factor contributing to perceived fatigue among flight attendants in both domestic (commercial/ regional) and international flights (Avers *et al*., 2011; Avers *et al*., 2009a). According to Dinges *et al*. (1996) a duty period exceeding minimum 10 hours or maximum 12 hours within 24-hour period, results in flight attendants being more vulnerable to a decrease in performance and increase in fatigue levels. It was also found that duty hours more than 10 hours contribute to increases in incidences or accidents (Caldwell, 2005). Therefore, as stated by Brown (2012) shifts or duty times longer than 8 hours should be avoided if the work task is safety critical and have high workload. The main factors contributing to extended duty period and long duty days include, extended waits between flight segments, early starts and late finishes (debriefing late at night) and unforeseen circumstances such as passenger delays, equipment malfunction, unloading or loading of cargo, unanticipated technical delay, air traffic delay that is beyond the control of the operator, medical reasons and unforeseen weather conditions, which may increase the duty hours to a maximum of 2 hours (Caldwell, 2005; Chang, 2002; Ono *et al.,* 1991; Gander *et al*., 1998). Therefore, exceeded work time is considered a major contributor to flight attendant fatigue (Shao *et al*., 2008).

Number of flights per shift

Standard short-haul schedules usually contain multiple flights of up to five a day (Dijkshoorn, 2008). Multiple flight segments during one duty period have been documented to significantly increase risk for reduced performance and increase fatigue (Bourgeois-Bougrine *et al*., 2003a). Due to the multiple legs or flights during short-haul operation, flight attendants often have no time to eat or drink between flights (no meal breaks) and as a result may decrease their energy levels (Nesthus *et al*., 2007; Nagda, 2000). They also often have no time to rest (Nesthus *et al*., 2007; Nagda, 2000). Scheduling factors of flight attendants that do not pay attention to long duty days, adequate time for meals breaks and sufficient rest breaks can affect flight attendant's abilities to perform on duty (Nesthus *et al*., 2007). Studies have shown that fatigue level increases with each flight leg (Galipault, 1980; Tritschler and Bond, 2010). Spencer and Robertson (2002) have shown that fatigue levels increased as the number of sectors progressed across a 4 sector flight duty period. Banks *et al*. (2009) notes that during a 12 to 14-hour duty day without getting adequate nourishment (eating food and drinking water) gradually decreases energy levels as a result of multiple legs. This increases the risk of fatigue and reduces safety margins (Banks *et al*., 2009). In addition, on each flight, flight attendants working cycle begins with the entry of passengers to the aircraft, passenger briefing, distribution of food and beverages, cleaning up, preparation for landing and clearing the passengers off the plane, are completed on each sector down the route. Overall this repetitiveness of work (performing the same task/ duties for each segment) increases the workload levels, leads to feeling of exhaustion, which enhances mental and physical fatigue among flight attendants (Yen *et al*., 2009; Nesthus *et al*., 2007). Repetitive tasks have also shown to produce emotional stress (Bonde *et al*., 2005).

Number of take-off and landings

Short-haul flight aircrew members work with more take-off and landing (Chang, 2002). On average short-haul flights undertake twice as many daily take-offs and landings for example on average 5-10 take-offs and landings in comparison to long-haul operations (Powell *et al*., 2008); Chang, 2002). Short-haul schedules involve three or four duty days, followed by one or two-day offs in a typical 7-day week (Day and Ryan, 1997; Avers *et al*., 2009a). However, aircrew members during short-haul flights also often work an average maximum of five to six consecutive days performing on average between one to five flights each day (Dijkshoorn, 2008; Avers *et al*., 2009a). Folkard and Åkerstedt (2004) argued that the accident risk substantially increases over consecutive duty days, indicating a cumulative fatigue effect. Therefore, consecutive duty days have been shown to induce fatigue among flight attendants (Avers *et al*., 2009a).

Early starts

Early starts are also a common factor contributing to fatigue among flight attendants as it shortens sleep quantity and quality before the flight (Dijkshoorn, 2008; Spencer and Robertson, 2002). It has been shown that flight attendants start work between 6:00am and 8:00am in the morning (Spencer and Robertson, 2002). According to Spencer and Robertson (2002) duties that start before 9:00am are associated with an increase in fatigue throughout the following duty period. Fatigue also increases as a result of consecutive duties that start at 8:00am or earlier as a result of increasing sleep debt over successive days (Spencer and Robertson, 2000; Spencer and Robertson, 2002). Early starts particularly those that start at 6:00am or earlier, impairs levels of performance (Spencer and Robertson, 2002).

Sleep duration

It has also been shown that overall flight attendants sleep time decreases on short-haul operations, this is partly due to the fact that cabin crew members usually report to duty 1 or 2 hours prior to departure time (flight duty period) which can be as early as 4:00am to 8:00am in the morning (Dijkshoorn, 2008; Nesthus *et al*., 2007; Avers *et al*., 2009a).Thus duty start time impacts the amount of sleep one obtains (Roach *et al*., 2012). However, factors such as the time it takes a flight attendant to get up in the morning as well as the time it takes them to commute to work and back home or to an hotel after their last duty period also influences sleep patterns and the onset of fatigue (Nesthus *et al*., 2007; Civil Aviation Authority, 2004). Commuting is known as an extension of a working day although forms part of crew members rest period. Depending on the commuting time, if it is long it will further increase the fatigue level of a crew member as they will be awake longer. On average it takes flight attendants approximately 20 minutes to an hour to commute to their scheduled base for work or back home or to an hotel (Dijkshoorn, 2008; Bennett, 2003). Flight attendants also take on average an hour and a half (1,5 hours) to wake up and get dressed (Dijkshoorn, 2008). Overall flight attendants have to get up in the early hours of the morning, resulting in them obtaining less than 8hrs of sleep (Dijkshoorn, 2008).

Studies have shown that sleepiness and fatigue are at its greatest and people are often unable to function effectively to perform mental and physical work during a time known as window of circadian low (WOCL) (Dinges *et al*.,1996). This time is usually around 2:00am to 6:00am in the morning when the body will have its lowest temperature (Dinges *et al*.,1996). Sleep opportunities may also be delayed due to late debriefing hours at the end of the duty period or shortened with an unexpected early wake-ups the next day (Thomas *et al.,* 2015; Ono *et al.,* 1991). This loss in overall sleep time may accumulate during the trip and lead to sleepiness and performance impairment on duty (Kushida, 2004). Repeated insufficient sleep without opportunity for recuperation, could cause cumulative fatigue and lead to great risk for aviation industry (Yuliawati *et al*., 2015). Sleep loss can degrade cognitive processes, vigilance, decision making and communication (Co *et al.,* 1999; Caldwell, 2005; Rosekind *et al*., 1996). Decreases in decision making abilities has been attributed to individuals finding it difficult to deal with unfavorable situations (Rosekind *et al*., 1996; Rhodes and Gil, 2003).

In addition, lack of sleep may also result in mental fatigue. Consequently, one can become increasingly inattentive while trying to concentrate on a specific task or tasks at work (Rhodes and Gil, 2003). A fatigued individual may find it difficult to concentrate as short-term memory becomes less effective and individuals may find it difficult to remember important information (Nesthus *et al*., 2007; Rhodes and Gil, 2003). According to Roach *et al*. (2012) aircrew members reporting to duty early in the morning often obtain less sleep, having higher fatigue levels in comparison to those that report to duty later in the morning. Roma *et al*. (2010) found that flight attendants on average sleep approximately 5.7 hours per night on workdays, thereby resulting in them often working in a fatigued state. In order to accommodate an early report time, crewmembers may attempt to go to sleep earlier than their normal sleep time in order to get their usual amount of sleep (Dijkshoorn, 2008). However, because the natural tendency of the circadian clock is to lengthen rather than shorten the day, crew members find it difficult to fall asleep earlier as they may be physiologically unable to do so (Dijkshoorn, 2008). Overall, timing of work hours, in particular early starts and late finishes and any subsequent impact of off duty sleep quality prior to flight duty period are known as a predictor of flight attendant fatigue (Nesthus *et al*., 2007; Cabon *et al*., 2012; Petrilli *et al*., 2006).

Standby duty

In addition, short-haul crew members duty schedule may also encompass standby duties. Standby duty refers to a period where an operation places restraint on a crew member who would otherwise be off duty, where they are not to be contactable until notification of duty is given (Civil Aviation Authority, 2004). In other words, it is a period of time at the airport, at home or at a hotel where aircrew members are required by an operator to be available to receive an assignment for a specific duty without disturbing rest periods (ICAO, 2012). The consequence of this duty to short-haul crew members however is that it may contribute to extended hours of wakefulness as they may be called to a duty of 14 hours of which they have already been awake for 16 hours (Co *et al*., 1999). Due to this it may result in inducing fatigue and sleepiness (Co *et al*., 1999). In addition, this may also decrease, and limit aircrew members sleep quantity and quality during the day. Due to this may increase sleepiness the following day, as standby creates unpredictability in their schedules, thereby finding it challenging to plan and decide their sleep and rest opportunities (Co *et al*., 1999).

Short turnaround times

Short turnaround times between flights plays an important role in determining workload for cabin crew workers. It is known as a crucial aspect of work factor contributing to fatigue among cabin crewmembers (van Drongelen *et al.,* 2013). Short turnaround times refer to the time cabin crew have on the ground between de-planning passengers and embarking passengers for the next flight (van Drongelen *et al.,* 2013). Short turnaround times between the multiple segments are about 15 to 35 minutes (Christoffels and Gluchshenko, 2017; van Drongelen *et al.,* 2013; Co *et al*., 1999). These short layovers do not take into account the need for cabin crew to have adequate rest breaks (Bourgeois-Bougrine *et al*., 2003b). It was noted that short layovers of up to 35 minutes could contribute to fatigue and daily strain for cabin crewmembers (Bourgeois-Bougrine *et al.,* 2003b).

4.2.3 Environmental factors

In addition to task and organisational factors, flight attendants work most of their duty hours in a pressurized cabin and are also exposed to a combination of specific environmental factors that can influence fatigue (Dijkshoorn, 2008). Environmental factors such as movement restriction, vibrations, high noise levels, low air quality and low light levels are known causes of fatigue (Edwards, 1991). These factors have also been shown to influence the health-related symptoms and comfort of passengers and cabin crewmembers (Edwards, 1991; Vidotti *et al.,* 2016). In the aircraft, noise is produced by the aircraft engines (Dijkshoorn, 2008). Studies have shown that aircraft noise and temperature lead to constraints and can enhance fatigue and as a result impairs performance (Bourgeous-Bourgrine *et al.,* 2003b, Yen *et al*., 2005; Saremi *et al*., 2008). Noise affects performance in a variety of ways that ultimately increases the incidence of accidents. Psychologically it increases annoyance, frustration, workload, anxiety and fatigue (Bosley *et al*., 1999). Over the years passengers and flight attendants have also repeatedly raised questions regarding air quality in the aircraft (National Research Council, 2002). The general concerns about air quality focus on air dryness, which appears to be caused by the cabin air humidification (Nagda and Hodgson, 2001). Prolong exposure to low humidity of air causes discomfort for example drying of eyes, skin and nose or generalized symptoms such as fatigue and difficulty in concentration (Lindgren and Norbäck, 2005; National Research Council, 2002).

4.2.4 Individual factors

Factors relating to the performance of the individual worker such as level of cabin experience, age, gender and general health are common individual factors enhancing fatigue (Nesthus *et al*., 2007; Kryger *et al*., 2017). According Castro *et al.* (2015) women was found to be more affected by several fatigue factors than men during a flight operation. In the same study it was also found that senior flight attendants (increased seniority) together with increasing age are more vulnerable to an increase in fatigue levels (Castro *et al.*, 2015). A similar study also found that fatigue levels increases with age (Galipault, 1980). However, Roma *et al.* (2010) demonstrated that junior ranking flight attendants may be more vulnerable to fatigue-induced risk in comparison to senior or mid-level flight attendants. In addition, lifestyle behavior, personal habits and individual attributes such as social life activity, family needs, secondary employment, commuting time, medical conditions and ingested chemicals/substances such as caffeine, alcohol and drugs (no-prescriptions or prescriptions) can ultimately lead to the onset of fatigue (van Drongelen *et al*., 2017; Bültmann *et al*., 2002). Physical inactivity (lack of exercise) is also considered one of the perpetuating factors of fatigue (Sharpe and Wilks, 2002).

4.2.5 Technologies and Tools

Lack of resources can interfere with one's ability to complete a task. Short-haul flight operations are often characterised with small regional airports and airfields having limiting facilities that may be lacking in embarkation and disembarkation infrastructure (jetway, airbridge or boarding stairs), thus due to this it may increase the responsibilities and workload of the single flight attendant (Edwards, 1991). As flight attendant on duty will have to assist in lifting or may carry each passenger with their hand on luggage onto and out of the aircraft safely without getting injured or falling. The working space and the equipment used on board the aircraft can also impose physical stress due to awkward postures, pushing and pulling food or service trolleys (Edwards, 1991; Chen and Chen, 2014).

