Fall 12-2022

Ultra-Long-Haul Commercial Operations: An Assessment of Current Health and Safety Standards

Aditya Rathi
Embry-Riddle Aeronautical University, rathia@my.erau.edu

Ultra–Long–Haul Commercial Operations: An Assessment of Current Health and Safety Standards

Thesis

Submitted to the Department of Safety Science

Embry-Riddle Aeronautical University

in partial fulfillment of the requirements

for the Degree of Master of Science in Safety Science

by

Aditya Rathi

Embry-Riddle Aeronautical University

Prescott, Arizona

13th December 2022

Thesis Approval

The thesis committee for **Aditya Rathi,** under the title of ***Ultra Long–Haul Commercial Operations: An assessment of current Health and Safety Standards***, is approved as partial fulfillment of the Master of Science in Safety Science.

Approval of Committee:

Committee Chair

12/13/2022
Date

Brian Roggow, MS, Safety Science
Chair & Asst. Prof., Safety Science
ERAU, Prescott, COA

Committee Member

12/13/2022
Date

Maxwell Fogleman, Ph.D., Industrial Engineering
Associate Prof., Safety Science
ERAU, Prescott, COA

Committee Member

12.13.22
Date

David S. Ryan, MS, Aeronautical Science
Exec. Director RSI & Asst. Prof., Safety Science
ERAU, Prescott, COA

Acknowledgments

I would like to thank my esteemed thesis supervisor and department chair, Professor Brian Roggow, for his invaluable supervision, support, and tutelage during the course of my Master's degree. I am incredibly grateful to my thesis committee for their invaluable continuous support and patience during my thesis study. Their immense knowledge, and plentiful experience in the field have encouraged and supported me throughout the thesis research and daily life. I would also like to thank Embry-Riddle Robertson Fellowship and Safety Science Department for their kind help and support that have made my study, research efforts, and life in the US a wonderful time.

I would also like to thank my mentors, Carl Holt and Robert Spencer, without whom I would not have decided to pursue my career in aviation safety. Thank you for your continuous support and for pushing me to become the best version of myself.

Lastly, I would like to express my gratitude to my grandparents, parents, and best friend. Without their encouragement and tremendous understanding over the past few years, it would be impossible for me to complete my degree.

Abstract

The international and national authorities, manufacturers, and commercial airlines have invested extensively in-flight crew operational research and aircraft system development in preparation for ULH flights. Conversely, the progress on health and safety and its impact and standards has received limited attention in the industry. Though stringent medical certification requirements by international and national regulatory bodies ensure no deviance in operational safety, less emphasis has been put on other occupational factors that can impact the aircrew while operating these ULH routes.

The current studies on the topic are sparse and have only focused on factors such as fatigue, sleep loss, circadian rhythm, and alertness for pilots operating these routes. Concurrently, limited and inconsistent studies have focused on flight attendants' experiences of these factors while operating ULH flights. This thesis research will help determine various regulatory health and safety standards and best practices for aircrew operating ULH routes. The study also reviews the current state of health culture and investigates if it is practiced in the current aviation operational dynamic. Correspondingly, this study also intends to identify and address gaps in the current health and safety regulatory structure that can help form a well-controlled baseline knowledge.

Based on the literature on health and safety in aviation, an online survey was developed, which consisted of a mix of open-ended qualitative and close-ended quantitative questions. The sample for this research was drawn from a population of aircrew who currently operate ULH operations. The analysis of the survey data

presented significantly different response experiences between pilots and flight attendants. Pilots reported a higher prevalence of cabin air quality and humidity, noise, and vibration concerning the cabin environment. In contrast, the flight attendant reported that in-flight rest facilities significantly affect their health while operating these routes. For in-flight job related, the pilot reported dehydration, improper diet, and lower back pain as the top three health-related factors. Conversely, the flight attendant reported dehydration, deep vein thrombosis, and neck pain as the top three health-related in-flight factors experienced on the ULH flight.

Further analysis of this study suggested that the regulatory authorities established very few specific regulations and advisory guidance concerning aircrew health and safety regulations for ULH operations. Most current regulations are prescribed for fatigue and its management, and only limited regulations have been established for other in-flight effects experienced by aircrew. Notably, most of these regulations are pilot-centric, and only a few specific regulations have been established for flight attendants. Due to the small sample size of this study, presenting any conclusion on health culture was challenging.

This study has identified that aviation regulators and operators should undertake additional research on a large scale to identify health and safety impact factors for aircrew operating these ULH routes. Lastly, aviation regulators must revise, address and improve many health and safety regulation areas pertaining to flight attendants.

Table of Content

List of Tables

List of Figures

Terms and Definitions

Aircrew A term used to refer pilot and flight attendant of an aircraft collectively.

Augmented Aircrew A flight crew (pilot) that comprises of more than the minimum number required to operate the aircraft in which each flight crew member can leave their assigned post and can be replaced by another appropriately qualified flight crew member for the purpose of in-flight rest.

ALPA The Air Line Pilots Association, International (ALPA) is the largest airline pilot union in the world and represents more than 66,000 pilots at 40 U.S. and Canadian airlines.

AME An Aviation Medical Examiner serves the Federal Aviation Administration and the flying community by medically certifying pilots.

ASRS NASA's Aviation Safety Reporting Program is a web-based system that collects, analyzes, and responds to voluntarily submitted aviation safety incident reports to lessen the likelihood of aviation accidents.

Bleed Air Bleed air, in the context of the turbine engine, refers to compressed air taken from within the engine.

Circadian Rhythm A circadian rhythm is a daily alteration in a person's behavior and physiology controlled by an internal biological clock in the brain. Examples of circadian rhythms include body temperature, melatonin levels, cognitive performance, alertness levels, and sleep patterns.

CAA The Civil Aviation/Aeronautics Authority is a national or supranational statutory authority responsible for overseeing the regulation of civil aviation, including the maintenance of an aircraft register.

CAAS Civil Aviation Authority of Singapore

CAMI The FAA Civil Aerospace Medical Institute (CAMI) is the medical certification, research, education, and occupational health wing of the FAA's Office of Aerospace Medicine.

CIC Crew-In-Charge is a senior flight attendant that leads other flight attendants and ensures effective cabin operations throughout the flight.

CRM Crew Resource Management is an airline aircrew management training program on aircrew interaction and human factors.

DVT	Deep Vein Thrombosis is a medical condition that occurs when a blood clot forms in a deep vein
EASA	The European Union Aviation Safety Agency is the Civil Aviation Authority of the European Union
ECS	The Environment Control System of an aircraft is an essential component that provides air supply, thermal control, and cabin pressurization for the aircrew and passengers
EPA	The U.S. Environmental Protection Agency is a federal agency that protects people and the environment from significant health risks, sponsors and conducts research, and develops and enforces environmental regulations
ETOPS/ EDTO	Extended-Range Twin-Engine Operations Performance Standard. Any operation by an aircraft with two or more turbine engines where the diversion time to an en-route alternate airport is greater than the threshold time established by the CAA of the Operator.
Fatigue	A general lack of alertness and degradation in mental and physical performance characterizes fatigue in aviation.
Fit for Duty	A requirement for each aircrew member assigned to a flight duty period is to be fit for duty before commencing a flight. Fit for duty means being physiologically and mentally prepared and capable of performing assigned duties at the highest degree of safety.
FDP	Flight Duty Period means a period that begins when a flight crew member is required to report for duty to conduct a flight, a series of flights, or positioning or ferrying flights, and ends when the aircraft is parked after the last flight, and there is no intention for further aircraft movement by a same flight crew member.
FSF	Flight Safety Foundation is an independent, nonprofit, international organization concerning research, education, advocacy, and communications in the field of aviation safety.
FAA	The Federal Aviation Administration is the Civil Aviation Authority of the United States of America

FRMS	A fatigue Risk Management System is a data-driven means of continuously monitoring and maintaining fatigue-related safety risk based upon scientific principles and knowledge as well as operational experience that aims to ensure relevant personnel is performing at an adequate level of alertness.
IATA	The International Air Transport Association is a trade association for the world's airlines, supporting many areas of aviation activity and helping formulate industry policy on critical aviation issues.
ICAO	The International Civil Aviation Organization is a specialized agency of the United Nations that coordinates the principal techniques of international air navigation and fosters the planning and development of international air transport to ensure safe and orderly growth.
ICMVT	Isolated Calf Muscle Venous Thrombosis is isolated thrombosis in soleal and gastrocnemius calf muscle veins without the involvement of deep stem veins.
NRC	The National Research Council is the operating arm of the United States National Academies of Sciences, Engineering, and Medicine. It is overseen by a governing board consisting of councilors from the three academies.
OSHA	The Occupational Safety and Health Administration is a large regulatory agency of the U.S. that ensures safe and healthful working conditions for workers by setting and enforcing standards and providing training, outreach, education, and assistance.
SARPs	Safety and Recommended Practices
UK CAA	United Kingdom Civil Aviation Authority
ULH/ULR	Ultra-Long Haul/Range. An operation involving any sector between a specific city pair (A-B-A) in which the planned flight time exceeds 16 hours, taking into account mean wind conditions and seasonal changes
14 CFR Part 25	This part prescribes airworthiness standards for the issue of type certificates and changes to those certificates for transport category airplanes.
14 CFR Part 36	This part prescribes noise standards for the different aircraft types and airworthiness certification.
14 CFR Part 67	This part prescribes the medical standards and certification procedures for issuing medical certificates for airmen and remaining eligible for a medical certificate.