4.3 Summary of system analysis

The outcome of the system analysis is highlighted in figure 5 below:

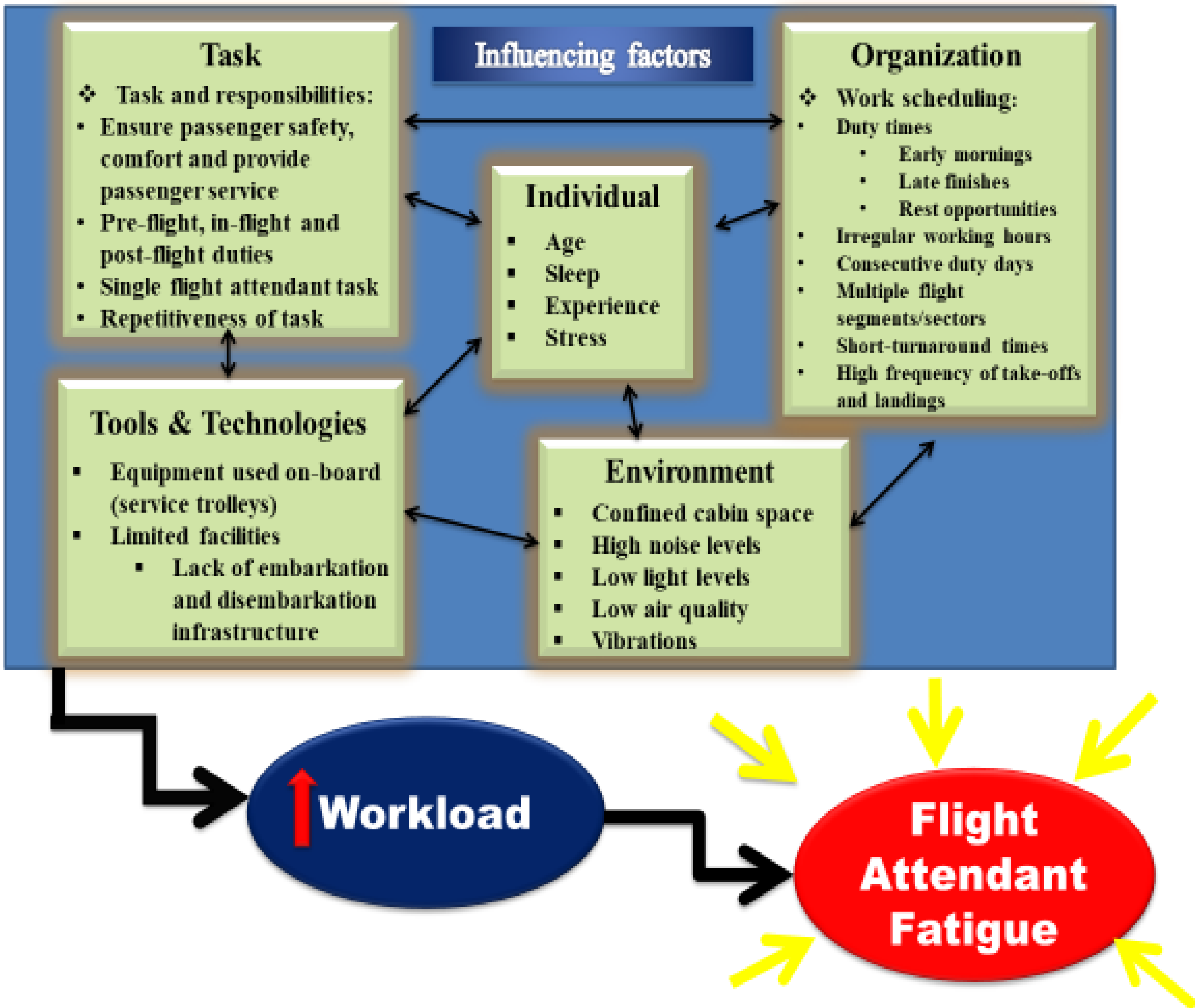

Figure 5: A model demonstrating the workload factors contributing to flight attendant fatigue during short-haul flights (the outcome of the analysis).

4.4 Expert interview

The results of the analysis of the interview data will be presented in this chapter. This section highlights and reports the qualitative data on issues that was raised from the different interviews of various experts (stakeholders). This section demonstrates the results presented for every theme, including a description of results and illustrative quotes (actual respondents' comments) for the most commonly identified issues relating to the research question. In other words, it will summarize some of the most relevant findings from the strategic interviews. This way readers can gain a sense of how widespread a particular view is among the experts that was interviewed. All quotations are indented and are displayed in italics with double commas for clarity of the descriptions results.

4.4.1 Sample characteristics

The experts were recruited via email and by snowball sampling. In total 4 (n=4) participants agreed to participate in this study. Recruitment was stopped after the last interview did not seem to reveal new information compared to the previous three. One of the interviews were carried out face to face, and the rest of the interviews were carried out using the Zoom program (online telephone video phone call). Each interview lasted between 30 and 45 minutes. They were conducted during the months of October and November 2018.

All interviewees were experts in either aviation or fatigue research or had a background and knowledge in commercial/regional aviation context. We interviewed one academic lecturer (P1) who specialized in sleep, circadian and fatigue research, one senior airline captain who is also a senior training pilot in commercial work environments (P2), one member of the South African aviation union in the Airline Pilots' Association of South Africa (ALPA-SA) who is also a senior captain (P3) as well as an aviation fatigue specialist for commercial/regional aviation airlines (P4). Thus, the experts were experienced individuals having a 100% knowledge in the field of aviation and fatigue (all answered 'yes' in one of the pre-screening questionnaire questions which was, do you have knowledge in the field of aviation and fatigue?), for example they had an experience level on average of 22.75 (±10.43) years in their respective jobs. Hence, were selected to partake in the current study. The experts interviewed were males with an average age of 47.27 (±8.93) years.

4.4.2 Expert interview (qualitative results)

The purpose of the interview as stated in the previous chapter (chapter 3) was to determine and explore general information and opinions on the research topic (aviation fatigue, aircrew fatigue and workload, and what factors experts perceive contribute the greatest to workload and fatigue in short-haul operations among flight attendants). In addition, the purpose was also to gain additional input and opinions on elements that the researcher was not sure about. To give a general impression on the opinions and perceptions of what the experts have discussed in the interviews, figure 6 highlights a word cloud of 1000 most used words by the interviewees. This was made using NVivo 12 program to perform query on word frequency. Overall from the interviews four main categories were identified through the coding process and within each category the main themes that emerged from the data were presented, this can be seen in table 3. Each theme within the category was discussed in detail.

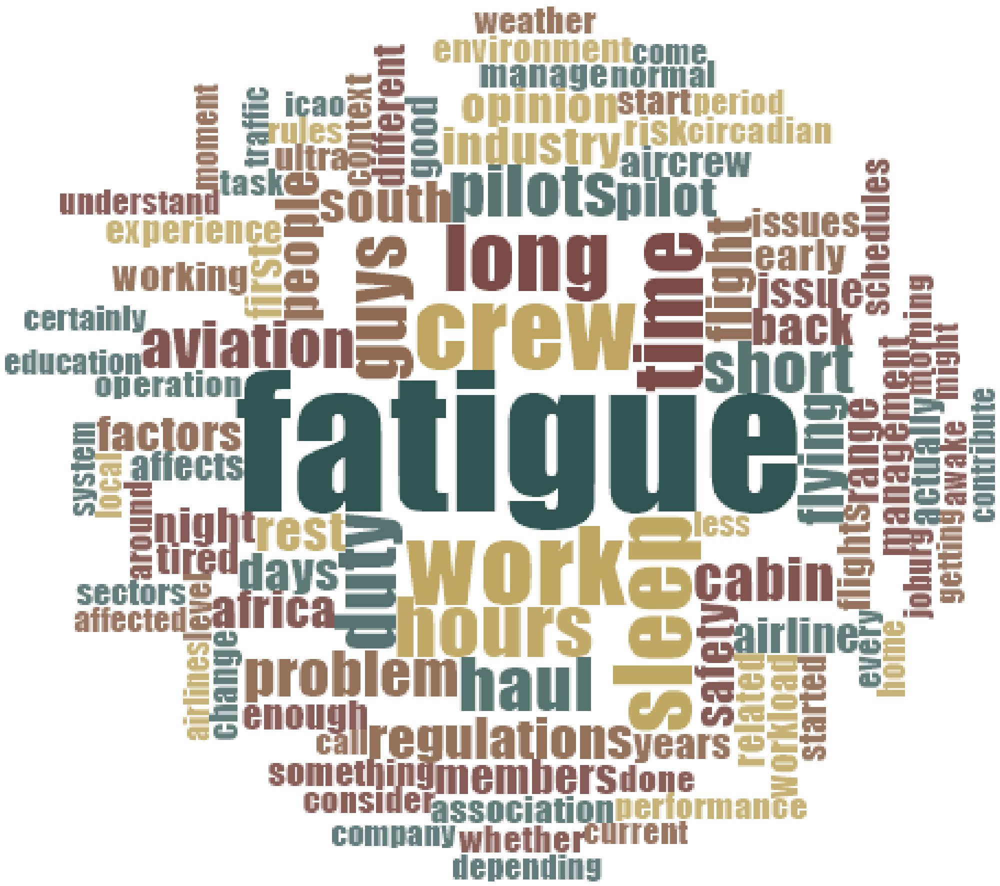

Figure 6: A word cloud displaying the most frequent words that occurred in the interviews based on short-haul flight operations.

Table III: The main categories and themes that emerged within the qualitative data

Categories	Main themes
What is fatigue and the importance of examining short-haul flight attendant fatigue	Aviation fatigue meaning Concerns with aviation fatigue
Contributing factors to short-haul flight attendant fatigue	Organizational factors Task-related factors Other related factors (non-work and individual factors)
Consequences of fatigue	Performance Heath implications Communication and mood
How to manage aircrew fatigue in short-haul operations	Education Address current regulations Address rostering practices Physical activity and sleep

What is fatigue and workload and the importance of examining short-haul flight attendant fatigue?

This section encapsulates each of the participants opinions on what fatigue means within the aviation context, particularly aircrew fatigue operating short-haul operations. In addition, it also encapsulates participants opinions on why it was important to examine short-haul operations and the impact is has on flight attendant performance. The opinions of the meaning of fatigue varies with each participant. It was noted that some of the definitions may be specific on the causes of fatigue. Interviewees defined fatigue as a human's interaction with the environment, fatigue is associated with personal attributes, it is also defined as both physical and physiological but also psychological aspects to it and is defined as a sense of mental and physical tiredness.

The definitions of fatigue raised in the interviews are as follows:

In one of the interviews the meaning of fatigue was stated as a human interaction with the environment:

> *P1 "Fatigue……. is a natural into some degree no, it's an inevitable result of the human interaction with their environment and a natural result of human being awake during the day, so there is number of different components to fatigue".*

P1 "Fatigue is the product of a human's interaction with the environment so certain, certain things like interacting with the type of task or activity that you are doing results in a certain , that requires resources being depleted whatever those resources are, whether they are physical, cognitive, again contribute to reduce the ability to perform or reduced inclination to perform, to carry on with the task depending on how long you do that task for. It would differ in that and then how other sort of the way that the work is structured, how people work whether they have to work at night, whether they have to work during the day, whether they have to work extended hours, all of those affect how humans can sleep or whether or not they getting enough recovery. And then while they are working, how the environmental factors and how other people either enhance that stress and that consumption of resources or make it easier it's just depend on the context".

P1 "Fatigue is a process where because of your interaction with the environment and in the things that you do and being awake it leads to a natural inclination, sometimes unnatural depending on what's being done to, to not being able to perform as best as you could".

Another expert noted that fatigue is associated with person attributes, this comment is stated below:

P1 "The first is that they are personal attributes, so that's the need for sleep naturally our performance ability to perform and our alertness changes over the course of the day depending on how long we've been awake and the quality of sleep that we obtained the night before. So there are natural changes to our ability to perform which are governed by sleep and circadian related factors".

While other experts have also revealed that fatigue is associated with physical, physiological, and psychological aspects and is sense of physical and mental tiredness. These comments are pointed out below:

P1 "It's it's shows that there is something that needs to happen probably aiming at the need for recovery, but it is something that results in a reduced ability of a human to perform, but also reduced inclination to want to perform. So, has both physical and physiological, but also psychological aspects to it, but it's difficult to define because it is so multifaceted.……………… I described it's *multifaceted it's very individual specific, it has many different ways in which its manifest and depending on the context that you're in".*

P4 "fatigue for me is a sense of tiredness both physical or mental. People tend to focus on the mental part, I try and encourage them to also look at the physical part and it can it is affected mainly by four things; whether you have slept enough, how long have you been awake, where are you on your circadian phase and what your workload has been, and depending on those will depend on how you going to feel or how its going to affect your performance, because sometimes you can feel good, but your performance is down although you don't realise it. So ya so it's a sense of tiredness. I always say we use the word tired when we at home and fatigue when we at work but I mean it's the same thing it's the context on the way we use it".

From the above definition it is noted that there is not one specific definition to define fatigue, because it is so multifaceted. However, even though fatigue is difficult to define it is still an issue that need to be examined, especially in short-haul operations as it could negatively affect short-haul crew members.

Several interviewees have noted that fatigue due to short-haul operations is a serious and major problem, thus it is an important to examine this operation. The comments are highlighted below:

P4 "the biggest risk is our short-haul, domestic flying especially the short-haul night freight flying can be quite challenging………. short-haul is much more tiring for the reasons that you work more consecutive duty days. On short-haul there is more disruptions of your sleep time, extended duty days and high workload with all the sectors you do".

P1 "So short-haul is a problem, because the number of flights that happen, the traffic in the sky, the fact that there is a pilot and cabin crew shortage, the fact that in South Africa you are operating an environment where the margins are very very small your return on investment are very small, and so if you got few planes, few pilots, cabin crew, large demand, large competition, you going to push that envelope hard and so ya it would present a challenge in my mind".

P2 “The international civil aviation organisation, they have obviously identified this problem as a huge problem! So, they have also looked at a lot of manuals on it for the regulators world wide and that is a threat and you need to manage it and the threat will always be there………. it is a serious problem if you not going to manage it”.

P3 “The short-range guys, repetitive early morning starts, multiple sectors and things like that as you know certainly for a short-range guy it has become a serious problem”.

One of the experts noted that it is a moderate concern. The comment is seen below:

P4 “I would put it more as a moderate concern and the reason why I say that is because crew become really good at managing fatigue. I mean there is often and I fly when I am tired properly and I know I am tired we very good at mitigating it, so with yes and the more you in it especially in the airline industry the more you do it the better you get it. In general, about 80% of the guys are really good at managing it about 20% of the population I would say are just poorly managing it they just cannot cope, they have to but they don’t manage it as well. So that’s why I say it’s a moderate concern”.

It has been stated by the experts that fatigue may present a risk to safety, reduce performance and may cause accidents or incidences, thus is an important topic to explore particularly short-haul operations because as stated by the experts:

P2 It is reduces performance at the end of the day and that is the big concern………. as you know your processing gets slower, your reasoning is not as good………., so obviously you can’t self assess it very well. So that's the problem with fatigue”.

P1 “it presents a risk to safety, it must be considered along with all the other factors that equally. It must be considered equally as important in terms of it's impact on safety as compared to a bird strike, as compared to technical difficulties, it presents a risk to safety………. it is a problem in the aviation industry”.

P1 "All of those the cabin crew the ground staff, air traffic control, pilots all play a role. They all in an integrated system that all have to operate optimally and do their job properly to maximize safety, so if somebody's ability to do the job is compromised because of issues of fatigue, then I would say that the thing that need to be dealt with".

P2 "It's a serious problem, because we have had all these accidents over the years".

Contributing factors to short-haul flight attendant fatigue

In line with the literature review several interviewees stressed that there are several factors contributing to aircrew fatigue because of the nature of the short-haul operations. The main factors of fatigue discussed with experts were grouped according to whether they are related to organization, the task, and other factors (including individual drivers or factors outside work), these were the main themes that emerged within the data. Comments on each cause are highlighted below.