14 CFR Part 117	This part prescribes flight and duty limitations and rests requirements for all flight crew members and certificate holders conducting passenger operations under part 121- operation requirements for the domestic, flag, and supplemental operations.
14 CFR Part 121	This part prescribes rules governing domestic, flag, and supplemental operations conducted by the commercial operator of the United States of America.

Ultra–Long–Haul Commercial Operations: An Assessment of Current Health and Safety Standards

Introduction

Background

Since the inception of the air transport industry, aircraft manufacturers and commercial airline operators have collaboratively pushed towards ingeniously increasing aircraft's operational capabilities. The race to cross the 1,880 miles across the Atlantic Ocean in an aircraft was seeded before World War I. However, aircraft technology and navigation systems that could support this ambition were not available. After the first World War, new aircraft design and navigation systems developments started supporting longer routes. Many aviators and aircraft companies in 1918 turned their attention to crossing the Atlantic, but the attempts failed. A US Navy team's attempt to cross the Atlantic was successful but accomplished only via partway stops. Not until June 1919 did two British aviators, John Alcock and Arthur Brown, accomplish the first-ever non-stop transatlantic flight (Blakemore, 2019).

On 14th June 1919, the two British aviators commenced their trip from St. John's, Newfoundland (a province in the eastern part of Canada). The aircraft was a modified World War 1 Vickers Vimy powered by two Rolls- Royce Eagle 360 hp engines. Maintaining an average of 12,000 feet altitude and 115 mph, Alcock and Brown crossed 1809.90 miles in approximately 15 hours and 17 minutes and crash-landed in Clifden, County Galway (West of Ireland) with minimal injuries (Blakemore, 2019). In context to today's modernized commercial aircraft, a flight from London to New York City now takes less than seven hours to complete. In hindsight, with the aircraft capability, aerodynamic understanding, and human capabilities knowledge of that period, Alcock's and Brown's first flight across transatlantic was at the cusp of the first ULH flight ever accomplished.

The advent of jet-powered aircraft allowed the pursuit of commercial airliners to conduct intercontinental air travel in an efficient and fast long-distance flight. Notably, the introduction of Boeing’s 747-400 in the late 1950s broke the barrier to long-distance routes with a significantly decreased flight time. In the pursuit of connecting the world and creating a ‘global village,’ the next barrier in air travel was to provide a point-to-point service that connects west to east and vice versa without a layover. This was achieved in early 2004 when Singapore Airlines first operated an Ultra Long Haul (ULH) flight from Singapore to New York, accumulating a flight time of more than 16 hours in length. The introduction of the ULH flight operation business model radically changed the passenger demand and route optimization structure that allowed commercial airlines to offer long-distance air travel in relatively decreased flight time.

Over the years, the popularity among the airlines to operate ULH flights has been turbulent due to fluctuating fuel prices and the cost of the aircraft that support these operations. However, major full-service carriers have shown promising commitment toward these operations to gain a competitive advantage. According to ICAO's World of Air Transport Report, in 2019, the demand for international travel grew 4.7% compared to the previous fiscal year. Provided the travel constraints posed by the pandemic, this demand will be back on steady growth in 2024 (IATA, 2022). Concurrently, post-pandemic, airlines like Qantas, Air New Zealand, Cathay Pacific, and Biman Bangladesh have recently conducted several experimental ULH flights connecting different city pairs round the world. This inclination towards experimentation and investment for these routes, complemented by continuous iteration of aircraft technological advancement, indicates a steady demand for these operations in the coming years.

ULR Crew Alertness Steering Committee

The ULR Crew Alertness Steering Committee, formed in late 2000, played a pivotal role in addressing the ULR flight operational and safety issues and further assisted the aviation stakeholders in making the ULR flights a reality. This committee was established through the co-sponsorship of Boeing, Airbus, and the Flight Safety Foundation (FSF). The main objective of this committee was to define operational and technological issues and develop standard methods using scientific and mathematical measures and evidence that can be promulgated into required ULR operational guidance (Flight Safety Foundation, 2003). Between 2001 and 2005, the committee conducted four workshops with participants from 14 countries, 2 aircraft manufacturers, three airline associations, 16 airlines, 12 pilot unions, 3 cabin crew unions, 14 scientific organizations, and 9 regulatory authorities. The outcome of these workshops presented recommended guidelines in four operational areas, i.e., operational best practices, operational validation program, global regulatory approach, and future research and development.

Within the series of workshops, substantial work was also conducted on the operational impact on aircrew. However, the operational impacts, such as fatigue, alertness, in-flight scheduled rest requirements, and operational patterns, were only studied and researched from the pilot's perspective. Limited attention was provided to the flight attendants' perspective. In addition, apart from above mentioned operational impacts, no other impact factor was part of this proceeding. The issues of health and safety experienced by aircrew were deferred for future research and development.

ULH Health and Safety Research

The international and national authorities, manufacturers, and commercial airlines have invested extensively in-flight crew operational research and aircraft system development in preparation for these flights. The limits of human performance while operating any kind of flight operation are axiomatic. The industry stakeholders have embraced these limitations and have incorporated effective socio-technical system thinking in areas of operations. Conversely, the progress on health and safety and its impact and standards has received limited attention in the industry. Though stringent medical certification requirements by international and national regulatory bodies ensure no deviance in operational safety, less emphasis has been put on other occupational factors that can impact the aircrew while operating these ULH routes. The current studies on the topic are sparse and have only focused on factors such as fatigue, sleep loss, circadian rhythm, and alertness for pilots operating these routes. Concurrently, limited and inconsistent studies have focused on flight attendants' experiences of these factors while operating ULH flights. Lastly, it was also evident that the industry has been predominately reactive toward mitigating the health and safety impact factors on aircrew. Based on this understanding this study aims to find answers for following research questions:

1. From current studies on aircraft cabin environment and in-flight job-related health impact factors on aircrew, has the industry made improvements to mitigate adverse effects on aircrew health?
2. What is the current state of health culture, and is it sufficient in the current aviation operational dynamic?
3. What are current health and safety-related prescriptive regulations, policies, and industry best practices adopted by commercial airlines operating ULH flights?

This thesis research will help identify various regulatory health and safety standards and best practices established for aircrew operating ULH routes. Correspondingly, this study also intends to identify and address gaps in the current health and safety regulatory structure that can help form a well-controlled baseline knowledge.

Structural Outline of this Thesis

Section 1. Introduction	This section of this thesis introduces the context of this thesis. It provides a brief background followed by the current dynamics of ULH flight. The research objectives and questions have been noted, and the value of such research is presented.
Section 2. Literature Review	This section of the thesis reviews existing literature that provides a definition and brief background of ULH operations. Further, the current knowledge on health and safety in aircrew and different impact factors have been discussed.
Section 3. Methodology	This section provides applicability and reasoning for the selected method, including ethical consideration, research method and design, study participants, instruments, procedures, measurements, and analysis method.
Section 4. Results and Discussion	The section presents the survey results of this study. Following the results, the section provides an analysis and discussion of the survey results, identified impact factors, and current health and safety standards established by the aviation regulatory authority.
Section 5. Conclusion and Recommendations	The last two sections of this thesis summarize the study and make several recommendations. This section also supplements future study considerations.

Literature Review

Since the commencement of the first ULH operation, the aviation industry has progressively changed; the current technology and automation have substantially upgraded, and the roles, responsibilities, and demands on aircrews have shifted. The aircraft cabin and the impact on aircrew's health and safety have long been recognized by the industry's Civil Aviation Authorities (CAA) and stakeholders dating back to 1975 (FAA,1975). The current literature on the health and safety of aircrew are sparse, and the topic of ULH operation and its impact on aircrew have been understudied. Corresponding to this, the progress in establishing appropriate minimum regulatory standards for the health and safety of aircrew has been slow (ALPA, 2022).

A comprehensive review of historical archival documents, research articles, studies, and conference proceedings from 1980-2022 relevant to Ultra Long-Range Flight, Long Range Flight, Health and Safety Impact Factors, Health & Safety standards, and aircrew operating standards was performed. The literature search was conducted using different research databases and publications, including:

- International Civil Aviation Organization (ICAO) E-Library
- International Air Transport Association (IATA) Data & Statistics Database
- Federal Aviation Administration (FAA) Database and Website
- Code of Federal Regulations (CFR) Title 14
- FAA Civil Aerospace Medical Institute (CAMI) Website
- European Union Aviation Safety Agency Regulations and Database and Website
- United Kingdome Civil Aviation Authority (UK CAA) Database and Website

- National Aeronautics and Space Administration (NASA) Ames Research Center Webpage
- Boeing Aircraft Company Webpage
- Airbus Industries Webpage
- Flight Safety Foundation (FSF) Flight Safety Digest Archive Publication Website
- Aerospace Medicine and Human Performance, formally Aviation, Space, and Environmental Medicine Database.
- Science Direct Database
- ProQuest Database
- PubMed Database

Search results with a primary focus on passenger, cabin fire, and emergency evacuation were excluded since these topics were beyond the scope of this research.

Defining the ULH Operations

The formal definition of ULH commercial operations was presented by Ultra-Long Range Crew Alertness Steering Committee (Flight Safety Foundation, 2003*)*:

> *"*An operation involving any sector between a specific city pair (A-B-A) in which the planned flight time exceeds 16 hours, taking into account mean wind conditions and seasonal changes*."* (p.13)

This definition has been jointly adopted by the International Civil Aviation Organization (ICAO), International Air Transport Association (IATA), and its Member States, i.e., each country's CAA (ICAO, 2017).

Development of ULH Commercial Aircraft

The first flight of the Wright Brothers in 1903 introduced a culture of overcoming challenges with the advancement of technology and automation. This notion has contributed to the exponential growth and modernization of the commercial aviation industry. In a century, remarkable progress has been accomplished in aircraft design and performance, revolutionizing the transport of passengers and cargo and making it a truly global industry (IATA,2019). The assurance of global aviation connectivity and current new-generation aircraft capable of flying long distances have been only possible because of the following (Salas & Maurino, 2010):

1. Advancement in aircraft technology is supported by a strong economic and political structure, an axiomatic fact that the aviation industry has heavily relied upon since the jet age.

2. In addition to the socio-political structure, focusing on near misses, incidents, and accidents revealing weaknesses is apprehended as a learning curve. The learning is invested in devising effective, efficient, safer aircraft airframes, control systems, fuel-efficient jet-powered engines, and flight decks (cockpit) automation systems.

With the advent of the aviation jet age, the capacity and capability of aircraft have doubled every 15-20 years (IATA, 2019). For example, the world's first jet airliner, the de Havilland Comet, entered service in 1952 with a range of 1,990 nautical miles (nm) and the ability to carry 36 passengers (Long, 2012). Comet 1 reduced the travel time between the transatlantic route by half and could fly at higher altitudes than any other airliner aircraft, which helped avoid adverse weather. Correspondingly, the Boeing 747-400, famously known as “The Jumbo Jet,” entered service in 1970 with a maximum range of 7,260 nm and the ability to carry up to 530 passengers (Boeing, 1998). The 747-400 brought significant upgrades to aerodynamics, new avionics, an efficient engine allowing greater thrust level, and the addition of new winglets, which reduced drag and unlocked the Long-Range routes. By comparison to Comet 1, which took close to 11 hours to commute between London and New York, the B747-400 took almost half the time, close to seven hours, with more than double the operational and capacity upgrades in aerodynamic structure (Boeing, 1998; Baxter & Bardell, 2017).

The Airline Deregulation Act of 1978 in the United States caused air travel to be democratized and introduced a free aviation market. The Deregulation Act gave access to air travel to individuals in a society initially only used by the elite (Simons,1997). These significant changes in the economic and political agreements and increased passenger demand for air travel accelerated the requirement for new innovative aircraft allowing longer-range routes with lower operating costs and significantly reduced travel time (Grimme et al., 2020).

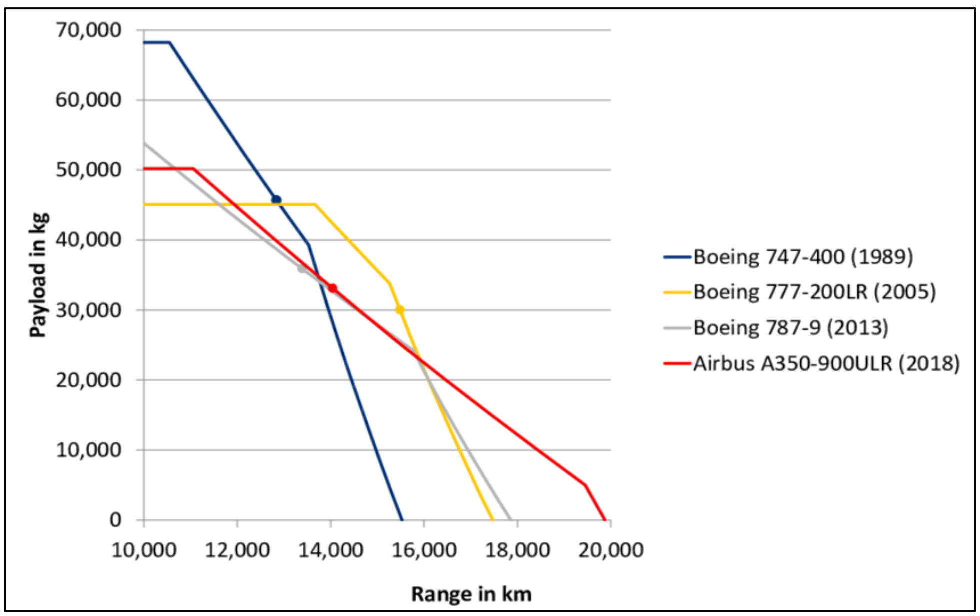
During 1970-1990, the only aircraft that fulfilled these demands of the commercial airline was B747-400, until the entry of the Airbus 340 (A340) series. The A340 series, also known as the “true globe-trotter,” was the aircraft concept designed by Airbus with a philosophy to serve on the routes that connect west to east and vice versa non-stop (Airbus, 2022). The A340 series has many variants designed based on airlines' needs and demands. The A340-500, which was designed to support ULH routes, could seat 440 passengers and have the ability to fly a maximum of 9,000 nm. What differentiated this aircraft from the B747 was the “fly by wire” flight control system, the ability to serve ULH routes, and the four-engine wide-body jetliner that gave it greater fuel efficiency (Airbus, 2022). Before the introduction of the A340 in the industry, only two long haul city pair cities with distances over 7,019.4 nautical miles: Atlanta - Cape Town and Atlanta- Johnsburg, were operated by South African Airways on B747 between 1990 and 2000 (Grimme et al., 2020). In 2004, Singapore Airlines began operating the first ultra-long-haul routes in aviation history between Singapore and New York (approx. 8,283nm) and Singapore Los Angeles (approx. 7,613nm) (Flight Safety Foundation, 2006). These routes became a reality because of the enhanced operational capacity and capabilities of the A340-500.

In the last two decades, Boeing and Airbus have dominated the market. The constant urge to push the traditional boundary of operations and the extent of human endurance has produced aircraft for longer-range operations (Baxter & Bardell, 2017).

The current generation aircraft, such as Boeing 777 long-range series, Boeing 787 series, and Airbus A380, are installed with high thrust and significantly efficient engines. These aircraft are supported with next-generation automated aircraft systems, satellite navigation systems, and data link communication systems that have concurrently supported airliners' desire to connect greater passenger loads to ULH intercontinental routes (Salas & Maurino, 2010; Grimme, 2011). To illustrate this, Figure 1 shows the manufacturers' efforts to increase the payloads and range of different ULH aircraft over the years.

Figure 1

Payload vs Range capacity increase over the years of different ULH aircraft



Note. This figure was adopted from “An analysis of the prospects of ultra-long-haul airline operations using passenger demand data” by Grimme. W, Bingermer. S, and Maertens. S, 2020, Journal of Transportation Research Procedia, 51, p. 209

In the current operational dynamics, the emergence of exploring and experimenting with new ULH city pair routes which connect the transpacific routes is underway. These efforts are currently pursued by Qantas Airlines and Air New Zealand (Qantas, 2019; Air New Zealand, 2022). Both airlines have selected a recently released new generation of aircraft for these operations. Qantas plans to advance with the A350-1000, whereas Air New Zealand is working closely with Boeing on the new B787-9 HGW Dreamliner to support the airlines' mission to commence ULH flights between Auckland and New York (Flynn, 2022; Russell, 2022). The key specification differences between these new generation aircraft are presented in Table 1 below:

Table 1

Specification A350-1000 vs B787-9

Specification	A350-1000	B787-9
Range	8,700nm	7,565nm
Passenger Capacity	238	296
MTOW	319 tonnes	227.9 tonnes
Cruise Speed	Mach 0.82-0.85	Mach 0.85

Though specifications and design philosophies differ between these aircraft series, they will complement the previous generation of ULH aircraft and make these route operations of greater efficiency. It is noteworthy that these aircraft have common revolutionary changes such as hybrid composite material that increases resistance to corrosion, a wing design that morphs and changes shapes in flight to enhance operational and fuel efficiency, a glass cockpit with increased flight automation that reduces the work, and greater space in the cabin for passenger comfort (Boeing, 2022; Airbus, 2022).

Evolution of Long-Haul Operations to Ultra Long Haul

Following the technological and economic environment around aviation changing through 1930, new aircraft concepts and designs like the flying boat Martin M-130 and the Boeing Clipper propelled long-haul flights (Wignall, 2022). The first transatlantic and transpacific flight, which covered more than 2000 miles, was operated by Pan American Airways in 1939 (Lombardi, 2008). During World War II, these limits of long-haul flying were pushed when Australian Qantas operated between Australia and Sri Lanka, carrying passengers and mail. By the end of 1950, Qantas expanded these routes to operate between Europe and Australia, famously known as “the Kangaroo Routes.” The archetypical route took a total travel time of 29-33 hours with 6-7 stops. The introduction of B747-200 in 1971 significantly reduced the flight time, allowing the trip to be completed in two stops. With progressive modification to B747 in 1989, the B747-400 could accomplish these routes with a one-stop layover and flight time of slightly above 20 hours (Stackhouse, 1997). The culmination of this trend was the non-stop operation between Atlanta- Johannesburg and Atlanta -Cape Town, the two city pairs with a distance of 7,019.44nm operated by South African Airways (Grimme et al., 2020).