Organizational related factors

One of the main factors that was highlighted in all the interviews was attributed to scheduling aspects of the organization. The most commonly cited issue that was brought up with regards to scheduling were long working hours, extended work hours, early starts and late finishes, issues relating to rostering practices and current regulations.

The following comments relates to issues raised and attributed to early starts, late finishes and extended working hours:

P2 "In short-haul operation its has its own set of issues………..so the short-haul operator has a lot of the early starts for every flight. Basically you have to be at the airport very early, so you getting up very early at 3 in the morning and then you can do a 12 hour day or whatever day……… you change from early flights to late flights where your roster can move away up and down quite a lot in the short-haul operation".

P1 "I think the main things that contribute to it are the very awkward sometimes very awkward working hours that the pilot's and cabin crew have to have to have to perform over multiple days. The fact that taking off and landing a plane is a stressful experience, so you have workload issues over and above that the working time probably interferes with sleep, because there's certainly in the South African context the working time does not always, is not the same ,so they have mixed schedules, so they have early start late finish, late finishes then a normal day. They also have extended work hours which is one of the major issues that are being so identified as the problem there's also the night work".

Some of the issues that were also noted from the experts contributing to aircrew fatigue was the rostering practices that short-haul crew members perform in the South African aviation context. Due to the rostering schedules crew members duty is often characterized with consecutive duty days with mixed schedules (early starts and late finishes). In addition, their rostering schedule also does not allow them to get adequate recovery and rest periods. Thus, aircrew members may feel fatigued as a result of lack of sleep.

The following comments relates to issues regarding short-haul crew members rostering schedule:

P2 "Short-haul operation,it's because your roster changes, so in one week I will start off lets say waking up 3 o'clock in the morning and the next night I can sign off at midnight or then legally you only need 9 hours off then you can start again, do you understand? So, you can cycle a guy in short-haul operations forwards and backwards, forwards backwards for 7 days giving one day off and then cycle him again for 7 days and he can do 60 hours of duty in that week. So the more obviously is not written for how you can get flown, so that is obviously a big issue and then obviously with short-haul it's a lot of sectors. So every sector you do, your fatigue will increase with the sectors as well, so that is obviously a big cause with short-haul operations".

P3 "You end off having 3 weeks of early starts in a row and have to take-off every morning for three weeks in a row. So that would mean you have to wake up about 4h30am and that was tiring by the time you had finished, that you had *enough and most days say we worked during the day and if any charter flight would come up we would do that and then we would do an evening shift which would finish about by the end of the day when we ended our shift we would work to about 7 o'clock and that was tough so it was a lot of up and down short flying………. by the end you would feel very trashed and that would be similar to what the guys are doing now the low-cost carriers".*

Interviewees also noted that although the rostering schedule allows two days off duty to recover, if you worked for five or six consecutive days. Crew members still does not obtain sufficient rest/recovery from duty.

One expert claimed the following:

P2 "Your recovery period is very short with long duty days, so that's the law, so that is an South African law not a country law, is like that so you can fly for 7 days. So, the airline I worked for now they roster works 6 days and then they give you two days off, but now with the problem with sit work you can finish on Day 6 let's say at 11 o'clock at night you finish and then you have your two days off but you get up on day 1 at 3 o'clock. So, the problem is although you have two days off you only get one night of unrestricted rest and that's a huge problem for us because, as you know as soon as you get less sleep or restrict sleep you need to give a guy at least two nights of unrestricted rest so that's a big issue with the crew, they don't have, get the enough time for recovery time because of the late sign off and early start. You although it's two days, you still don't have the recovery period".

Another expert stated the following:

P1 "In South Africa it seems that they roster 5 days on 2 days off depending on the operational demands and so if you're flying awkward schedules early starts mixed with late finishes, mixed with operational you know delays, whatever and you knocking off at 10 o'clock or 11 o'clock on a Friday evening and then you have to report for duty at 4 o'clock in the Monday morning, that really allows you 1 night of adequate rest. And so, short-haul is an issue it needs to be legislated properly and in addition to that it also needs to be those who are *rostering, those who are designing the roster need to realise that the rostering practices contribute to that fatigue because, again they don't see how do I keep someone away from those limits, they use them as a target and that. And they use these systems that are, that you just plug in the regulations, what are the regulations? They have limited weekly weekly duty periods, flight duty periods, they have every 2 weeks, they have monthly, they have yearly and so the way that the system is designed is to try and ensure that they don't violate those lengths of duties in each in each level. I can't remember what it is for South Africa at the moment, but certainly in the proposals you have a 14 day limit of how many hours you can fly or how much duty you should have. You have every 28 days, you have and have every year or calendar 12 months whatever and the system designs or is designed in a way that none of those are violated, but doesn't people still fly, they still fly and work long long hours at very awkward times and they don't factor in commuting".*

The comment associated with not getting adequate amount of sleep and rest were mainly attributed to lack of sleep as a result of irregular working hours including, late finishes as result of operational delays, reporting to duty in the early hours of the morning (early starts), and trouble falling asleep in an unfamiliar environment. One expert noted the following:

P1 "So the inadequate sleep, accumulating sleep debt because of, because of suboptimal hours of work and sleep, extended work hours sometimes……….your Ba's and your kalula's and whatever will fly origin, they will fly as far as Nigeria, they will fly far as Mauritius and those are extended flights with quite quick turnaround times and so that's an issue sleeping away from home something that happens quite often in a hotel environment………..the pilot and cabin crew in my mind struggle with because, sleeping in an unfamiliar environment and also the definition of in the law of what is considered a local night because, when they have their periods off the definition of a local night as it stands in the legislation is 8 hours between the hours of 10pm and 6am, so if you if you do the math if you clock off at 10pm, 8 hours later is 4am in the morning which means that you can start your duty at 4am which we know as a problem because, the people have to wake up early *enough and that is where your sleep debt accumulates, the commuting all of that kind of comes in and then you assume everything, that everything is going fine but, more often than that there are operation delays for a variety of reasons and these operation delays allow or require that they extend their duty and I think legally they're allowed to extend by one hour per day or per duty period, but not more than twice in one week".*

Another expert claimed:

> *P4 "The cabin crew still fly out of the countries duty, so we don't fly the same flight and duties. I have work with them as well and we had a lot of fatigue issue………. we got a lot of complains from them because of the reduced rest. I think the reduced rest is 10 hours off and if it includes a local night but only 9 hours off. If you working with the regulator, so still got to get to your place of rest, whine down and still try and get an 8 hour sleep opportunity, so it also presents a challenge".*

Other issues raised in the interviews contributing to aircrew fatigue related to issues on the current regulation for crew members carrying out short-haul operations in South Africa. Firstly, regulations are rules that use various criteria to control crew members scheduling and rest periods in order to reduce fatigue and promote airline safety. As stated by one of the respondents:

> *P1 "So your regulator who gives out the law cannot regulate how work is scheduled, so they they can't do that, so they just regulate on limits really. So what are the limits associated with the duty period that starts at 6 and what you will notice is that I don't know if you've looked at their FDP? have you looked at the regulations? they have tables and so the duty period changes depending on the time that the duty period starts and the number of sectors that are flown. They legislate the amount of rest that you allowed to have, they legislate around you know how how long a duty period should be if a pilot or crew are climatised or not climatised, the whole the whole issue around standby and reserves and how that works".*

However, industry practices and regulations have not been adequately followed. As noted in the above issues short-haul aircrew members often work extended working hours, often more than 14 hours. The regulations do not consider commuting times and wake up times and adequate sleep/rest time, thus aircrew fatigue is currently still a major issue. Interviewees stated that the regulation is outdated, and that they are inadequate and because of this, it may significantly play a part in influencing fatigue experienced by short-haul aircrew members.

The comments on this issue is stated below:

> *P1 "I would say they are because, in my opinion the current regulations in South Africa are excessive. You can on any given day if you started a duty at you know in the morning sometime, you can fly no not fly you can be on duty for 14 hours, that does not consider your wake-up time, does not consider commuting time and it considers the time that you actually report for duty and the time that you actually knock off. And so what that means is that by enlarge if you have a full day like that, you probably been awake for 2 hours before that you'll likely awake for 2 hours to 3 hours after that depending on the extent of the community, depending on other things that happen which means that you are awake for 18 hours in a day. Now depending on the timing of that flight landing and whether there is operational delays or not means you landing a plane after say 3 or 4 sectors having been awake for 16 -17 hours which is where we know things our alertness is not where it should be and so in my mind and this is why this process of of of establishing where they not whether that they should change how they should change is happening because, they are too long and the risk to the industry is that pilots, cabin crew are just gonna leave and go and fly or work somewhere else where they can fly, work more comfortable rosters. So, my opinion the current regulations are inadequate and they allow for extended duty periods at times when pilots, crew shouldn't shouldn't be flying and working planes and that's that's because of the actual tables but, also the definitions of how long people can be on standby for because they consider standby or reserved standby if you are reserved you can be on reserve for 24 hours but, what does that mean for the quality of sleep. Did you get and what happens if you get called out for duty? Same with standby standby if you are there at the airport you know it is is monotonous, it is a monotonous task it is just you being there and what is the impact on your level of alertness if you've been awake again for a long period of time. It's so a lot of the time the current*

regulations are not up to date with our current understanding of sleep and circadian physiology and the necessary amount of sleep that people need and also how much rest people need and it largely comes down to the definitions of certain things in the, in the regulations the main one is your local night, how that is defined and also what they called that the WOCL period, so the windows of circadian low the definition of that influences the duty length of somebody's how long a duty can be so if you define the window of the circadian low between 2 and 5 in the morning or between 2 and 6 in the morning it has, it an implication for how you can roster somebody because, you can't you know if your if your duty period goes into the WOCL period, then it has implications for how long you should rest afterwards legally you know so it's those definitions that have an impact on on how how the regulations are applied but, I do think that there are issue currently in South Africa in a long way".

P4 "Yes I do think that they contribute, they are shocking I think the current regulations of South Africa are outdated. They are not good at protecting sleep, that is the problem………. the duration of the sleep time that is provided is too short, that is the problem. You can work too many consecutive days in a row, you can work seven days in a row and I think that needs to be quartailed, you should not have quicker time to recover from the cumulative fatigue after seven days giving you one day off, is not enough time to recover from the cumulative effect of fatigue. That is not my opinion that is facts".

One of the experts noted that the issue of fatigue among short-haul crew members due to the regulation are also dependent on the airline. Some of the airlines in South Africa such as SAA crew have the 12 hours off including the local time, however other South African airline crew members from airlines such as Kulula, Comair, Airlinks, Semair and Mango may only get 9 hours off duty as they follow the CAA countries regulations which are outdated and challenged. Thus, fatigue is known to be airline dependent. The comments are stated below:

P4 "Small example, like the flight and duty in saa is a well negotiated flight duty, the one lets say comair, the kulula, and ba's they fly to the caa rules which is a lot harder so certainly amongst airlines……….purely by the rules they *operate……….there is a real threat so there you can see a different in fatigue between airlines".*

P4 "The current regulations are the main endurance to fatigue, but not at saa because they have got the 12 hours off, they have already got that ………. the other airlines, so at comair, mango, semair and airlink they only get 9 hours and it's just not enough time to rest so it's the countries regulations that is the problem".

Another expert also pointed out the current issue on the regulations, however he also states that they are currently addressing this issue on the rules as noted in the comment below:

P3 "I think current regs are outdated………. you know of EASA which is the European regulations, European aviation safety authority had revised fatigue and it is something that we are debating at this project that we are doing at the moment to address this. The industry and what they call the airline association of South Africa AASA which represents the major airlines like comair, saa, airlink, sa express all of these are members, the company are members of AASA sorry not South Africa, its southern Africa including Namibia as well they have said they quite like the latest ER rules. They want to just cut and paste those rules……….So, there is certainly a move in South Africa to address these rules which are outdated because of the nature of the game has changed".

In addition, apart from the regulation being outdated, one of the experts also highlighted that the prescribed limits are treated as targets and not as limits for guidance. Thus, it is a problem.

P1 "Your management will look at how can we sweat that asset properly and the regulations are their to limit the hours of duty and to an extent that considers the circadian rhythm and sleep related factors but, the regulations are looked at looked at as targets, not looked at as limits and so your your scheduling crew, *your scheduling people will say, how can I fly this person so that their legal? they don't say, how can I fly this person so that we maximize safety?".*

Apart from the scheduling factors and current regulations. It was also noted by one of the respondents that Organizational culture may also be considered a factor contributing to fatigue. This issue was not highlighted anywhere in literature. One of the experts stated the following comment:

> *P1 "That the prevailing culture in the in in some aspects of the aviation industry is is a major factor that contributes to the perpetual challenge of fatigue in in the industry……….the culture of being honest about challenges that you face at work or basically the the culture is that you can't complain about the challenges that you have at work and so pilots are reluct pilots and cabin crew are reluctant to come forward with issues that they might have in relation to flight and duty periods or they have to do it anonymously because, there are they are fear full of retribution from management and that organisational culture is not conducive to a safety culture………. but if you don't create a culture where you allow people to be honest about how they feel which they say they do you say you you must be fit for duty when you report and if you're not fit for duty you must be honest about it but it's how that honesty is dealt………. so if people are having to fly or work and If people are having to push themselves at without being able to say it's actually challenging it's actually a problem".*

Task-related factors

> *P1 "We must know that you know, we must acknowledge the fact that the type of work that they do, the amount of work, the stress that is associated with that work is also something to consider"*

Thus, the second most factor highlighted by the experts were attributed to the task that flight attendants perform. In the interviews it was noted that fatigue among short-haul flight attendants was caused by high workload due to the nature of their job characterized with multiple sectors, high take off and landings, constantly interacting with people, constantly have to be cognitively alert and perform physical demanding tasks.

The following respondents' comments relates to issues of high workload due to multiple sectors and high number of take-off and landings.