In 1990-2000 these non-stop operations were still a concept that few airlines were operating. In 1998, Singapore Airlines articulated its desire to operate the first non-stop flight between Singapore (SGA) and Los Angeles (LAX) using A340-500 aircraft. Following the airline's application in 1998, the Civil Aviation Authority of Singapore

(CAAS) recognized the need to evaluate the scientific validation and feasibility of these flights since these proposed sectors would involve exceeding the aircrew flight time limitation (FTL) of more than 16 hours, as set forth by CAAS (Flight Safety Foundation, 2005). In response to this, the CAAS created the Ultra-Long Range (ULR) Task Force, which comprised delegates from CAAS, representatives of Singapore Airlines, and the Singaporean Airline Pilot Association, tasked to adopt scientific methods in establishing best practices and recommendations to operate this ULH flight. In the initial phase of this research, the task force recognized these ULH flights would require a new regulatory framework, and these regulations would require to be validated by conducting scientific studies of flight crews' FTL for the prevention of cumulative effects of fatigue. The associated areas of concern that were looked in detail by the CAAS to prevent the accumulation of fatigue were:

1. Number and composition of pilots with the duration of a flight.
2. Regulations and scientific studies are available that governing the FTL.
3. To gauge a better understanding of pilot in-flight fatigue and alertness levels using the available data from long haul operations.

In conjunction with the efforts of CAAS, the European Joint Aviation Authorities (JAA), in the deliberation of providing an airworthiness certificate of A340-500, commissioned the European Committee for Aircrew Scheduling and Safety (ECASS) to conduct a study on levels of alertness on a ULH flight operated by four pilots (Spencer, 2002). The ECASS used the case study of the proposed route by Singapore Airlines and conducted simulated-based modeling to predict the levels of alertness for ULR flights. Other assumptions of this study were to break down the scheduled route into hours and evaluate the fatigue and alertness levels, including the following variables:

- Defined Round Trip Departure windows between SGA and LAX
- Flight Duty Period
    - SGA – LAX = 18 hours 10 minutes
    - LAX -SGA = 20 hours 25 minutes
- Time difference of nine hours
- Layover of 48 to 72 hours
- Division of flight and cruise phase to evaluate the feasibility of in-flight rest periods.

Based on this modeling, the findings of this study indicated that a four-pilot flight crew could operate these ULR routes without experiencing any difference in the fatigue level experienced by the flight crew operating long–haul flights. However, these results were limited to the particular route that was planned to be scheduled. Additionally, the model predicted that fatigue levels could be significantly decreased if each pilot could be provided with in-flight rest periods (Spencer, 2002; Belyavin and Spencer, 2004).

The CAAS ULR task force decided to validate JAA-ECASS findings with a study designed to test and gather data from Singapore Airlines pilots. The Singapore Airlines volunteer pilots were asked to retain a sleep diary for 10 weeks. They were required to note the quantity and quality of all sleep periods from duty beginning 48 hours before departure from Singapore and ending 48 hours after the return (Flight Safety Foundation, 2005). They were also required to record information on the level of alertness during each phase of flight and immediately after each in-flight rest period. The result of this study validated the ECASS findings:

> "...with four pilots, having two in-flight rest periods each, the levels of alertness for the Singapore – Los Angeles ULR city pair were projected to remain as high as those seen in the current Singapore airlines route studied." (Flight Safety Foundation, 2005, pg22)

In concurrence with these findings, the CAAS issued provisional rules in 2004, which allowed Singapore Airlines to operate between SGA and LAX. The CAAS also shared this operating regulation with ICAO, FAA, and JAA, which were grouped under these five categories below (ICAO, 2004):

1. Requirement of a four-person flight crew (pilot) with at least two commanding captains.
2. Requirement for two in-flight rest periods.
3. The quality of the in-flight rest period should meet the prescribed standards.
4. The operator should define pre-flight and post-flight rest periods for its flight crew.
5. The operator should define the departure window for both the home and foreign destination.

Flight Safety Foundation - ULR Crew Alertness Steering Committee

In parallel to the efforts of the CAAS ULR task force, it was internationally recognized as a requirement to address and define the operational and technological shortcomings and issues associated with ULH operations and pilot alertness and performance during the ULH operations (Flight Safety Foundation, 2003). Keeping these aspects in perspective, in late 2000, through the co-sponsorship of Boeing, Airbus, and the Flight Safety Foundation, the ULR Crew Alertness Steering Committee was established (Flight Safety Foundation, 2003). The steering committee's objective was to define these operational and technological issues and develop standard methods using scientific evidence that can be promulgated into required ULR operational guidance (Flight Safety Foundation, 2003).

Between 2001 and 2005, the committee conducted four workshops (Flight Safety Foundation, 2003):

1. Washington D.C. – 12th to 14th June, 2001
2. Paris – 4th to 7th March, 2002
3. Kuala Lumpur –12th to 14th March, 2003
4. Los Angeles – 24th to 26th May, 2005

The 4 workshops had participants from 14 countries, 2 aircraft manufacturers, 3 airline associations, 16 airlines, 12 pilot unions, 3 cabin crew unions, 14 scientific organizations, and 9 regulatory authorities. The outcome of these workshops was recommended guidelines in varied operational areas for the ULR operations listed below:

1. **Operational Best Practices** – These addressed vital issues and their related countermeasures concerning flight crew complement, education requirements, departure delays, and in-flight environment that could affect crew rest facilities for ULH operations.

2. **Operational validation programs -** These addressed the methods to conduct validation for above listed vital issues. One of the most significant outcomes of this program was the introduction of the Fatigue Risk Management System (FRMS) Framework, which allowed effective management of flight crew fatigue. Additionally, other recommendations were made to airlines to develop tools for continuous monitoring of city pairs, aircraft types, departure windows, routing, pre-ULR rest, post-ULR rest, crew complement, in-flight rest strategy, and rest rostering.
3. **Global Regulatory Approach** – These addressed requirements for regulatory bodies to develop a systematic procedure to approve city pairs submitted by airlines. Additionally, the committee suggested that this approval process should be based on an operational process for pre, in-flight, and post-flight. The primary emphasis was on the importance of the FRMS and a recommendation to include FRMS in the current regulatory standards to ensure levels of crew alertness remain within acceptable limits.
4. **Research & Development** – These efforts addressed future studies and research work that needs to be completed on ULH operations. The critical area of focus was developing mathematical models that can support the data collection process and identify trends for fatigue and alertness experienced by the flight crew. Additionally, researching long-term health implications for the crew of ULR and other schedules was also recommended by the committee within the list of varied areas of future study.

Most aviation regulatory authorities adopted the recommendations presented by the committee. Between 2004-2014, ICAO incorporated most of these recommendations in its Annex 6 and subsequently developed guidance material on the Fatigue Risk Management System (FRMS) and Extended Diversion Time Operational (EDTO) (ICAO, 2004; ICAO, 2017).

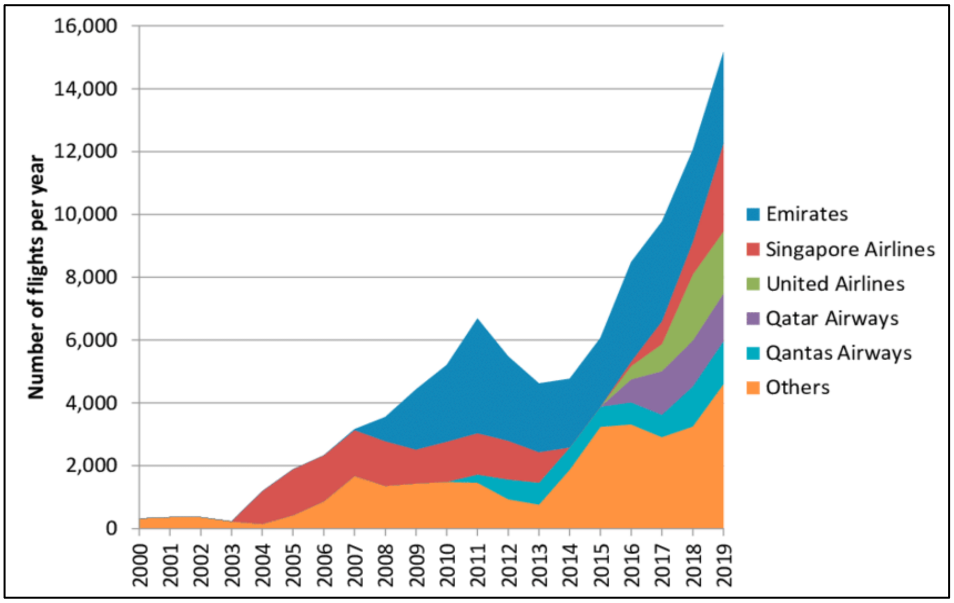
The steering committee's efforts undoubtedly helped the industry by providing necessary recommendations on scientific and mathematical tools to validate the operational and safety issues concerning ULH flights. However, Hains (2006) noted this understanding only centered on the operational aspects of pilots. Limited attention was provided to the operational aspect of the flight attendant population. Moreover, except for fatigue experienced in a different phase of flight and alertness level, no other factor was considered in these studies. Especially the long-term health implication was deferred for future study and research (Hains, 2006; Van Dan Berg et al., 2015).