One of the experts highlighted the following;

> *P1 "In short-haul like in South Africa, I think the fatigue mechanisms are different, but you you flying more intensely that's that's that is what's happening you know, you are you are you are you have a high workload because of high number of sectors because the duty periods or the sectors are short".*

Another expert highlighted a similar finding to the above comment. He stated the following:

> *P2 "With short-haul as you know when that aircraft lands and push backs again in the half an hour, so in the short-haul operation its go go go, so we do a lot of sectors and a lot of flights".*

In addition, one of the experts highlighted the issue of high take-off and landings. The comment is stated below:

> *P2 "There is always high pressure the whole time take off and landing, so you've got a lot of high workload in short-haul operation".*

Two respondents noted the issue of high workload due to constantly interacting with passengers and being cognitively alert, contributing to short-haul flight attendant fatigue. It was also noted that flight attendants' experiences of fatigue are different to that experienced by pilots. These comments are stated below:

> *P1 "Pilot experience fatigue because of the nature of the job, but probably to a lesser extent to cabin crew because, cabin crew have to continually interact with passengers continually have to work whereas in a cockpit setting as soon as you taking off then and in flight you cruising. It's largely becomes observation where is the nature of the nature of the task for cabin crew is different and so they have to, they have to be more cognitively engage they have to be more cognitively alert to what's going on and and that interaction might present different type of tiredness with fatigue to that experience by captains or by pilots".*

P3 "They have to stay awake and check around the cabin and so on making sure that guys are not sleeping on the floor or lighting cigarettes".

Two of the experts also noted that flight attendants become fatigued because of the high physically demanding tasks that they must perform throughout their duty schedule.

P3 "So certainly like short range flying up and down those guys are busy, there is no doubt I am sure you have been on flights from PE to Cape Town and especially very short sectors like Durban they do four of those a day 4 sectors. So like Joburg to Durban, back to Joburg, back to Durban and then Joburg especially for these high density airplanes like the mango, kulula and safair and they would carry a minimum so 4 cabin crew looking after 180 lot passengers and depending if they offer a full service then its more or strain handing out a packet of chips and cool drink but, that's not too much but still they have to pull a lot of trolleys up the aisle and those things are heavy. So short-haul cabin crew those guys are possibly, physically sweating more demanding at some parts but short range flying up and down if it's specially through light thunderstorms and you know if you been through a day with four sectors and so on".

P4 "Fatigue of cabin crew and in the context, they do a lot more walking, they do a lot more communicating, they do a lot of lifting pushing those trolleys, they are mental and physical".

Overall flight attendants during short-haul flight operations as indicated by the experts in this section are both mentally and physically demanding. Due to them performing their tasks over multiple sectors and often everyday depending on the number of consecutive duty days they are assigned to with either one day of rest/recovery, individuals can experience high workload, thus can result in a cumulative effect of fatigue.

Other related factors

Apart from the scheduling and task-related factors, various other issues were also noted in the different interviews that need to be considered when determining the contributing factors which may lead or influence the onset of short-haul flight attendant fatigue. The issue that were raised by the experts were the impact of age, health status, context they operate in, the airline, experience levels and non-work-related factors such as family responsibilities which ultimately has an impact on the quantity and quality of sleep crew members may obtain.

The experts pointed out the following comments:

> *P1 “One must consider what happens when they get to the destination, where they're flying to and the timing of that flight in relation to rest because, that would affect the quality of sleep that they would obtain prior”.*
>
> *P1 “The issue of fatigue is also context-dependent, where are you in South Africa? are you are you operating remotely away from home? when do you get to come home? what are the people like that you have to interact with me? If you're not in South Africa so it all depends, so it's so complex which makes it's management complex but, that doesn't mean that it shouldn’t be”*
>
> *P1 “Health status and and I don't I don’t, I know that the pilots and cabin crew need to undergo regular health checks to ensure that they are fit for flight and but, health status would have an impact on that (fatigue), as would age, prevalence of sleep disorders all of those sort of come into that are things that need to be thought about as an integrated approach to managing the issue of the risk of fatigue in operations………. their health status has an impact on sleep, sleep has an impact on the risk of fatigue”.*
>
> *P1 “(……) changes with I suppose home arrangements and whether you have got kids, family stress etc. All of those add to some sort of physical and psychological ability to either perform or not to perform”.*

Experts have also noted that level of experience plays a significant role in individuals experiencing fatigue. The comments are highlighted below:

> *P4 “So, in general the less experienced you are, the quicker you get fatigued because you have to put so much more effort in, the more experienced you get the more easier it becomes to manage your work environment and you don’t get as tired as quickly but, if you had to look at let’s say a brand new first officer would get more tired than an experienced first officer who has seen it all before*

so he doesn't have to use his brain as much………. it take about for me 10 years, often I don't freak as much or get stressed as to someone less experienced who hasn't seen it as much so, it depends on a number of things".

P4 "Once again the seniors maybe not getting enough rest than the juniors because, they have a lot more responsibility. Its sounds a bit odd because, the more experienced you are, the better at it, but you may have more responsibility if you take it too much to heart it could affect".

Another expert noted that when crew members are off duty, the time that is required for them to rest either at home or a hotel, they often do not manage their time for rest wisely, however, factors such family responsibilities, kids and social commitments may have an impact on this:

P4 "I just think individuals are not very good at managing fatigue or managing their time off to make sure that they are better prepared, and I understand why they have kids, families, you got social commitments, you got other work commitments we always trade off on the sleep. So, I think there is a big issues with people are not utilising their off time as they could to prepare everything for the next duty".

In addition, non-work-related factors such as physical fitness, alcohol, one's sleep environments all have some sort of influence on the amount of sleep you obtain before a duty. One of the experts claimed the following:

P2 "Obviously as you know the fitter you are the better you can handle fatigue so obviously alcohol, your sleep, if you need sleep you need to sleep in a dark room in a cool environment. How noisy it is when you sleep a lot of the pilots and crew have small kids and babies or whatever so there's obviously a long list of factors that affects them".

Consequences of fatigue

In general, research have shown that fatigue can cause individuals to experience symptoms such as decreased vigilance, slow reaction time, poor decision making, forgetfulness, individuals been lethargic and results in communication difficulties.

Thus, ultimately affects performance. In the aviation industry, particularly short-haul operations, because of the nature of the operation characterized of long working hours, early starts, late finishes, extended working hours and high workload due to the multiple sectors, high take-off and landings and the tasks that flight attendants perform, it has been identified by the experts that these factors contribute significantly to short-haul flight attendant fatigue. Due to this the experts have noted that a fatigued short-haul flight attendant can have major consequences on their performance. Three main themes emerged in this section which were attributed to performance, health communication and mood. Experts have stressed that fatigue affects alertness, decision making, processing of information and flight attendants may become quite, irritable, anxious and neurotic. In addition, experts have also pointed out that fatigue may have a negative impact on their health as well as a fatigue person also has negative effects on communication.

The following comments are associated with the theme ‘Performance’. This includes opinions on fatigue that may affect individual’s alertness levels, decision making, processing of information and reasoning.

The comment pointed out below relates to fatigue affecting alertness levels of crew members as stated by one of the experts:

> *P1 “The productor fatigue is the product of inadequate sleep of physical or mental exertion of time on task, of all of those things and all of those factors now affect cabin crew, aircraft maintenance, pilots in a way where you're not as alert and attentive to what's going on which means that if there's a change in the environment………. if there is a change and something isn't right you are less alert to that”*

One of the main consequences of fatigue noted by several experts was the impact of fatigue affecting decision making and processing of information. Thus, may result in flight attendants been more prone to slip, errors or/and lapses.

The comments can be seen below:

> *P1 “It affect decision making, it affects risk-taking perception, it affects executive decision making, it affects how you respond in emergency situation. Which is why you are trained so heavily, why you exposed to so many different scenarios as a pilot and cabin crew because, in emergency if you fatigued and*

you not able to think rationally and to make decisions effectively, one run the risk of reverting back to something that's inappropriate and inappropriate response to a scenario which could lead to an operation tragedy".

P2 " You have to make decisions you have to make it quickly, so if you get injured, So if you get a fire or you've got bad weather and need to divert you must be able to process information quickly because, everything is time critical, it's not a kind or type of work where you can take your time and sort it out. You need to make a decision within a second or two and as you know the big thing with fatigue is your processing just becomes so much slower your reasoning is, just not good enough so if you rested you can maybe handle that situation where if you are tired your processing is just not there that's what makes it such a big treat".

P2 "It is reduces performance at the end of the day and that is the big concern………. as you know your processing gets slower your reasoning is not as good………., so obviously you can't self assess it very well so that's the problem with fatigue".

P4 "(….) from a performance perspective is definitely just a slowing down like more forgetting and its all unintentional".

P3 "So fatigue definitely effects crew performance and slips, errors, lapses and that sort of stuff and certainly you are more prone to it the more tired you are".

P4 "So the big issue with fatigue is, you start making more mistakes for every reason and that's how I see it within myself so when I start mixing up my call signs, so when I start forgetting the odd check, when I start missing out on radio call and then I start thinking and tell the guy listen here I think I am getting tired here we need to watch each other………. I just notice the error rates go up and I think the cognitive slowing down due to the lack of sleep".

The theme attributed to 'Health" is outlined below. One expert raised the issue that fatigue may have a negative impact on health status among flight attendants. He stated that flight attendants may have mental and physical health implications because of the constant disruptions to their sleep due to the nature of short-haul operational effects. The comment is stated below:

> *P1 "An operational effect of long work hours, long days on the home environment and then ultimately it affects it affects in the long term you involved in the career of this where you constantly having your sleep shortened and circadian rhythms disrupted, there is health applications and so it's not only sort of the immediate effect it's also the long-term effect what's a career in aviation where you have these constant disruptions………what is it doing to your your mental and physical health and and what are you using to cope with it it's the coping coping mechanisms that perhaps you know cigarettes that might also now add add add some challenges to to their health which again ultimately affects their ability to work and willingness to work. So I think this issue of fatigue is a very good an very good avenue to explore other issues of health and psychological health in in in aviation or in any context really because it has far-reaching implications for safety but also for the health of the crew".*

The following comments below are associated with the theme 'Communication and Mood':

Several experts also pointed out that an individual that is fatigued have poor communication with people, this can either be with the pilots in the aircraft or with the passengers they attend to in the aircraft during a flight.

> *P1 "It also affects on how you relate to each other, communication between pilots, communication between cabin crew, communication in cabin crew and passengers which ultimately affects the experience of the passengers if a cabin crew cabin crew attendant is is rude or short or abrupt or is not dealing with the needs so there's many different ways in which you can, it can affect the the perceptions of the passenger the perceptions of the crew……. so I wouldn't say it present just a risk to safety that it has an impact on whether the people are gonna come back to your plane or fly with you again it's more that"*

> *P2 "If you are tired you don't want to communicate, so obviously you will do less or give them less information if you are tired, so communication will definitely be affected".*

One of the experts also noted that when individuals are fatigued their mood often changes. This can potentially affect their communication skills with the passengers as they are required to constantly be engaged with them during in-flight duties.

> P4 “I know with other people they start getting a little quite or they get a little irritable or they just more complaining”.

In addition, another expert has also claimed that fatigue may cause flight attendants to become anxious and neurotic:

> *P1“Is there, is research saying that fatigue is also associated with increased cross checking, so you become more sensitive to the fact that you your compromise, then so you become more anxious and become more neurotic”.*

How to manage aircrew fatigue in short-haul operations

The experts have revealed that flight attendants operating short-haul flights is a serious problem and have also shown that there are many factors contributing to it. Therefore, interviewees have stated that it is important to effectively address and manage fatigue among short-haul flight attendants. Thus, four main themes have emerged relating to expert opinions on how fatigue can be handled and managed. The themes are education; address current regulation in South Africa; address the rostering practices; and physical activity and sleep.

> *“There is now this pretty robust discussion on short-range fatigue………. most airline schedules have no idea about this stuff but, I think if you it's a question on education, educating those guys as well. I think once that is done then you can probably end up with a win win”.* Commented by one of the experts.

> *“So the big thing here is you need to educate a crew member on what those factors are, so they can manage it as good as possible”.* Commented another expert.

Thus, as highlighted in the above comments one of the key ways on how to manage fatigue raised in all the interviews was education.

Educating all stakeholders on the issue of fatigue during short-haul operations in order to manage fatigue was raised in two of the interviews. The comments are highlighted below:

> *P1 "The need for vertical integration between all levels of stakeholder and it goes from government to regulator to company level to management to staff to actual work processes and there must be a vertical integration between all of those. So, in my mind the first thing is to get all the stakeholders onto the same page which is what happened here, so we have government to an extent but they're probably need to be involved more, but government are there and they represented by the regulator the civil aviator authority. You have management you have the unions and you have pilots and cabin crew all of those individuals need to be together and then need to understand the problem at hand………. that's the first step is education awareness around this issue………. so I guess the first recommendation is education of all levels of stakeholders so we're all on the same page around the fact that the science matters this is what the science says it's one view".*

> *P2 "ICAO like I said is the global aviation industry or they tell each regulator how to do it. So what's important about fatigue is its a three way process your government must have its fatigue management law in place, regulations in place and so they got a responsibility to make sure that that's correct and that's in place, then obviously the company has got the responsibility for them to roster the crew member who ever does the work in a responsible way, then obviously the third one is the crew member themselves has also got a responsibility to manage it and that's the only way you can manage this threat is when all three work together the regulator, the operator and the crew member to work as a team so that's an important part".*

> *P4 "They said to the company's education number one, lets start a personal intervention, and try and find some reporting system to identify the hazard".*

Apart from educating all the stakeholders as a whole, it was also noted that it is important to educate aircrew members themselves to recognize fatigue in order to address it. These comments are stated below:

> *P1 "Is to educate all crew on adequate sleep and and the need for recovery and the implications of it, so education, regular education is an important aspect of it as well".*

> *P1 "Using fatigue risk management systems which you have to apply and motivate for that's another aspect. So, what are the ways in which you can counter fatigue, what are the countermeasures so again it comes to educational programs and how how crews can use these let's not say fatigue management practices but, lets say alertness management practices to maximise alertness so that they are fit for duty I think all of that is quite key".*

The second key aspect on how fatigue can be handled and managed that was raised in two of the interviews was, to address the current South African regulations and rostering practices of short-haul operations. These comments are highlighted below:

> *P1 "The second is that……….we have to continually address whether or not the regulations pertaining to flight and duty period are appropriate it's been agreed that they're not, they are outdated and as I said there is number of different countries around the world that have gone through this process of trying to change it and so the second after the education is to interrogate the regulations, we are interrogating the regulations and we agree at they are outdated so they're going to change to probably become slightly more restrictive so less flying time is slightly more rest periods".*

> *P1 " If everybody is educated and understands this then on a if you get the regulations right and management in the different operations, understand the importance of this, it hopefully start to change the way that they treat the issue and that they don't look at these limits as targets to sweat the asset and*

maximize income but, to see them as there's the limit I'm gonna move away from them slightly and rather take a human centred approach to how the work is scheduled rather than maximise the productivity and sweep the asset and I have seen it as a fine it's a constant battle between those two that's never gonna go away but hopefully it changes, it changes the attitude and the cultures of those who are managing and rostering flight and duty periods to try and look after the the pilots and the crew rather than fly and work them hard so I don't know that's something, that I hope changes in time with an increased understanding".

P1 "So have that operational flexibility to be able to manipulate your your your rostering software so that it's more suitable for the people".

P4 *"Develop the regulation based on science and operational knowledge".*

Lastly it was noted in one of the interviews that physical activity and sleep are essential in alleviating fatigue. This comments if highlighted below:

P3 "Either exercise or go for a run and when you are tired sleep don't try and force yourself not to sleep".

Overall, all the above-mentioned factors are essential to manage fatigue among short-haul flight attendants. Thus, if aircrew members and stakeholders start to understand and implement these management practices and interrogate the rostering and regulations in South Africa then this may help mitigate the effects of fatigue experienced among flight attendants operating short-haul flights.

"if we get everyone on the same page, integrating the understanding, interrogating the appropriateness of the regulations, rostering properly and rostering using science and making sure that individuals involved in the working environment are aware of the need to use their time appropriately and to report for duty rested and perhaps even involving their families in the process, again that is not necessary realistic. But all of those are things that that can be used". Commented by one of the experts.

4.5 Summary of results

Overall the literature analysis and the data from the expert interviews highlighted similar findings. The reasons for flight attendant fatigue operating short-haul flights can be found at organizational, task, individual and environmental levels. The main factors of flight attendants' fatigue are thought primarily as a function of scheduling due to mixed schedules with early starts and late finishes, extended duty day, flight duty and rest regulations as well as high workload, for example fatigue from stress and workload due to the short turnaround flights, the number of sectors flown in a single duty period and duty length. The high frequency of take-off and landings to be performed per daily flight attendant schedule and number of passenger movements in and out of the aircraft consequently implied per day, compound workload and stress. Due to these operational effects, it can significantly impact on the amount of sleep a flight attendant may obtain, impact on their health and performance levels. Thus, may compromise the safety of the organization, as aircrew members working at any airline are required to be mentally and physically prepared to perform their tasks in a safe manner. Therefore, it is important to understand the contributing factors to the risk of fatigue and workload in order to manage and mitigate the effects experienced by short-haul flight attendants.

CHAPTER V

DISCUSSION

5.1 Overview of the chapter

The present study examined the workload factors contributing to flight attendant fatigue during short-haul flight operations. This study is unique as it is the first study to examine the risk factors of fatigue among short-haul flight attendants carried out in South Africa aviation industry. The key to identifying workload factors contributing to fatigue among flight attendants operating short-haul flights and to reduce the risk of fatigue and workload was achieved through a complete understanding of the work system of short-haul flight attendants. This section discusses the final findings of the study, the limitations of the study as well as future works/recommendations.

5.2 Outline of the process of system analysis development

As stated in the previous chapters a system analysis provides a unique way to examine the broader system, taking all aspects of the situation into account by breaking and understanding apart the parts within a system and figuring out how it works and interact with each other in order to achieve a goal (Beimborn, 2003; Kendall and Kendall, 2005). Thus, the main goal of the study was to understand and determine the risk factors contributing to flight attendant fatigue due to the nature of short-haul operations. Work system model developed by Smith and Carayon-Sainfort (1989) was used as a framework for this study to characterise the structure of a short-haul flight attendant work system to address the research aim. The work system model as noted before includes factors such as tasks, organization, tool and technology, individual (person) and the environment (Smith and Carayon-Sainfort, 1989). Understanding the interaction of these elements, the individual worker and at the systems level of organizational factors (the design, policies and procedures), including the task (looking at type of task performed by an individual and how they affect worker performance/ what task do individuals perform in their daily work routine?), facilities and equipment (looks at the tools, equipment and facilities used and how they work), the environment (understanding the physical environment people work in) as well as the individual factors (understanding individuals experiences, their sleep quality and quantity and non-work related factors such as social environment), facilitated in the understanding of fatigue and workload (Dul *et al*., 2012).

For this study a work system analysis was undertaken in two phases: firstly, it was based on existing literature and secondly based on expert input (individual interviews with experts). To our knowledge this is one of the first studies in South Africa aviation context, which has investigated the contributing factors to flight attendant fatigue using work system analysis (using existing literature and views of leading experts) in the field of aviation fatigue that identified factors as a whole system rather than examining one component of the system in isolation of a system and the systematic understanding of the interactions between the work system components and how they contribute to and relate to fatigue of short-haul flight attendants in the South African aviation context.

The study findings represent a robust first step into the scientific area of fatigue and workload in short-haul operations among flight attendants in the South African aviation context. All components of the work system of flight attendants operating short-haul flights have shown to contribute significantly to flight attendant fatigue. However, some contributed to a greater extent, while other components identified contributed to a lesser extent. However, it is important to include those factors as they may in some way enhance workload and fatigue. The results highlighted in Chapter IV indicated significant interactions between work system components influencing fatigue. Thus, the work system analysis contributed to an increased understanding of short-haul flight attendants operating short-haul operations.

5.3 Key findings to short-haul flight attendant fatigue

Human capabilities have been recognized as a critical factor in maintaining safety in the aviation industry. In general flight attendants forms an important part in the aviation industry in South Africa as they are responsible for offering customer service to passengers, ensuring cabin safety and comfort of passengers (Henning, 2015; Holcomb *et al.*, 2009). However, flight attendant fatigue is being tackled as a significant risk both personally and operationally as fatigue is stated as a leading factor that impacts performance psychologically, physically and physiologically as well as occupational safety (Dijkshoorn, 2008; Caldwell, 2005). The results obtained from the present study have noteworthy implications for understanding fatigue experienced among flight attendants operating short-haul (commercial/regional) flights. It is abundantly clear in the current study that flight attendant fatigue operating short-haul operations is real, as their work is known to be physically, mentally and emotionally demanding as a result of their interactions with the environment (the type of task they perform, how long the task is been executed, how the work is scheduled and structured, how long one has been awake and the quality of sleep one obtains). Therefore, it is considered a serious problem, one that is growing and needs to be dealt with. Thus, the possibility of fatigue and the implications it has on performance and safety of aircrew members (flight attendants) has prompted concern as the safety of flight attendants and passengers working or flying in short-haul/regional operations are been compromised.

It has been found that because of the nature of short-haul flight operations, fatigue and high workload are known risk factors in this operational environment. It was apparent and acknowledged in the literature and expert input data, that flight attendants fatigue operating short-haul flights are manifested from a variety of factors. The research findings demonstrated that the reasons for fatigue can be found at individual, task, environmental and organizational levels. However, the most frequently identified factors in both the literature and expert's data contributing to fatigue were attributed to task-related factors (high workload) and organizational factors. Individual, environmental and tool and technological factors were highlighted to a lesser extent, however it was acknowledged that it adds to some sort of additional stress placed on the flight attendant which also enhanced the workload and fatigue experienced among flight attendants.

The specific operational characteristics of short-haul operations (regional/commercial operations) has been noted to create challenges with regards to fatigue experienced among flight attendants. The current study identified that scheduling factors such as unpredictable, irregular working hours (early duty report times, late finishes), multiple flight legs/sectors, working consecutive duty days, extended duty hours (long duty days), reduced rest breaks and short-layovers are known organizational factors contributing to flight attendant workload and fatigue. This is because, the scheduling practices of short-haul operations, poses significant problems to sleep and circadian rhythm (internal body clock) which are two main physiological factors known to cause fatigue (Co *et al*., 1999). Thus, is evident in both literature and experts interview data that flight attendant fatigue depends on how long individuals have been awake, the quantity and quality of sleep obtained and resting opportunities which are noted to be governed by these operational effects.

Short-haul operations are known to have more disruptions to ones sleeping time. The quantity and quality of sleep may be influenced by early starts and late finishes. The present study demonstrated in both the literature and interviews that flight attendants may report to duty one to two hours before duty commences. This can be as early as 4am in the morning. In addition, the time you get ready for work and communing time prior to start of duty may also add an additional 2 to 3 hours of them been awake. Thus, this can cause significant sleep loss and pose challenges. It was also noted that cumulative early starts may also lead to sleep deprivation and sleep dept accumulates. In addition, because of the early start times, often flight attendants may be awake at the time between 2:00am-6:00am in the morning which is the period known as window of circadian low when the body temperature is at its lowest and sleepiness peaks. This time corresponds to lowest levels of alertness and performance, consequently flight attendants may be unable to function effectively particularly mental and physical work (Co *et al*., 1999; Dinges *et al*.,1996). According to Bourgeois-Bougrine *et al*. (2003b), sleep reduction prior to duty start time can have a significant impact at the end of the duty period. In addition, duty start time impacts the amount of sleep (Roach *et al*., 2012). The quantity of sleep may also be shortened due to late finishes as a result of late debriefings at the end of the duty day. This can be as late as 11:00 pm in the evening. In addition, commuting time at the end of the duty day may also extend wakefulness periods, thus, may also shorten sleep opportunities. Duty days that stretch far beyond 12 hours have shown to increase experiences of fatigue because extended duty hours have shown to restrict the available time for sufficient sleep which can put a strain on flight attendants bodies, especially if you have an early duty shift the next day which results in sleep periods to be shorter (Co *et al*., 1999).

Overall continuous wakefulness and shorter sleep periods due to long duty days contribute substantially to flight attendants' fatigue. As stated by Powell *et al*. (2007) the timing of duty and duration of duty impacts the timing of sleep. Caldwell (2012) also stated that scheduling practices in airline industries continues to focus on more hours of service regulation rather than on sleep. Therefore, it is important to minimize and limit the length of duty period which contribute to extended wakefulness and irregular patterns of sleep, because if humans are well-rested and sleep/wake cycle is in synchrony with circadian cycle, then aircrew members are most likely to maintain high levels of alertness and performance for 16 hours, however if sleep is less than normal sleep required of 8 hours, then alertness and performance can be compromised, and fatigue is likely to set in (Dijk *et al*., 1992; Caldwell, 2005; Mallis *et al*., 2010). Cohen *et al*. (2010) noted that constant disruptions of sleep can lead to sleep loss, thus can result in profound performance decrements for example, individual's reaction time can become ten times slower than normal. Williamson *et al*. (2011) also pointed out that sleep loss lead to impaired performances. In addition, Akerstedt (2003) noted that irregular patterns of sleep contribute to high complaints of sleep disorders and fatigue.

It is also evident in the present study that insufficient rest and short recovery periods contributes significantly to flight attendant fatigue as a result of specific organizational need and airline operating requirements. Short-haul operation is characterized with quick turnaround times between the multiple sectors which can be on average 5 sectors in a duty period. The time between the sectors often do not allow for flight attendants to get adequate rest between flights and one to eat a meal. Thus, this high pressure can create a challenge because if flight attendants work long duty hours without sufficient rest and nourishments, this can contribute to high fatigue levels and reduces safety margins (Banks *et al*., 2009). Therefore, Avers *et al*. (2009a), reported that short-haul schedules should provide adequate time for meals breaks and rest, especially if they are working domestic trips with multiple legs with quick turnaround times. It has also been noted that the days off duty do not allow sufficient recovery or rest from the days they have worked, which induces a cumulative fatigue effect. As some of the rostering may be characterized with late finishes and unexpected early starts (Powell *et al*., 2007). A study by van Drongelen *et al*. (2013) pointed out that short-haul schedules are characterized with multiple and consecutive duty days of between 4-7 days, however it only allows 1 or 2 days off which is not enough time to recover as the recovery period is very short with long duty days. Therefore, it is important to ensure adequate minimum number of days off to recover, in order to minimize cumulative fatigue effects.

Standby duties provide an important element in operational flexibility, however, as noted in the previous chapter (chapter 4) it was acknowledged in both the literature and interviews that this duty may contribute to extended wakefulness and individuals obtaining insufficient rest. This is because flight attendants may be in suspense on whether or not an operator will assign them for a specific duty, thus may result in them remaining awake for approximately 16 hours before they could be called for a duty period of which may be approximately 14 hours. Consequently, this may induce fatigue. This was highlighted in a study by Co *et al.* (1999). Hence, standby duty may be a scheduling factor contributing to short-haul flight attendant fatigue.

Schedules are regulated by flight and duty rules. In general, the primary aim of flight and duty regulations are to ensure that crew members obtain adequate rest prior to the beginning of duty period to ensure that they avoid fatigue in order to perform their duty effectively and safely (Civil Aviation Authority, 2004; Steiner *et al*., 2012). These are managed through prescriptive limits on the minimum duration of rest periods as well as on the maximum duration of work periods (Signal *et al*., 2008).The aviation industry is a 24-hours operation, many changes in commercial aviation as a result of the advancement in technology and operational demands have been implemented , however, this has affected duty cycles and workload (Co *et al*., 1999; Dinges *et al*., 1996). In addition, the scientific understanding of the impact of circadian factors, work hours and sleep has advanced. Consequently, the associated regulations designed to manage crew fatigue have not kept pace with these changes (Caldwell, 2005). In the present study the issue on the current South African regulation have been raised. These issues were attributed to the prescriptive rules, the limits and regulations not good at protecting sleep, which have been noted to contribute significantly to flight attendant fatigue. The regulation of fatigue by delimiting operating or other working hours is problematic in short-haul operations, partly because operators tend to disregard the rules routinely in order to get their work done. Lack of coherence of the regulations in some cases have been noted to contribute to fatigue. As stated in the expert's interviews, the countries regulations, South African Civil Aviation regulation (the flight and duty regulations) for short-haul operations are outdated and does not provide sufficient rest opportunities. Therefore, it was pointed out that they contribute to short-haul flight attendant fatigue because it creates a barrier or obstacle to optimal performance. It was pointed out that resting period provided is too short, it includes factors such as commuting time to and from layover accommodation. The recovery/rest periods prescribed also do not account for additional factors such as family responsibility, the opportunity to eat meals after work and before work in the morning, the time they get ready for bed or the time they have to get up in the morning to get ready for work (the opportunity to shower and change), and social life. In addition, the time since awake, the type of task as well as the amount of time performing the task are not considered in crew rest need. Thus, resting opportunity may only allow crew members to obtain approximately 5 to 6 hours of sleep prior to start of duty which is less than the required amount of sleep individuals should obtain which is 8 hours to be able to have sufficient alertness and performance to perform their duty effectively. It is also less than the prescribed minimum rest opportunity of 9 hours if one works more than 12 hours in a 24-hour period. The current finding of this study based on the regulations and regarding the issue of sufficient rest periods are consistent with previous studies. Banks *et al*. (2009) reported that prescriptive rules are problematic in scope because they do not include essential factors that affect sleep. Another study pointed out that, prescriptive rules do little to address individual fatigue issues that many flight attendants endure for example factors such as, lack of proper nutrition, difficulty falling asleep and interrupted sleep (Dawson and McCulloch, 2005). Overall Dawson and McCulloch (2005) stated that prescriptive rules manage the duty time of flight attendants but, they do not effectively account for the amount of sleep a flight attendant will receive between duty periods. Hence, they fail to optimally manage the risk of fatigue. In addition, it was also pointed out by one of the interviewees that the prescribed resting opportunities are airline dependent as some of the airlines in South Africa allows for adequate rest opportunities of 12 hours within a 24-hour period and include local night time such as the SAA airline. In contrast South African airlines such as Kalula, Mango, Comair, Semair and Airlink however, follow the South African Civil Aviation Regulations that are outdated, and only allow 9 hours of rest opportunity within a 24-hour. Consequently, this does not provide adequate rest compensated after a long hour working day. Thus, aircrew members operating in these airlines were mainly affected by fatigue. In addition, it was also noted in the current study that flight crew and cabin crew report to duty at different times for the same flight. Flight duty period is one-hour greater for flight attendants in comparison to pilots, however the maximum flight duty period and rest period is based on the times at which flight crew start their duty. Based on this, it is a problem because it does not consider the extra hour that flight attendants are at work which extend periods of wakefulness, and extends the length of duty period (Nesthus *et al*., 2007). This induces fatigue experienced among flight attendants, therefore prescribed maximum flight duty period for flight attendants should be changed.