Current and Future ULR Route Operations

According to ICAO's World of Air Transport report, the total number of passengers carried on scheduled service in 2019 increased by 3.6% compared to the previous fiscal year. The demand for international travel also grew by 4.7% relative to 2018 (ICAO, 2019). Provided the travel constraints posed by the pandemic, this demand will be back on steady growth in 2024 (IATA, 2022). With this steady growth in passenger demand to travel yearly, the industry stakeholders predict an overall 45% increment in this demand by 2040. Correspondingly the demand for ULH flights has been significantly increasing since 2004. This progression is illustrated in Figure 2, which presents the number of ULH flights operated by different airlines since 2000.

Figure 244

Number of ULH flights operated by different airlines per year



Note. This figure was adopted from “An analysis of the prospects of ultra-long-haul airline operations using passenger demand data” by Grimme. W, Bingermer. S, and Maertens. S, 2020, *Journal of Transportation Research Procedia, 51*, p. 210

According to Freed and Hepher (2018), Qantas & Singapore Airlines have been on a competitive edge to set the record for the longest flight ever operated in aviation history. Singapore Airlines holds the record for the world's longest flight, completed in late 2020, flying 10,000 miles –a non-stop 17-hour journey from Singapore to New York City (Pallini, 2020). Correspondingly, Qantas Airlines is investing substantial resources in its "Project Sunrise," whose mission is to test the viability of operating the first non-stop commercial flight between New York - Sydney and London – Sydney (Qantas, 2019). In 2019, Qantas Airline accomplished the experimental non-stop ULH flight between Sydney and London with a plan to offer scheduled flights in 2023 (Quest & Neild, 2019). Table 2 shows the top five longest scheduled flights operated in 2020

Table 2

Top 5 global ULH international routes and operation frequency in 2020

Route			Flights	Miles
EWR-SIN	Newark	Singapore	728	8,277
AKL-DOH	Auckland	Doha	721	7,843
LHR-PER	London Heathrow	Perth	730	7,829
AKL-DXB	Auckland	Dubai	710	7,664
LAX-SIN	Los Angeles	Singapore	1,034	7,611

Note: This table was adopted from OAG. (2020). Busiest routes 2021. [pdf]. Retrieved March 21, 2022, from https://www.oag.com/hubfs/free-reports/2020-reports/busiest-routes-2020/busiest-routes-2020.pdf?hsCtaTracking=284f64d1-685f-42d3-9d1e-8d98ac96eac1%7C66a747bd-4f88-4f13-9265-1b32e3cad838

More recently, Biman Bangladesh's experimental flight between Dhaka and Toronto (Ranabhat, 2022) and Air New Zealand’s experiment flight from New York to Auckland (Slotnick, 2022) have been successful. These experimental flights are anticipated to be converted to scheduled services by 2024 (Limb, 2022).

Health and Safety of Aircrew in Commercial Aviation

One of the early studies on the safety and health experience of pilots and flight attendants noted:

> "Air transportation workers have a comparatively high rate of disabling injuries and illnesses. Pilots and flight attendants commonly sustain serious sprains and strains." (Reardon, 1992)

These conditions for pilots and flight attendants are inherent to the current operational dynamics of the nation's commercial airlines, particularly in their search for economic viability, which has tried to outplay the competition in providing services to its passengers. These airlines' present attempts to gain a competitive advantage have led to providing onboard services beyond aircrews' capabilities. This competitive environment has been fostered partly by each airline trying to acquire a larger share of the market, a legitimate corporate objective. There is no argument for this competitive spirit; it is inherent in the socioeconomic order of the industry (Dedmon, 1968).

Analogous to economic viability, the changing regulatory, technological, and operating environment factors have been responsible for commercial aircraft modernization. These elements have allowed the nation's commercial airlines to schedule services that cannot be completed at a normal pace within the currently scheduled operations; however, they have helped airlines place themselves strategically in a competitive market. These elements are also predominantly responsible for changing the roles and responsibilities of aircrew (Haines, 2006). The role of the pilot in a cockpit, which was formerly considered a control operator, has now evolved to system manager and decision maker; the primary role of the flight attendant, which was primarily intended for the safety of their passengers, is now service–loaded with marketing and promoting passenger experiences in concurrence with maintaining operational and passenger safety. These changes to roles and responsibilities with service overload have impacted aircrew's health and safety (Haines, 2006).

Health and Safety studies of aircrew in commercial aviation were only recognized in the late 1980s. Although the issues regarding health and safety topics reported by aircrew became acute in 1975, aviation regulators' actions were limited to cabin environment, air quality, and related toxicological risks. These actions failed to address other safety and health aspects of the in-flight work environment of the aircrew (DOT, 2013). Between 1985 and 2000, two noteworthy studies reviewed health and safety in aircrew and their performance. The first notable research was attempted by Kraus (1985) to review epidemiological studies of health effects on commercial pilots and flight attendants but discovered published literature to be sparse on this group of workers. The study recommended a requirement for a well-designed and executed epidemiological study that focused on aircrew (Kraus, 1985). Reardon (1992) conducted the second notable research on pilots' and flight attendants' safety and health experience. The study found similar challenges, with the sparse literature and only one study that investigated the health and safety of transportation workers. A comparative study analysis of the 1988 U.S. Bureau of Labor Statics data reported by 14 participating U.S. states on occupational injuries and illness in transportation and other occupational industry workers was conducted. The analysis identified conditions and incidences such as strains, sprains, fractures, and occupational disease were significantly greater to be experienced by aircrew than by employees working in another occupational environment. In addition to these factors, the study findings also suggested in addition to the aircraft cabin environment, the airlines' post-deregulation economic environment characterized by consolidation and mergers had shifted focus to producing a tight oligopoly market that strongly correlated with impact on aircrew health and safety. Despite this study's limitation to further understanding why the aircrew suffers a higher incidence of health and safety impact factors by employees working in another occupational environment, this study made an early attempt to provide a qualitative and quantitative measure of different occupational factors experienced by aircrew (Reardon, 1992).

Over the years, the aviation industry's understanding of significant health issues correlated with cabin environment and its effects has significantly improved. However, in-flight job-related health and safety impacts on aircrew remain an understudied topic in the aviation industry (Lamp, 2018). The current sparse studies presented a trend in which the studies have either focused on general or specific flight experiences impacting the health and safety of aircrew. In the case of ULH flights, studies have noted that flight attendants and pilots experience different health impact factors. This difference prevails due to the different sets of job requirements and regulations governing the roles and responsibilities of both cohorts (Flight Safety Foundation, 2005).

The most cited cabin environment factors that affected the aircrew are cosmic ionizing radiation (ozone), air quality, smoke and fume events, temperature, humidity, reduced air pressure level, noise and vibration causing sleep deprivation, and time zone shifts (NRC 2002; Nagda & Koontz, 2003). Alternatively, the most cited in-flight job-related occupational factors by aircrew are presented below:

- For pilots, the health and safety cited factors are age and its impact on operations, a musculoskeletal disorder such as lower back pain and deep vein syndrome (DVT), fatigue and sleep loss, mental fatigue, circadian disruption, dehydration, airline water and food safety, cancer, laser and other illumination hazards, smoke and fume events, and psychosocial issues (Flight Safety Foundation, 2005; Caldwell et al., 2006; Signal et al., 2013; Williamson and Friswell, 2013; Demerouti et al., 2019; Albermann, 2020; ALPA, 2022). However, the most cited and consistent factor since 1975 was fatigue and its cumulative effect on pilots.
- For flight attendants, the most cited factors were acute respiratory syndrome, foodborne disease, irritation of the skin, eyes, and throat, musculoskeletal disorders and injuries such as swelling of legs, lower and upper back, neck, and shoulder pains, DVT, cancer, reproductive hazard, fatigue caused by insufficient scheduled in-flight sleep, and pre-departure stress and anxiety (T Brown et al., 2001; DeHart, 2003; Nagda and Koontz, 2003; Hains, 2006; Griffith and Powell, 2012; Van Dan Berg et al., 2015; Grout and Leggat, 2021)

Although these above-mentioned cabin environment and in-flight job-related factors are commonly experienced on either short-range or long-range flight operations, these factors are variable to flight length and time (Hains, 2006; Grout and Leggat, 2021). As suggested by Haines (2006):

> "The increase from a 14-hour flight time to a 16-hour flight time seems minor, but these new aircraft can operate 18, 20, or 22 hour flights where the difference and impacts will be noticeable. The difference between a 14-hour flight time and a 20-hour flight time is 43%, a level where impacts will appear, that means 43% more exposure by occupants to the cabin environment and other aircraft influences." (p3)

Cabin Environment and its Impact on Aircrew

Over the past three decades, aviation industry regulators and stakeholders have extensively studied the cabin environment and its influences on aircrew. The aircraft flight deck and the cabin have been recognized as industrial in nature and possess a greater risk to individuals than many other occupational settings (TP Brown et al., 2001; NRC, 2002; ALPA, 2022). Before discussing these influences, it is imperative to understand the characteristics of the aircraft cabin environment. The U.S. National Research Council (NRC) and their research on airliner cabin environments have significantly improved current cabin conditions. In their first studies of the aircraft cabin environment, the NRC characterized the aircraft cabin to be similar to any other indoor environment, such as general offices and households, in which individuals are exposed to a combination of recirculated and outside environment air. However, what differentiates the cabin environment is the high occupant density in confined space, the incapability of occupants to move at convenience, a combination of environmental-induced factors like humidity, low levels of air pressure, and possible exposures to contaminated air, such as carbon monoxide, carbon dioxide, ozone, semi-volatile organic compounds (NRC, 2002).