Another problem that was raised with regards to the current regulation in South Africa is that operators are routinely scheduling up to the regulation limits, which could result in an increased likelihood of fatigue. This is evident in the expert data as it stated that the prescribed limits are treated as targets not as limits for guidance. This finding is consistent with a study by Steiner *et al*. (2012) that stated that the flight time limitation rules are crew planning target, not guidelines because they represent a legal line dividing what is safe from what is unsafe. According to Cabon *et al*. (2008) all the complexity and interactions for factors that are connected to the hours of scheduled work are not recognized in the prescribed limits rules. Dawson and McCulloch (2005) also highlighted that the prescribed rules do not consider schedules with early starts, late finishes and night flying. Thus, they are considered to be limiting and inflexible as they allow legal scheduling to extreme fatigue levels (Dawson and McCulloch, 2005). Overall these current regulations are an issue, therefore it has been noted as a contributing factor to flight attendant fatigue. It does not reflect the recent developments to our understanding of fatigue and factors that contribute to it in short-haul operations, for example there are no regulations regarding the number of segments a flight attendant can fly in a day and scheduling of inconsistent or early reporting times of short-haul operation which are known factors contributing to fatigue experienced among flight attendants (Avers *et al*., 2011).

Workload is an important factor in determining human performance capabilities in complex systems. As stated by Lysaght *et al*. (1989) workload is defined as the amount of work assigned to or expected from a worker using his or her resources to respond to an external physical or cognitive demand in order to perform a task effectively. In other words, it is the amount of work done by an individual depending on task demands in relation to the amount of work that one can produce (Bainbridge, 1974). It has been noted that increments in fatigue is a result of task demands (both mental and physical) performed over a prolong period. When reviewing the results of both the literature and expert input, it is evident that the task demands of short-haul flight attendants contribute significantly to high workload, thus contributing to fatigue. High workload has been identified as a major safety and workers stress concern in the aviation industry (Damos *et al*., 2013).

Flight attendants carry out their duties both on and off the aircraft, for example they perform pre-flight, in-flight and post-flight duties. Thus, their workload varies, however most of their task are performed on board an aircraft therefore during this duty, workload is considered to be high. It is evident in the current study that flight attendant is a highly stressful occupation with high job demands performed under tight schedules. These demands include maintaining high levels of cognitive performance (rapid decision making, alertness and vigilance) in order to be able to perform unobtrusive and highly disciplined responses to medical and other emergencies and be vigilant during flights for activities within the cabin environment that may accidentally or deliberately threaten the safety of passengers. Thus, also describe as emotional stressors. High level of cognitive performance for every flight performed have been noted to contribute to increases in mental workload, as a consequence increases mental fatigue. In addition, their job also includes more physical activity such as bending, standing and walking or long periods of time in a confined working space for about 8 to 12 hours or more, heavy lifting and pushing and pulling objects which may put a strain on the body and result in physical fatigue. The physical demanding tasks also contribute significantly to health risks such as lower back pain. In addition, flight attendants' job is a high social involvement occupation. It involves dealing with rude, aggressive and demanding passengers during the flight, thus can result in them been emotionally challenged as they have to manage their emotions effectively in order to fulfil the emotional requirements of a job (MacDonald *et al*., 2003b). It was also noted that it is emotionally draining to act normal when individuals may feel angry, anxious or distressed. Due to this, it may lead to emotional exhaustion (Kinman, 2009; Chang and Chiu, 2009). Overall flight attendants' tasks operating short-haul flights are described as being highly mentally, physically and emotionally demanding. There are clear limits to performance when scheduling multiple tasks, thus is believed that the requirement to perform multiple tasks is a major contributing factor to performance levels, therefore workload (Wickens and Yeh,1982; Kantowitz, 1987).

In addition, the current study acknowledges the link between the task performed by flight attendants and specific operational environments of short-haul operations increases the load placed on flight attendants which ultimately contributes significantly to high workload. It is evident in the literature and interviews that the different operational effects of short-haul flights such as multiple number of sectors, high number of take-off and landings and time on task have been shown to increase the duties and responsibilities of short-haul flight attendants, thus increasing the task demands (mental, physical and emotion workload) which induces fatigue. These finding are consistent with a study by Stewart (2009) that have noted that workload on the day of duty is associated with number of sectors, number of duty hours, task demand and include factors such as operational hassles such as congested airspace and delays. The present study demonstrated that short-haul flight operations allowing flight attendants to work more than 4 sectors each day, workload can be a consequence and is a significant causal factor to fatigue. Bourgeois-bougrine *et al*. (2003b) highlighted similar findings to the current study. This study noted that repetitiveness aspect of work such as performing pre-flight, in-flight and post-flight duty prior, during and after each flight back and forth to the same flight destination several times in the same day which can be on average of up to 5 to 6 sectors during a duty day, have been shown to contribute to high workload (Bourgeois-bougrine *et al*., 2003b).

Furthermore, it was also noted that ratio of flight attendants to passengers that they have to attend to (which can be a single flight attendant attending to on average 9-50 passengers or two flight attendants attending to approximately 51-100 passengers) together with long working hours of short-haul operations contribute significantly to work overload (high workload), thus increase the fatigue levels as well as stress experienced at the end of duty day. The current findings are similar to a study by Sharma *et al*. (2013) stating that increases of workload are associated with hours of in-flight service/duty and ratio of flight attendants to passengers. Overall the consequence of increases in workload demands as a result of long duty days and extended hours of wakefulness, multiple sectors amplifies the fatigue level, consequently, results in performance degradation of aircrew members. Banks *et al*. (2009), pointed out that the combination of workload and flight and duty period (FDP) has the potential to magnify the effects of fatigue significantly therefore, prescribing a proper balance between workload and the number of working hours scheduled is critical to prevent fatigue.

Organizational culture of flight attendants operating short-haul flights in some aspects of the aviation industry was also identified in the current study that contributes to the perpetual challenge of fatigue in in the industry. The expert stated that often aircrew members are reluctant to raise important challenges that they may face at work, whether it is experiences of fatigue, issue on disruptive or rude passenger in the cabin or issues that they might have in relation to flight and duty periods. Thus, those that do raise certain issues do so anonymously because they are afraid of dismissal, judgement or being redistributed. If you don't create a safety culture, where crew members can be honest about the challenges this can result in major problems, for example if you are not honest about being unfit for duty when you report to duty or if you are overworked. This can result in compromising overall performance and aviation safety. According to Steiner *et al*. (2012), effective safety reporting based on generative safety culture is essential and their must be adequate trust and respect among all relevant stakeholders.

Furthermore, the current study also highlighted issues on environmental factors, individual factors and non-work-related factors that is commonly reported as interacting with, and/or exacerbating fatigue. The common environmental factors that have been notable identified in both the literature and interviews were confined space in the cabin and vibrations which restrict movement, high noise levels, low air quality and low light levels. These factors have been known to influence performance as well as health-related symptoms of flight attendants (Dijkshoorn, 2008; Edwards, 1991; Steiner *et al*., 2012). Consistent with previous studies, the individual factors that was noted in both the literature and interview data were, the impact of age, stress and health status which is known to impact on sleep, thus sleep has an impact on risk of fatigue. In addition, physical levels were also noted to induce fatigue. It was noted that flight attendants' jobs are characterized with heavy physical job demands, thus physical inactivity is noted as a factor that may induce fatigue. It was highlighted that the fitter individuals are the better one is able to handle fatigue. In contrast, if one in unfit, individual struggle to handle risk of fatigue which further induces fatigue experienced among flight attendants.

This study also noted that individual factors (e.g. level of experience of flight attendants) influence fatigue. The study highlighted that the less experienced one is in the job the quicker one experiences fatigue. These finding are similar to a study conducted by Roma *et al*. (2010) which highlighted that junior flight attendants are more vulnerable to fatigue induced risks in comparison to senior attendants. However, the study also highlighted that the senior flight attendants were notable getting less rest than the junior flight attendants as a result of them having more responsibility, nevertheless they manage fatigue better than the juniors. These current findings are similar to a study conducted by Castro *et al*. (2015) and Galipault (1980), which noted that senior flight attendants together with increasing age contribute to significantly to fatigue.

The current study also demonstrated that non-work-related factors such as lifestyle behavior, family responsibilities and unfamiliar sleeping environments for example, sleeping in new environments, unfamiliar bed and generally away from their, at home routines influence fatigue. in addition, social commitments and personal habitats such as drinking caffeine and alcohol could influence the amount of sleep one can obtain which can impact risk of fatigue. Thus, all of these factors add to some sort of physical and psychological ability not to perform.

5.4 How to manage flight attendant fatigue

In this work system model, the individual (flight attendant) is at the middle of the work system. The main objective of work system should be designed in a way to enhance and facilitate performance by the individual and to reduce and minimize negative consequences on the individual such as fatigue and not the other way around where the worker should be designed to fit to the organization. Therefore, effective approaches to redesign the current system into a safer one is essential to transform flight attendants operating short-haul flight operations to a better and safe organization, thus optimizing performance and safety. However, research has noted that countermeasure targeting fatigue among short-haul operation are relatively lacking. Thus, this current study may aid in how one can handle and manage fatigue during these operations.

In the current study many potential contributing factors have been identified contributing to fatigue, therefore close attention to these factors is needed to mitigate and manage fatigue experienced among flight attendants. In order to handle and manage flight attendant fatigue operating short-haul flights, the experts in the study have highlighted potential fatigue management strategies that should be implemented. It was noted that the airlines in South African context should consider implementing a number of fatigue management strategies. One of the main aspects to handle and managed fatigue was ‘Education Awareness’. It was noted that there should be a vertical integration of all levels of stakeholders (government, company, regulators, crew members, operational decision-makers) to understand the problem of short-haul fatigue in order to get everybody on the same page, thus educating all stakeholder is essential. A study by Avers *et al*. (2009b) noted that an effective approach to mitigate and manage fatigue is to involve everyone (the flight attendants, regulator and the operators), highlighting a systematic fatigue management. This is because flight attendants in the aviation system are responsible for getting adequate sleep (optimizing rest opportunities), implementing fatigue countermeasure and to be fit in order to maintain alertness and mitigate fatigue. The operator in the system are responsible for working conditions, work schedule design and workload distribution and the regulator is responsible for regulations. Therefore, it is important for everybody to be involved in mitigating fatigue (Avers *et al*., 2009b).

Apart from educating stakeholders as whole, educating and training crew members is also essential. Crew members (flight attendants) should be educated on sleep practices (the importance of adequate sleep and rest) and the effects of lack of sleep and rest opportunities on short-haul operations. Co *et al*. (1999) reported that education plays an invaluable role in managing fatigue. He stated that with education, aircrew members may learn important fatigue countermeasures such as the importance of naps and how to develop and practice sleep habits. Caldwell *et al*. (2008) pointed out that education about sleep can help optimize the restorative nature of sleep prior to duty and during layovers. Several studies have also noted that education is vital in mitigating fatigue, particularly educating crew members on the importance of sleep and proper sleep hygiene (Avers et al., 2009b; Caldwell, 2005; Dawson and McCullough, 2005; Rosekind *et al*., 2002; Rosekind *et al*., 2001).

As noted in the current study, the current South African regulations on flight, duty and rest limitation is outdated, largely inadequate as a means of ensuring safety, overly restrictive, and lacking a significant amount of the latest scientific knowledge on sleep and fatigue, thus have been shown to be a serious problem contributing to short-haul flight attendant fatigue, therefore further action to ensure that the current system operates in as safe and efficient is required. Thus, it was stated that the regulators should interrogate the current South Africa regulations on scheduling and rostering practices, as the currents short-haul rostering creates operational inflexibility. It is proposed that airlines could develop strategies based on scientific information incorporating scientific findings and operational knowledge into their scheduling practices. For example, focus on scheduling optimization by using tools that can help predict the impact of scheduling factors as well as sleep and fatigue monitoring by doing empirical measurements of sleep and activity using actigraphy (Caldwell, 2012). Thus, these procedures could guide rostering individuals to develop schedules that are in-line with sleep/wake cycle and circadian rhythm and providing more opportunities for rest. In addition, the scheduling procedures should also take into account the long working hours, multiple flight segments which creates imbalances in workload and rostering of early starts. An effective way to address the current issue regarding the regulation on scheduling practices of short-haul operations which in turn contributes to fatigue is that, the scheduling should focus on three essential things. Firstly, schedules should focus on appropriate rest breaks as being important. It should focus on sleep as being equally important and lastly it should focus on adequate recovery periods for each work cycle as being important (Caldwell, 2005). In addition, it was also noted that personal strategies such as doing regular physical exercises help to manage fatigue. Dijkshoorn (2008), highlighted similar finding to this. The study noted that regular exercises increase energy levels which ameliorate the overall condition of the body. Due to this it increases the ability of dealing with and combat fatigue.

Overall to manage flight attendant fatigue during short-haul operations is important to take an integrated approach to address the contributing factors, thus it can ensure that short-haul flight operations contribute to higher overall safety margin. Effective action against fatigue could be to combine regulations with operational practices, countermeasures, and education. For example, education (to raise awareness of/from an individual, government and company level regarding the causes and consequences of fatigue), effective redesign in working schedules workplace policies, current South African regulations and procedures. In addition, improve and change certain aspects of the task (single flight attendant work, timing of task), and provide training on scientifically-based countermeasures designed to better manage on and off-duty fatigue (Caldwell, 2005; Dawson and McCullough, 2005; Rosekind *et al*., 2001; Rosekind *et al.*, 2002).

5.5 Implications for Denel SARA project

The current findings of the study demonstrate significant scientific evidence and knowledge on the contributing factors to flight attendant fatigue and workload due to the nature of short-haul operations which allow flight attendant to perform beyond what is expected from them. Consequently, it has been noted that flight attendant fatigue can significantly impair performance and is a major treat to aviation safety in commercial/regional environments. Thus, because Denel SARA would implement the short-haul duty cycle in the South African aviation context. It is important that they should take into consideration and understand these factors identified and the short-haul operational effects of the short-haul environment as their crewmembers would perform their work in this work environment. This may help to alleviate, and limit fatigue experienced by flight attendants to an acceptable level.

A key factor that has been identified contributing significantly to fatigue is the scheduling practice of short-haul operations. Denel SARA project managers, developers and regulators that would regulate the schedules for crewmembers, should develop appropriate rostering strategies that creates operational flexibility to ensure flight attendants do not experience fatigue and high workload. For example, the rostering practices should embrace scientific findings and operational knowledge. They should take into account the rostering of continuous early starts, late finishes, long working hours, working consecutive duty days without adequate rest periods and multiple flight segments which contributes to imbalances in fatigue and workload levels among flight attendants. These factors have been known to contribute to extended wakefulness and reduce sleep or disturbs the sleeping opportunity of flight attendants. Thus, schedules should be developed in-line with circadian rhythm and sleep/wake cycle. In terms of the long working hours flight attendant should not be scheduled for flight duty period of more than 10 hours. They should not work on average more than four consecutive duty days in a 7-day week without appropriate recovery period. Thus, schedules should provide adequate rest/recovery periods for each work cycle of approximately 12 hours or two days of unrestricted rest when working consecutive duty days. In addition, the recovery periods should not include commuting time to their place of work and back home or vice versa. All stakeholders from Denel should be educated on the importance of sleep and how to manage sleep and fatigue during off-duty periods, as it is essential that they obtain sufficient sleep prior to start of duty.

Schedules should consider reducing the number of multiple flight segments of 4 or more sectors in a duty day and provide adequate rest breaks in between each sector for meals.

With the increase in commercial flights and technological advancements the number and complexity of tasks that flight attendants need to perform has increased. This has resulted in increased workload levels. Therefore, it is important that Denel SARA management and regulators do not assign one flight attendant in a single duty day as this was seen as a major factor compounding high workload levels which put a specific burden on the physical body and mental capability of a cabin crewmember. Therefore, they should consider assigning two or more flight attendants per duty day, this can reduce the number of tasks and responsibility of a single flight attendant, that way they could share the responsibilities and duties. In addition, with two flight attendants they can rotate duties especially if their duty period consists of multiple flight segments, thus providing opportunities for them to rest between the segments. Overall this can reduce high workload.

5.6 Limitations

Although the current study provides robust insights into the workload factors contributing to flight attendant fatigue operating short-haul flights, there are a few limitations that should be acknowledged, which can provide avenues for future research. The limitations and conceptual issues will be outlined in this section. There are certain limitations and conceptual issues that should be noted.

The current study does not provide objective fatigue data, but rather provides context from literature and interpretative evidence from the experts on the contributing factors to flight attendant fatigue. Qualitative research can facilitate rich descriptions of the research participant that can offer valuable insights into the settings, however a limitation on this research method can be seen as subjective, as the information provided by participants is dependent on their opinions and perceptions. It may be difficult to prove that there is rigidity in the information that is collective and reliable as the human mind tends to remember things in the way it wants to remember them. In addition, a limitation of this study that can be addressed in some future research is the fact that this research is mainly descriptive in nature. The findings of our research are based on the literature review. For the purpose of our study, we have used only previously mentioned electronic databases Google Scholar, Emerald, MedLit and Academic Search Complete. Further researches should be focused on deeper investigation of this topic and could include case studies of fatigue with quantitative data.

Another limitation is that some of the existing literature was pilot specific to fatigue studies as there are currently not a lot of research been conducted among flight attendants operating short-haul flights, hence it was stated that pilot studies are consistent and relevant to flight attendants' duties as they work under the same operations and their scheduling are sufficiently similar. However, the effects of fatigue among flight attendants may be different to that experienced by pilots because their duty does not only encompass mentally demanding work, they also perform considerable physical demanding tasks. In addition, the literature data is based on international data as there are limited research on this topic in the South Africa context, however the finding of the experts, that highlighted issues among South African aircrew operating short-haul flights are similar to some of international data literature that has been presented.

Most of the interview were conducted with experts from academics, aviation fatigue specialists or existing pilots/captains. More research should be conducted among actual flight attendants operating the short-haul flights in South Africa to better understand first hand in-sights on fatigue and workload.

The participants response to the online survey/questionnaire depended on subjective perceptions. Self-assessed data introduces the possibility of bias because information received from the participants was purely based on their own perceptions.

5.7 Future works/recommendations

Future works from the foundation of this thesis is needed to examine fatigue. Survey studies should be conducted to look at individuals' subjective perceptions of their sleep, fatigue and workload levels. In addition, further studies should also conduct objective studies on psychological and physiological aspects to verify finding of the survey data.

Field study (quantitative research) where they will be asked to report and monitor their duty periods, sleep and activities using wrist activity monitors (actigraphy) and a variety of surveys including sleep diaries, duty diaries as well as subjective measure of fatigue (for example Samn-Perelli fatigue scale to assess fatigue levels), stress (for example using the 5-point likert scale to assess the stress levels) as well as workload measures (for example using NASA-TLX scale to assess workload levels). It will be worthwhile to investigate what and how kind of changes to short-haul schedules (duty duration, number of flights per day, number of days off) could contribute to cabin crew member fatigue. It will be also worthwhile to get an overview of their work schedules and sleeping quantity and quality in order understand how these factors contribute to lack of sleep increase the workload of flight attendants and in turn fatigue. As stated before (refer to chapter 3), we planned to conduct the abovementioned research method as part of the work system analysis (Phase 3), however, unfortunately we could not obtain permission from the airlines in time. Thus, future research should implement this method especially in South African short-haul operational context. These findings can also be used to propose further measures to combat fatigue. How these factors impact flight attendant's performance and in turn fatigue.

Quantitative research design (empirical analysis) incorporating a mixed method approach can be adopted whereby a researcher can test the objectivity of the themes and factors that were identified in this study. A mixed method is proved to hold much more objectivity, reliability and validity than opposed to a single approach.

Future work should build on the findings and variables identified in this study to further evaluate fatigue using more standardized measures.

Future research should also look at ways on how to redesign the South African Civil aviation regulations on flight, duty and rest limitations. Thus, allowing airlines to develop more efficient strategies for cabin crew not to have the same flight and duty period as the flight crew because the level of fatigue for flight attendants maybe greater, since they normally exert more physical activity than flight crews

Future research could contribute to an integrated approach for developing fatigue management strategies across all sectors of the aviation industry, involving airlines, regulators, operators, safety bureaus, and cabin crew.

CHAPTER VI

CONCLUSION

6.1 Concluding remarks

In conclusion the study determined that flight attendant fatigue is a significant problem in modern industry of short-haul operations. The study demonstrated how the research concept of literature and expert interviews based on the framework of the work system model developed by Smith and Carayon-Sainfort (1989) contributed to an increased understanding of fatigue and risk factors that span the entire work system and aid in identifying the patterns in combination of work system variables that are associated with increased risk to flight attendant fatigue. Using this systematic approach allowed for an accurate representation of the complexity of flight attendant work environment in short-haul aviation industries. It is evident in the finding of the study that flight attendants' fatigue is a product of lack of sleep, extended wakefulness and insufficient recovery, as well as high workload which are influenced by the operational effects of short-haul operations characterized with long duty days, early starts and late finishes, multiple flight sectors, short-turnaround times and short layovers and the type of tasks and demands that they are required to perform under these operational demands which are characterised with high productivity expectations. In-turn the operational demands are influenced by the current flight and duty, rest regulations which are noted to be outdated and inadequate and organizational requirements (certain aspects of organizational culture). In addition, environmental factors such as confined work space in the cabin, vibrations, noise and lighting, individual factors such as stress, age and work experiences, health status and non-work-related factors such sleeping in an unfamiliar environment, family responsibilities all add to additional stress placed on the body which can influence workload and sleep and consequently influencing fatigue. Therefore, flight attendant fatigue is a product of interactions with the environment.

This provides evidence that short-haul flight attendant fatigue can have a negative impact on safety, performance and well-being. This is because it impairs individuals physical and mental abilities, cognitive performance (vigilance and alertness), decreases problem solving and decision-making abilities and reduces communication abilities which are critical in performance duties of flight attendant to perform their duty effectively and safely. Hence it needs to be dealt with in the near future.

6.2 Practical relevance

This was the first study that looked at the contributing factors to fatigue and workload of this understudied group of workers (flight attendants) working in short-haul operational environment in the South African context.

In addition, this was the first study which provided an understanding of flight attendant fatigue and workload during short-haul operations as a whole system (holistically) where all components of work system were identified and quantified which yielded descriptive data about the whole system of flight attendants.

Practical relevance of the study is that it provides scientific information, knowledge and awareness of the contributing factors to flight attendant workload and fatigue during short-haul operations which can provide guidance to manage and mitigate the factors identified, thus providing a suitable working environment for them. Science informs practice and practice inform science.

This study informs future research priorities to change the flight, duty and rest regulation in South Africa for short-haul operations as this was noted as a significant issue that contributes to fatigue.

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APPENDICES

APPENDIX A: GENERAL INFORMATION

APPENDIX A1: LETTER OF INFORMATION TO THE SUBJECT

APPENDIX A2: CONSENT FORM

APPENDIX A3: DENEL MANAGEMENT PERMISSION LETTER

APPENDIX A4: RU GATEKEPPER PERMISSION LETTER

APPENDIX A5: ETHICAL CLEARANCE

APPENDIX A1: INFORMATION TO SUBJECT

Human Kinetics and Ergonomics Department, Grahamstown Eastern Cape, Rhodes University

Chloe Bennett, g13b7154@campus.ru.ac.za/ bennettchloe.cb@gmail.com, 0835080539

Dear Participant,

Thank you for your willingness to partake in this study titled "**The workload of flight attendants during short-haul flight operations. A system analysis**".

This letter serves to brief you about the purpose of the study, risks and benefits associated with the study as well as what is required of you to partake in the study. It is important that you read through the letter carefully as well as the consent form. The consent form will be signed before the commencement of the interview session. Your contribution to this study is greatly appreciated.

Background, Aim and Purpose:

The aim of the study is to determine the workload factors contributing to flight attendant fatigue during short-haul flight operations. The aviation industry recognizes workload as a significant issue, as the nature of aircrew members job demands are often characterised with high productivity expectations in a demanding environment with high time pressures. Due to this aircrew members often experience high levels of fatigue, thus poses a threat to aircrew safety, performance effectiveness and personnel well-being. In the aviation industry, fatigue has been addressed by several studies and documents' proving it is a major concern with the need to identify hazards associated with fatigue as risks to flight and crew safety.

Flight attendant fatigue is a significant problem in the aviation industry as it continues to jeopardize the ability to fulfil important safety and security roles which is critical in performance duty of a flight attendant. High workload is known to have a direct correlation to fatigue and has been shown to significantly influence fatigue among flight attendants operating short-haul flights, due to job/ task demand which may put them at higher risk of fatigue and burnout. However, it is not clear which factors contribute mostly to flight attendant fatigue during short-haul flights operation and where the workload lies in this profession as flight attendant fatigue operating short-haul operations are not well developed. Knowledge and awareness of the contributing factors to flight attendant workload and fatigue during short-haul flight operations and how these factors impact performance duty of flight attendant will help to predict, prevent and mitigate the occurrence of fatigue experienced among short-haul flight attendants.

Procedure

The breadth of fatigue sources/ risk factors identified in previous studies on fatigue points to the need for macroergonomics approach to better understand and address factors contributing to/ or preventing fatigue among short-haul flight attendants work systems. One such macroergonomics approach is work system analysis which will be based on the work system model developed by Smith and Carayon-Sainfort. For this study a work system analysis (Smith and Carayon-Sainfort, 1989; Hendrick and Kleiner, 2001) will be undertaken in two phases: **I)** Literature based (based on the existing literature to collect, identify information about the work elements and work structure of short-haul flight attendants and identify, describe and quantify the main factors contributing to short-haul flight attendant fatigue and workload (this section will be done by the primary researcher) and **II)** Expert Input, where individual interviews will be conducted with experts to gather more information about fatigue and workload, the impact of fatigue, aircrew fatigue and short-haul flight attendants work. The results from each analysis will be combined in order to produce the results of this study.

Expert Interview

We are inviting all experts (Managers, HR personnel's, flight attendants etc.) with the knowledge and background in the field of aviation or/and aviation fatigue, aircrew fatigue and workload, to participate in the second phase of the work system analysis which is the 'Expert input interview' section. You will be required to attend an individual interview session with researchers. The main purpose of the interview is to obtain additional unknown information and opinions of the research topic (In general on aircrew fatigue and workload, the impact of fatigue, what you as individuals perceive contributes to aircrew fatigue or/and flight attendant fatigue and workload operating short-haul flights) and to gain input on elements that the researcher was not sure about. The individual interviews will be conducted via telephone (telephone interview) or face to face meetings. Before commencement of the interview, you will be required to complete a pre-screening questionnaire online and sign the consent form which will be sent to you via email. This will include demographics information (age, sex) and questions on your current job (type of employment, work experience). The researchers will meet up with volunteered expert or via telephone phone call who are interested in the study and will explain the procedure and purpose of the study and interview, and answered issues related to the project. Thereafter the discussion will be set forth. Each interview will last between 30 and 45 minutes and will be conducted at a time and location that best suits you. Before commencement of the interview, permission will be granted from you to record the interview. The interviews will be audio-recorded via voice recorder on the researcher's mobile phone or via tape recorder and recorded in full writing. The interview is semi-structured and includes a set of open-ended questions that allows for spontaneous and in-depth responses. Please note that participation is voluntarily and if at any stage you wish to withdraw from the study you may do so without any adverse consequences.