Between 1985 to 2020, the United States and the United Kingdom governments and aviation regulatory bodies were instrumental in probing different cabin environment characteristics and their associated health factors impacting aircrew and passengers. Their efforts and understanding of the cabin environment are presented in the subsequent paragraphs.

The United States Congress and FAA Research

Between 1975 and 1985, aircraft's operational capabilities were significantly improved; the ability to cruise at 35,000ft and travel longer routes in significantly shorter flight time. These improvements in the design and performance of aircraft have benefitted airlines in scheduling strategic routes to gain a competitive advantage. However, these changes in operations posed acute implications for the aircrew that presented significant concerns regarding air quality and associated health effects (FAA, 2012). These issues were addressed in the U.S. Congressional hearings in 1983 and 1984. Following the Congressional hearing, it was realized that the knowledge and information on cabin air quality were paradoxical and required better clarity and understanding of these issues. In this pursuit, the U.S. Congress commissioned the NRC to mandate a study on the airliner cabin environment (Public Law 98-446, 1984). The finding of the subsequent study concluded that due to the insufficient data present at the time on cabin air quality, no scientific evaluation could be determined on the associated health risk. Despite this limitation, this study laid a foundation for necessary research by issuing a recommendation, in part, to develop a systematic measurement program that focuses on several aspects and variables of cabin air (NRC, 2002). The study also recommended altogether banning cigarette smoking on commercial flights. In the following years and several phases, the FAA issued 14 Code of Federal Regulation (CFR) 252 rule that banned smoking on all commercial flights. The smoke-free flight regulation significantly decreased flight attendants' second-hand smoke exposure by 14 times that of the average person (Repace, 2003). Even though the new regulation helped reduce the toxicological risk in the aircrew cohort, other unresolved issues concerning aircraft air quality and health issues became severe in the year 2000. The U.S. Congress, in coordination with FAA, recommissioned the NRC to conduct the same study but with additional scope to specifically collect and examine the sources of toxicity and health effects associated with these contaminants and, based on this understanding, provide recommendations for improving cabin air quality (NRC,2002). The key findings of this study, in Table 3, identified primary air quality characteristics and their impact on potential health effects for cabin occupants.

Table 3

NRC findings on primary air quality characteristics and its potential health effects

Characteristics	Potential Health Impacts	Frequency of Exposure
High Concern Cabin Pressure	Severe health effects may occur in some people (e.g., infants and those with cardiorespiratory diseases) due to decreased oxygen pressure. Temporary pain or discomfort may occur due to gas expansion (e.g., middle ear or sinuses).	Reduced cabin pressure occurs on nearly all flights.
Ozone	Health effects (e.g., airway irritation and reduced lung function) may occur at concentrations as low as 0.1 ppm, increasing severity at higher concentrations, exposure durations, and respiratory rates.	Elevated concentrations are expected primarily on aircraft without O3 converters that fly at high altitudes; substantial uncertainty exists regarding the frequency and duration of elevated concentrations on these flights.

Moderate Concern Airborne Allergens	Inhalation can result in irritated eyes and nose, sinusitis, acute exacerbations of asthma, or anaphylaxis.	The frequency and intensity of exposure sufficient to cause sensitization or symptoms are unknown.
Carbon Monoxide	Headaches and lightheadedness occur at low concentrations; more severe health effects result from higher concentrations and longer durations.	High concentrations could occur during air-quality incidents. The frequency of incidents is highly uncertain but believed to be low.
Hydraulic Fluids or engine oils	Mild to severe health effects can result from exposure to these fluids or their degradation products.	The frequency of incidents in which these fluids or degradation products enter the cabin is very uncertain but is expected to be relatively low.
Infectious Agents	Exposure may have no effect or cause an infection with or without symptoms.	The presence of some infectious agent is likely, but the frequency of exposure that results in infection is unknown.
Pesticides	Health effects (e.g., skin rashes) can result from dermal or inhalation exposure.	Health effects (e.g., skin rashes) can result from dermal or inhalation exposure.
Low Concern Carbon Monoxide	Indicator of ventilation adequacy. Elevated concentrations are associated with increased perceptions of poor air quality.	Indicator of ventilation adequacy. Elevated concentrations are associated with increased perceptions of poor air quality.
Deicing Fluids	Health effects can result from inhalation of high concentrations.	Health effects can result from inhalation of high concentrations.
Nuisance Odors	Annoyance and mucosal irritation can occur.	Can be present on any flight.
Relative Humidity	Temporary drying of skin, eyes and mucous membranes can occur at low relative humidity (10 to 20%).	Low relative humidity occurs on most flights.

Note: This table was adopted from “National Academies of Sciences, Engineering, and Medicine. 2002. The Airliner Cabin Environment and the Health of Passengers and Crew. Washington, DC: The National Academies Press. https://doi.org/10.17226/10238.”

Based on these key findings, the NRC issued 10 recommendations to the FAA which are illustrated in Table 4 below (NRC, 2002; FAA, 2012).

Table 4

NRC recommendations to FAA responses and current regulations

NRC Recommendations	FAA Actions and Current Regulations
1. Establish Federal Aviation Regulations (FAR) for the air quality (Carbon Monoxide, Carbon Dioxide, Ozone, cabin pressure, and ventilation) related to design, performance, and operational standards for aircraft.	14 CFR Part 25 Subpart D • FAR 25.831 Ventilation • FAR 25.832 Cabin Ozone Concentration • FAR 25.841 Pressurized Cabins • FAR 25.843 Tests for Pressurized Cabins
2. Effective measures to be taken on Ozone regulations and to update the current regulation to ensure that commercial airlines comply with these regardless of altitude. Additionally, FAA should require commercial airlines to install and maintain ozone convertors on aircraft.	14 CFR Part 121 Subpart T • FAR 121.578 Cabin Ozone Concentration Advisory Circular (AC)120-38 Transport Category Airplanes Cabin Ozone Concentration
3. FAA to test the feasibility to installing air-cleaning equipment that helps removing particles and vapors from cabin.	14 CFR Part 25 Subpart D • FAR 25.831 Ventilation Note – Current generation aircraft have High Energy Particulate Air filtration system, which removes 99.97% particulate material (FAA,2012).
4. FAA to establish a regulation for installing carbon monoxide monitor equipment in the air supply ducts to aircraft cabins.	14 CFR Part 25 Subpart D • FAR 25.831 Ventilation 14 CFR Part 121 Subpart J • FAR 121.219 Ventilation
5. Prohibition of small animals to be transported in aircraft cabins due to the potentially serious heal risk related to exposure to allergens in sensitive people.	14 CFR Part 121 Subpart T • FAR 121.589 Carry-on Baggage AC 121-36 Management of Passengers who may be Sensitive to Allergens
6. Promotion of health issues related to air travel and this information to be provided to cabin crew, passengers and health professionals.	FAA has established various Health and Safety Medical Topics on its official website, accessible to everyone.

7. FAA to establish a regulation that requires the cabin occupants to deboard the aircraft within 30 minutes in a ventilation failure or shutdown situation.	AC 121-35 Management of Passengers during Ground Operations with Cabin Ventilation
8. FAA to establish an Air Quality and Health Surveillance Program with an objective to collect air quality data and analysis to suggested the relationship between health effects and cabin air quality.	Following this recommendation, in 2004, FAA's Office of Regulation and Certification established the National Center of Excellence (COE) for Airliner Cabin Environment Research (ACER, 2004), which was renamed in 2007 to the National Air Transportation COE with a broadened scope to research in the Intermodal Transport Environment (ACERite). Over the decade, the FAA sponsored various cabin air environment studies which focused on the following: • Ozone concentration and effects in the aircraft cabin; • A comprehensive study of the airliner cabin environment and its implication on health and safety on aircrew and passenger; • Different studies on emerging technology that had the potential to eliminate Bleed Air contaminants and filter aircraft air supply • Infectious disease transmission n Airliner cabin
9. FAA to develop research program to answer questions related to • Ozone concentration and its health effects. • Effects of Cabin Pressure and oxygen partial pressure • Distribution of outside to inside air quality and quantity • Air quality incident rate • Magnitudes of exposure to pesticides in aircraft cabins and its effects. • Effect of relative humidity associated to dry cabin environment during flight	
10. In reference to the development of research program recommendation (9), Congress should designate a federal agency that conducts research in the proposed areas to help fill gaps in the current knowledge.	

Note: This table was adopted from "National Academies of Sciences, Engineering, and Medicine. 2002. The Airliner Cabin Environment and the Health of Passengers and Crew. Washington, DC: The National Academies Press. https://doi.org/10.17226/10238."

The FAA and its sponsorship of numerous studies have significantly improved and standardized the current understanding of cabin environment risk factors. In 2012, one of the rising concerns in U.S. commercial aviation was “Fume Events” that generated bleed air contaminants (FAA, 2012). The environmental control system (ECS) is the system in current-generation aircraft which supply air to pressurized aircraft flight deck and cabin. The replacement or make-up air, i.e., fresh air outside the aircraft, enters the ECS via aircraft engines. The compressed air is “bled” from the engine compressor section and ducted through the ECS cooling and humidity components before the conditioned air gets mixed with the recirculated air, which is ultimately distributed through the aircraft. Hence, the cabin's breathable air is a mixture of make-up and recirculated air. The “Fume Events” or air-contaminated events can occur due to this inbound makeup air interacting with oil/hydraulic fluid leaks or from failures in the engine compartment (Day, 2015). This air can be contaminated with volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs), which can result in health effects like headache, dizziness, euphoria, and irritation of the eyes and nose (Day, 2015). In response, the FAA conducted a study on cabin air quality. This study found the actual cabin fume events rate were less than 33 events per million aircraft departures (FAA, 2015). The study further noted despite the rare occurrences of these events in an aircraft cockpit and cabin, the future studies should explore different strategies for hazardous sampling constituents and develop a greater understanding of bleed air and its associated health risks.