Anonymity

All data and personal information recorded during the study will be stored in either electronic or paper format. Participants' confidentiality and anonymity will be preserved by allocating each a code. No information that could lead to identification of any individual will be released, thus you will remain anonymous with regards to your data and results. Only the primary researcher and academic supervisor will keep the main lists of codes and names. Irrespective of the affiliation that you work for, the airline/institution will not be mentioned anywhere in the thesis (it will remain anonymous). The interviews will be audio-recorded via voice recorder on the researcher's mobile phone, tape recorder and be recorded in full writing, but will only be granted with your permission. All audio recordings will be uploaded onto a secure password protected computer and saved as voice files on the computer hard-drive as well as the transcripts. Access to computerised data and transcripts will only be in the sole custody and available to the researcher and academic supervisor and will be locked up in the Human Kinetics and Ergonomics Department. The data used will only be used for purposes of this research study; it will not be made available to others for re-use. At the end of the research project once everything has been compiled, the data collected will be kept for a minimum of at least 5 years.

Risk and Benefits

The risks resulting from the data collection procedures are minimal. However, some of the questions in the interview may seem personal, but you may participate as much or as little as you wish, and you do not have to answer any questions if you do not want to. We cannot promise any direct benefit to you or others from taking part in this research; however, the results and research conducted may enhance an improved understanding of the factors that may contribute to aircrew fatigue and flight attendant fatigue and workload during short-haul flight operations and an improved understanding of existing research related to short-haul flight attendant fatigue.

Please feel free to contact me if you are unsure of the aim of the study, risks, benefits and requirements as well as if you have any concerns or questions and queries about the study.

Your participation is highly appreciated.

Yours sincerely,

Chloe Bennett

Primary Researcher: HKE master's student

g13b7154@campus.ru.ac.za or bennettchloe.cb@gmail.com

0835080539

Rhodes University

Dr Swantje Zschernack

Supervisor

s.zschernack@ru.ac.za

046 603 8472

Rhodes University

APPENDIX A2: CONSENT FORM

Human Kinetics and Ergonomics Department, Grahamstown Eastern Cape, Rhodes University
Chloe Bennett, g13b7154@campus.ru.ac.za/ bennettchloe.cb@gmail.com, 0835080539

PARTICIPANT CONSENT FORM

I, ________________________________, do hereby consent to participate in the study entitled: "**The workload of flight attendants during short-haul flight operations: A system analysis**"

I confirm that I have read and understand the information sheet as well as understand the purpose and procedure that I am expected to partake in, for the above study and have had the opportunity to ask questions to clarify any concerns or misunderstandings. I have been told about the data collection procedure (expert interview) and the related risks as well as the benefits of partaking in the study. I understand that my participation is voluntary and that I am free to withdraw at any time, and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn. I understand that all my information gained from this project will be treated confidentially, that I will remain anonymous at all times. I understand irrespective of the affiliation that I work for; the airline will not be mentioned anywhere in the thesis (it will remain anonymous). I understand that the data used will only be used for purposes of this research study; and that the data obtained may be used and published for statistical or scientific purposes. I understand that all the data from the audio recordings and transcripts for the interview session will be securely filed and uploaded onto a secure saved on computer/laptop which is password protected. These will only be available to the primary researcher and academic supervisor. I am informed that feedback on the summarised results of the study will be given to the Denel SARA institutions, once the study has been compiled. Feedback will also be given to me once the results have been compiled, after the entire study has been compiled. I understand the risks and benefits of partaking in the study.

I am fully suitable to participate in the study and meet the participation criteria as stated in the letter of information. In agreeing to participate in this study, I accept joint responsibility together with the Human Kinetics and Ergonomics Department, in that should any accident occur as a direct result of the study, the Human Kinetics and Ergonomics Department will be responsible for any costs and will compensate the participant to the full amount. However, the department will waiver any legal recourse against the researchers of Rhodes University, from any and all claims resulting from personal injuries sustained whilst partaking in the investigation due to negligence on the part of the participant or from injuries not directly related to the study itself. This waiver shall be required upon my heirs and personal representatives.

I have read the above information and the information from the participant letter and have understood both and I accept the conditions proposed.

______________________	____________	__________________
Name of Participant	Date	Signature
______________________	____________	__________________
Name of Researcher	Date	Signature
______________________	____________	__________________
Witness (Print name)	Date	Signature
______________________	____________	__________________
Witness (Print name)	Date	Signature

APPENDIX A3: DENEL MANAGEMENT PERMISSION LETTER

INSTITUTION PERMISSION LETTER

RHODES UNIVERSITY

Grahamstown • 6140 • South Africa

DEPARTMENT OF HUMAN KINETICS AND ERGONOMICS
Tel: [+27] 046 6038471
Fax: [+27] 046 6038934
E-mail: hke@ru.ac.za

[16/10/2018]

Denel Aeronautics
Denel Kempton Park Campus
Atlas Road
Bonaero Park
1620
Johannesburg, Gauteng

Dear Sir/Madam

Re: Invitation to conduct research at your institution

I am writing to request permission to allow me to recruit 'experts' at your institution with the knowledge in the field of fatigue and workload, aviation, aviation fatigue and existing flight attendants to participate in the second phase of the work system analysis which is the 'Expert input interview' section. I Chloe Kayla Bennett (under the supervision of Dr Swantje Zschernack) am currently enrolled as a master's postgraduate student in the Department of Human Kinetics and Ergonomics at Rhodes University, South Africa. I am currently funded by DENEL SARA, carrying out research on 'The workload of flight attendants during short-haul flight operations. The aim of this research is to determine the contributing factors to flight attendant fatigue during short-haul flight operations. The participation and cooperation of your institution is important so that the results of the research are accurately portrayed.

To address the research, question a work system analysis will be conducted. A work system analysis will be undertaken in two phases: **I)** Literature based (based on the existing literature to collect, identify information about the work elements and work structure of short-haul flight attendants and identify, describe and quantify main factors contributing to short-haul flight attendant fatigue and workload and **II)** Expert Input, where individual interviews will be conducted with experts to gather more information about fatigue and workload, the impact of fatigue, aircrew fatigue and short-haul flight attendants work. The interviews will be conducted via telephone and face to face meetings with the researcher. Attached for further information about the study (the background, aim/purpose of the study, procedures and requirements) is a copy of the participants 'Information letter' and 'Informed Consent Form'.

The identity of your institution/airline will not be mentioned anywhere in the thesis (it will remain anonymous) and the experts who voluntarily consent to participate in the second phase of the work system analysis (Expert Interview) will be treated with complete confidentiality. Participants' confidentiality and anonymity will be preserved by allocating each a code to be

INSTITUTION CONSENT FORM

Participation Consent
I consent for you to approach employees [Experts/managers/ flight attendants] to participate in the 'The workload of flight attendants during short-haul flight operations.
I acknowledge and understand:
• The role of the institution is voluntary. • Employees (the experts/ flight attendants) will be invited to participate and that permission will be sought from them too. • Only employees who consent will participate in the project. • All information obtained will be treated in strictest confidence. • The employees' names will not be used, and individual employees will not be identifiable in any written reports about the study. • The institution will not be identifiable in any written reports about the study. • Participants may withdraw from the study at any time without penalty. • A report of the findings (summarised results of the study) will be made available to the institution and volunteered participants. • I may seek further information on the project from Chloe Bennett (researcher) on 0835080539 or via email, bennettchloe.cb@gmail.com or g13b7154@campus.ru.ac.za

Full Name:	CHRISTIAAN DIRK VERSLUIS
Position:	MANAGER: R&D AND ENG TRAINING
Signature:	[signature]
Date:	2018-10-24
Please return the form to:	bennettchloe.cb@gmail.com or g13b7154@campus.ru.ac.za

APPENDIX A4: RU GATEKEPPER PERMISSION LETTER

RHODES UNIVERSITY
Where leaders learn

Human Resources Division
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11 October 2018

Chloe Kayla Bennett
Human Kinetics and Ergonomics
RHODES UNIVERSITY

Dear Chloe

REQUEST TO CONDUCT RESEARCH WITH RHODES UNIVERSITY STAFF AND/OR STUDENTS

This letter is to confirm that your request to conduct research on ***"The workload of flight attendant during short-haul flight operations"*** topic has been approved by the Ethics Committee. In my capacity as HR Director, I do not have any objection should you wish to follow a coordinated approach by surveying and/or interviewing staff.

Should you require further information please do not hesitate to contact me.

Yours sincerely

Loshni Govender
HR Director

APPENDIX A5: ETHICAL CLEARANCE

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

HUMAN KINETICS & ERGONOMICS
Tel: +27 (0)46 6038468
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Email: m.mattison@ru.ac.za

02 November 2018

Chloe Bennett – g13b7154@campus.ru.ac.za
Swantje Zschernack – s.zschernack@ru.ac.za

Dear Chloe and Swantje,

Final Ethical Clearance – Application HKE-2018-01

Your application for ethical clearance for the study titled "*The workload of flight attendants during short-haul flight operations"* (reference number HKE-2018-01) has been approved by the HKE Ethics Committee. This clearance is valid until the end of 2018. Should your data collection extend into 2019, please notify the HKE Ethics chair, so that an extended letter for ethical clearance can be provided.

Please also note that this final approval relates to the amended application you submitted, and that any significant changes made to the study and procedures need to be communicated to the HKE Ethics Committee (this includes changes in investigators), and another full review may be requested. Should you fall back onto the protocol of your initial application, you will need to provided gatekeeper permission letters from the various airlines that you will be sampling your participants from.

Upon completion of your study, please submit a short report indicating when and whether the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the HKE Ethics committee should be aware of.

Sincerely,

Miriam Mattison

M.C. Mattison
2018 HKE Ethics Chairperson
Department of Human Kinetics and Ergonomics
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APPENDIX B: DATA COLLECTION

APPENDIX B1: PRE-SCREENING QUESTIONNAIRE

APPENDIX B2: EXPERT INTERVIEW SHEET

APPENDIX B3: PARTICIPANT INVITATION INSTRUCTIONS TO JOIN ZOOM MEETING WITH THE RESEARCHER

APPENDIX B1: PRE-SCREENING QUESTIONNAIRE TO EXPERTS

PRE-SCREENING QUESTIONNAIRE

Please fill in the following questionnaire. The questionnaire will include questions on demographics information (name, age, sex) and questions relating to your current job (type of employment and work experience). All responses to the questionnaire is anonymous and confidential.

1. What is your Name? *

Short answer text

2. What is your Sex? *

- ○ Female
- ○ Male

3. What is your Age? *

4. Do you have some knowledge on the research field of aviation/ or fatigue? *

- ○ Yes
- ○ No
- ○ Maybe

5. What is your current occupation (please elaborate on who you are, institution/ occupation you work for, what do you do at your current job)? *

Long answer text

6. Please indicate your qualifications *

Long answer text

7. How many years of experience do you have in your current job? *

Short answer text

Thank you for completing the questionnaire

Description (optional)

APPENDIX B2: EXPERT INTERVIEW SHEET

General Introduction **Purpose of the research and intent of the interview** **Inform about recording and consent (Everything is anonymous)** **Answer questions** **Discussion will be set forth (Interview procedure will begin)**

1) Give a brief overview on your background of yourself and experiences within the aviation context?
2) Do you have any idea of what fatigue means? What does fatigue, mean to you? Can you elaborate on your expertise/knowledge with fatigue?
3) In terms of fatigue, in your opinion, to what extent is fatigue a concern in the aviation industry? Do you think it is a minor, moderate, serious/major or not a problem at all? Why/why not?
4) In your opinion, which aircrew members (role types) is most likely to be affected by fatigue?
5) Which operations are mostly affected by fatigue in the aviation industry [short-haul (commercial, domestic/regional), long-haul, ultra-long-haul]
6) In your opinion, what do you think are the causes of fatigue? (In other words, what would you perceive contributes the greatest to fatigue and high workload among aircrew members)?
   a) Do you think that the current regulations into duty schedules or shift schedules is one of the main issues contributing to fatigue and why?
   b) Do you see any trend in how the working hours have evolved in the industry?
   c) Is there pressure for aircrew members to work more than their normal duty schedule?
   d) Where do you think the problem lies?
7) In your opinion, what other factors apart from the duty and shift schedules could contribute to fatigue? (task-related, non-work-related: sleep related factors).

8) In your opinion, how do think selected members (aircrew members) in the aviation industry perceive the challenges of fatigue and workload?

   a) In what way, do you think fatigue affects aircrew performance?
   b) What are the consequences of fatigue to safety?

9) In your opinion, what can be done individually, on a company level, at a governmental level in order to mitigate fatigue?
   a) What steps/ideas would you consider appropriate?
   b) Describe how you would like fatigue to be handled/spoken about in an airline?

10) Are there any other important factors that has not been noted in the interview, that you find problematic in relation to fatigue in the aviation context?

Thank you for your time and participation in this research aimed at determining the contributing factors to workload and fatigue of flight attendants operating short-haul flights. Your participation is highly appreciated.

APPENDIX B3: PARTICIPANT INVITATION INSTRUCTIONS TO JOIN ZOOM MEETING WITH THE RESEARCHER

Please follow the following instructions, once you have received the link. It takes about 5 minutes to connect. You can use your laptop, mobile phone, tablets or any other electronic device with internet access.

1) Click on the link provided by the research in the email.

2) A Redirect Notice page will appear on the screen, click on the first message stating "The page you were on is trying to send you to http.... (click on this link).

3) The link will send you to the Zoom program and it will automatically download the program. If it does not download automatically then click "Download Here".

4) Then open the program that you downloaded, it should run till 100.

5) At the bottom of the screen click on the icon illustrated with a video camera in blue which is the program you just downloaded.

6) In the Zoom program a box will pop-up which states open Zoom meeting.

7) Click on open Zoom meeting to proceed in order for it to connect.

8) Once you are in, a video computer audio will appear on the screen, then click join with computer audio.

9) The program will ask you to provide your name (type in your name).

10)Thereafter the interview session will proceed. Thanks

Note: Please make sure the speaker on your laptop or mobile phone or any other device that you are using is on high volume.