More recently, in 2018, the FAA commissioned a study by ACERite to develop techniques for monitoring bleed cabin air quality. According to FAA, this study will take approximately 54 months to be completed (FAA,2020).

The United Kingdom Government, UK CAA, and EASA Research

Corresponding to the United States government and regulatory efforts, between 2000 and 2008, the government of the United Kingdom commissioned a series of research that focused on the effects of the aircraft cabin. Primarily, the central focus of these studies was on passengers' health, safety and comfort. However, air quality and its effects were studied with a focus on passengers and aircrew (House of Lords, 2007). To a certain level, these studies addressed similar findings to what NRC and FAA concluded and categorized the topic as a high priority to understand the possible effects of the health of the aircraft cabin environment. The difference between NRC and the UK Committee research was that the UK committee (House of Lords, 2007) provided a greater emphasis on the following:

- Contaminated air events concerning two major health threats at the time, i.e., the outbreak of severe acute respiratory (SARs) syndrome in 2002- 2003 and the influenza pandemic of 2004
- A comprehensive review of fume events was caused due to contamination of ventilation systems by engine oil fumes.

In 2001, the United Kingdom Civil Aviation Authority (UK CAA) commissioned a research program into cabin air quality after receiving reports on events in which the pilots were partially incapacitated due to contamination of ventilation systems by engine oil fumes. The research was conducted in two phases and focused on cabin air contamination and its effects on the pilot's ability to operate the aircraft safely. Phase One of the study primarily investigated the toxic byproducts of engines and aircraft that could cause in-flight incapacitation or impair pilots' ability to operate the aircraft safely. This was conducted by heating the hydraulic fluid or oil in the engine beyond the temperatures typically experienced in the engine. The findings concluded that except for short-chain organic acid, which causes irritant effects, no other toxic components or byproducts were identified that could potentially cause symptoms reported in the incident, i.e., partial in-flight incapacitation of pilots. Phase Two of the study investigated if chemical content contamination is present in the cabin air supply duct. This was conducted by passing airflows of different temperatures and humidity through the air ducts to identify any toxic byproducts that could be substantially liberated in the air condition system and can flow into the flight deck. The findings concluded that the ducts were contaminated with carbonaceous material and summarized that the byproducts of this material could cause the symptoms experienced by the pilots in the reported incidents. The toxicology review also suggested that these substances are unlikely to be in sufficient concentration that can cause a significant physiological effect. Based on the findings and results of this study, the UK CAA required manufacturers and operators of selected aircraft types to make modifications to reduce oil leaks into bleed air (UK CAA, 2004). In response, Airbus and Boeing have installed high-energy particulate air, which filters the recirculated air by capturing 99.97% of particles in the aircraft cabin (Day, 2015).

In 2009, there was increased debate on cabin air quality and its significant degradation on board large aeroplanes due to contamination caused by abnormal engine or auxiliary power units (APU) lubrication fluid leakage. In the rising cases and events on board, the EASA issued an Advance Notice of Proposed Amendment (A-NPA) “Cabin Air Quality of onboard Large Aeroplanes” (EASA, 2009). In 2011, the comment response document (CRD) to the A-NPA was issued, which stated that no safety case is to be found and, instead, these events are rare in nature, thus no justification for an immediate rulemaking action. It was also identified that no research at the time reported a causal relationship between oil/hydraulic fluid contamination and aircraft cabin air quality (EASA, 2011). In 2012, the decision was made, based on CRD's justification, to terminate the rulemaking task of 25.035, “Cabin air quality Onboard Large Aeroplane” (EASA, 2012).

Following this in 2014, to better comprehend the scientific knowledge about cabin air quality on large aeroplanes operated for commercial transportation, EASA commissioned two studies, with results published in 2017 (EASA, 2017).

The first study focused on measuring reliable cabin air. A total of 69 measurement flights were performed between 2015-2016. Approximately 8 of the 69 flights were bleed-free Boeing 787 equipped with an electric compressor. The measurements were taken at the defined flight phase, which allowed tracking of potential sources and impact of cabin air contaminants. This study's findings (Table 5) suggested that the frequency, pattern, and concentration were similar to any other occupational indoor environment. The study also found small meta and para tricresyl phosphate (TCP) traces. However, the levels of TCP were below the limit of any impact on human physiological effects. Thus, the authors concluded that the results of this study were consistent with other cabin air quality measurements previously conducted by the regulatory authority (EASA, 2016).

Table 5

EASA research finding on cabin air contaminants potential sources and their potential impact

Potential Sources	Potential Impact
Engine start during pushback	Exhaust gases (e.g., CO, CO_2, NO_X, fuel, particles)
Bleed air switch off during engine start	Short-time increase of CO_2
Cabin cleaning in general Interior cleaning	VOC, e.g., alcohols, flavors (terpenes), aldehydes Residual of tetrachloroethene
No ozone converters installed	Ozone, particularly in cruise
De-icing fluids	1,2-Propanediol (major constituent) and various additives (e.g., dyes, thickener, antioxidants)
Aircraft traffic at the airport	Exhaust gases (e.g., CO, CO_2, NO_X, fuel, particles)
Car traffic at the airport	Exhaust gases (e.g., CO, CO_2, NO_X, gasoline, particles)
Passengers	Emission of CO_2, various VOCs, offensive smell
Restrooms	Smell, VOC from cleaning products
Furnishings	VOC/SVOC, particulate organic matter (POM), flame retardants e.g., organophosphates
Maintenance	Various VOCs, lubricants
Lubricants	Oil base stock, organophosphates, POM
Hydraulic fluids	, e.g., Tributyl phosphate (TBP), triphenyl phosphate (TPP)
Engine oils	Tricresyl phosphate (TCP), trixylyl phosphate (TXP), Amines
In case of thermal degradation	VOCs, organic acids, aldehydes, CO, CO_2, potential unknown products

Note: This table has been adopted from “European Aviation Safety Agency. (2017). Preliminary cabin air quality measurement campaign (CAQ) (Technical

Report EASA. 2014.C15.SU01). EASA. Retrieved October 16, 2022, from https://www.easa.europa.eu/en/downloads/22219/en”

The second EASA study focused on the characteristics of the chemical composition of turbine engine pyrolysis oils and the toxicological risk that can be potentially released in the cabin or cockpit air. The study reported, “If seals within the engine are not performing effectively, oil and possibly thermal degradation products of oils can result in contamination of bleed air. Besides contaminated bleed air, the ECS itself and the ducts can also be a secondary source of contaminants.” (EASA, 2017, p. 18)

The study found 127 chemical compounds in different simulated flight phases in all the tested oils. The study found neuroactive products and TCP but concluded that the presence was too low to be a significant concern to any neural function of cabin occupants. However, the study was unable to find the effects of chemicals combined with other occupational stressors and human sensitivity variability to these industrial chemical exposures, and recommended future work is needed in this aspect.

The commonality between both studies is that these recommended large-scale studies to be commissioned concerning chronic and acute bleed air contamination exposures. Based on the findings and recommendations of these extensive studies on cabin air quality, in 2017, EASA commissioned a larger-scale study to focus on primary oil contamination. The study planned to be published in 2024 aims to bridge the gap by step-advances in the investigation process of the exposure levels of the quality of air onboard commercial aircraft and the potential health impacts on crew and passengers (EASA, 2022).

In Flight Job-Related Factors and its Impact on Aircrew

Most studies on in-flight job-related health and safety impact factors are longitudinal cohort studies focused on pilots or flight attendants. Limited studies have focused encompassing both cohorts. For example, between 1994 and 2004, the Scandinavian Airlines of Norway conducted a series of studies on working conditions and their influence on aircrew health. In one of the early survey studies, Haugli et al. (1994) identified that aircrew operating long-haul transmeridian routes report more health problems than those who operate short-haul routes. The pilot population of the study reported problems such as irritability, fatigue, sleep disturbance, and lower back pain as most frequently experienced health effects. In comparison, the flight attendants reported skin and eye disorders, digestive disturbances, fatigue, and musculoskeletal pains as common health effects experienced on long-range flights.

Similarly, T. Brown et al. (2001) investigated aircraft industry stakeholders' subjective views and concerns on health issues related to long-range operations. These stakeholders were selected from nine different occupations within the industry, one of which were pilots and flight attendants. Using a semi-structured interview questionnaire, the study found that the main concerns fell into five areas which are:

- Deep Vein Thrombosis (DVT)
- Air Quality
- Cosmic radiation
- Jet Lag

- Work Pattern influencing sleep problem and fatigue

In the case of ULH flights, most recent studies have focused on the impacts of extended flight time on aircrew (Flight Safety Foundation, 2005; Signal et al., 2005). These ULH studies primarily focused on fatigue and alertness level impact on pilots in different phases of flight. Subsequently, the countermeasures, including pre-and post-flight extended rest, standardization of in-flight rest facility, the quantity of sleep acquired, and crew composition, were introduced on the bases of in-flight sleep subjective and objective measurements.

Haine's (2006) study on impact factors experienced by flight attendants in ULH is one of the notable studies on the health and safety impact experienced on ULH flights. A mixed methodology study had flight attendants' participants (n=119) from nine airlines identified fatigue, dehydration, and in-flight sleep loss as primary health impact factors. Concurrently, in 2007 House of Lords, the second chamber of the UK parliament, presented a revised study on air travel and health. The primary focus of this study was on passenger comfort and health safety effect. However, this study did examine factors like DVT, fatigue, contaminated air causing the respiratory syndrome, and other occupational health factors relative to work/rest patterns experienced by flight attendants.

The study approaches adopted by the above-stated studies in identifying different influencing factors experienced by pilots compared to flight attendants present certain limitations. Especially for flight attendants, Griffiths and Powell (2013) noted in their structured literature review of flight attendants' health and safety:

"The lack of standardized approaches to collecting data on exposures and health outcomes for flight attendants makes it very difficult to make inferences about health outcomes." (p. 514)

Studies on ULH flights have focused only on passenger comfort in the last decade. Limited progress has been made in identifying and researching health and safety impact factors for aircrew. Although, an effort toward collecting greater fatigue data for ULH flight attendants is underway. The main objective of gathering and enhancing the current knowledge of fatigue and its cumulative effect on flight attendants is to develop baseline data set which can be used for ULH flight scheduling and FRMS fatigue reports.

The first field study, by Van Dan Berg et al., 2015 focused on the perceived workload associated with flight attendant fatigue on ULH flights and identified a positive correlation between higher perceived workload and fatigue in flight attendants. The study used different subjective, cognitive, physiological, and psychomotor vigilance tasks (PVT) to assess fatigue in flight attendants. However, the study suggested that the workload warrants ongoing monitoring, which can be achieved by including workload questions in the airline's fatigue reports.

The second study used the same methodology to monitor flight attendant fatigue, sleep, and performance on ULH flights. The study found that the flight attendant participants ($n=55$) sleep averaged 7 hours. However, sleepiness and fatigue were significantly lower on the outbound flight (west to east) to what was experienced on the inbound flight (east to west). This result is consistent with the data collected for pilots on ULH flights. Although for FRMS data collection, the study suggested that operational difference needs to be considered between pilots and flight attendants.

Current Health and Safety Regulatory Environment

In the current regulatory environment, regulations pertaining to cabin environment and in-flight related working conditions of aircrew are under the jurisdiction of their respective CAA. In a broad sense, in many high-reliability organizations such as oil and gas and nuclear industries, these jurisdictions fall into the nation's health and safety government agency. However, most aviation CAA has a memorandum of understanding (MoU) with their nation's health and safety agency over air transport's roles, responsibilities, and jurisdiction. For example, in 1970, the U.S. Congress limited Occupational Safety and Health administration's authority to exercise its authority when another federal agency exercises such statutory authority. Subsequently, in 1975 the FAA published guidance detailing the agency's roles and interface concerning occupational health conditions affecting aircrew while on aircraft in operation (FAA, 2012). Analogously, the UK CAA, the Health and Safety Executive (HSE), and Health and Safety Northern Ireland (HSENI) have established duties and interface arrangements for aircrew while they are on aircraft in operation (UK CAA, 2017).

In the following three decades, pilots' and flight attendants' reports concerning the cabin environment and in-flight working conditions indicated acute effects on their health. Following these concerns, the CAA recognized the need to apply specific health and aviation standards for aircrew (FAA, 2012; UK CAA, 2017). Both the FAA and UK CAA have incorporated certain standards established by their respective health and safety standard agency. These are to a certain level identical, and therefore for consistency, FAA application of OSHA standards are reviewed.

In 2012, FAA and OSHA renewed the MoU intending to enhance certain occupational safety and health standards to the working conditions of aircrew in the aircraft cabin. The MoU (FAA,2012) noted OSHA would enforce its regulations on aircraft aircrew in three specific areas:

- Hazard Communication
- Bloodborne Pathogen Exposure
- Occupational Noise

The MoU further reiterated the FAA retains authority over the flight deck crew's occupational safety and health aspects. Recently a study conducted by ALPA (2022) noted that: “although the FAA has staked out this authority, it is not using it to the maximum practical extent to adequately establish appropriate minimum standards for occupational safety and health.” (p. 5)

The FAA’s Civil Aerospace Medical Institute (CAMI) is the research, education, medical certification, and occupational health branch. The main focus of CAMI is to conduct research and recommend best practices for the health and well-being of passengers, aircrew, and air traffic controllers. Contempt to these efforts of CAMI, the FAA has developed very few specific pertaining occupational and safety of aircrew (ALPA, 2022). Further, ALPA (2022) found that FAA does not have a formal process for monitoring and conducting any inspections of airline and aircrew occupational health and safety programs. Though, the FAA has provided a dedicated website that contains comprehensive medical topics, studies, and research conducted by CAMI (FAA,2012). Nevertheless, by comparison, the website contains most information for passengers, whereas only limited studies and vital information is present for aircrew (ALPA,2022).

In addition to the application of certain OSHA standards, the other standards are in reference to medical certification requirements for pilots, in-flight ozone regulation, flight time limitations, and rest periods for aircrew (FAA, 2022). For ULH flights, there are additional regulations, such as the in-flight rest period, which requires the augmented aircrew operation should be provided a minimum of 8 hours of in-flight scheduled rest to manage fatigue and alertness level.

The ozone regulations established by FAA in 1980 were to eliminate the levels of ozone that causes discomfort, such as mouth, eye irritation, and dryness. The regulatory standards require the cabin ozone levels not to exceed more than 0.25 parts per million (ppm) at any time or 0.1 ppm on average over 3 hours for any flight operating over 4 hours. In supporting this standard, the FAA has also published Advisory Circular (AC), AC120-38, which guides commercial operators on ways to comply with these regulations (FAA, 1980). In a meta-analysis review of the current study and regulatory requirements for ozone, Pottinger and Marcham (2018) found gaps in the AC and regulatory requirements established by FAA. Firstly, the ozone levels and measurement data in the AC are outdated and provide no other data source acceptable to FAA. Secondly, the AC fails to address any cumulative effects of ozone exposure on aircrew over multiple flights. Lastly, they also identified a gap in current regulation, which does not require continuous monitoring and follow-up measurements to ensure the ozone levels remain below the required levels (Pottinger and Marcham, 2018).

In 2022, the FAA issued a final rule which increased the flight attendants' rest period from 9 hours to 10 consecutive hours between shifts. Previous studies which reviewed flight attendant rest periods between shifts noted that these regulations fail to account for activities such as traveling to the hotel, checking in, winding down, commuting back to the airport, and getting through security for which the prescribed rest period hour is insufficient (Hains, 2006; Avers and Johnson, 2011; Grout and Leggat, 2021). Interestingly, in this instance, the FAA did address this concern in the final rulemaking document. The justification FAA provided was that they lacked data and supporting research on pre- and post-flight fatigue association, which could support the notion of considering these activities and increasing the rest period beyond 10 hours (FAA, 2022).

Health Culture

The current literature on aircrew health culture is sparse, and these studies have investigated this notion from commercial airlines' pilot's experiences. From a general perspective, health culture can be defined as:

> "Health culture is concerned with every individual's or the society's patterns of living, celebrating, being happy in life, suffering, and dying. It is not enough for the individual to acquire only health-related information but basic skills such as comprehending health-related values, developing a healthy lifestyle and self-evaluation must be developed. The main purpose of developing health culture is to raise the level of health in the country scale. This can only be ensured by the fact that health education standards be established by well-trained and conscious individuals into practice with the help of their knowledge and skills" (Değer, 2018, p. 567-569).

Arguably, in the context of aviation, the notion of health culture can be found synonymous with aviation safety culture. However, understanding the health culture requires exploring the culture and context in which the aircrew operates (Lamp, 2018). For example, the 2015 accident involving Germanwings flight 9525 brought the sensitive topic of mental health in airline pilots to the forefront in aviation. In response to this catastrophic event and to better support the mental fitness of pilots, the aviation regulator, such as EASA, introduced new regulations for developing a mental health support program for pilots. Under this program, the airlines must mandate psychological assessments of pilots as a part of the hiring process.

Additionally, the airlines should introduce systematic drug and alcohol testing of the aircrew (EASA, 2016). Concurrently, in addition to the medical examination required by FAA for pilots, the regulator has also established additional guidelines and support programs for the aircrew to support mental health issues. Despite these efforts to stringent and introduce new regulations, a survey study (*n=1848*) conducted in 2016 found a statistically significant proportion (12.6%) of the pilot population suffering from depressive symptoms. The study also found that the pilots progressively manage depressive symptoms without the possibility of treatment due to fear of repercussions on negative career impacts (Wu et al., 2016). The study suggested a requirement for an in-depth examination of health management and current barriers that the pilot experiences in managing their health.

One distinct study on commercial airline pilot health culture (Lamp, 2018) identified that commercial aviation pilot health culture exists within the:

1. Pilot's career aspiration to choose this profession.
2. The CAA health regulations
3. The operating environment of commercial airline operators

Based on this context, the study investigated 11 commercial aviation pilots and management personnel from two major commercial airlines to identify the state of health culture in the pilot community. The findings suggested the following:

- The pilot feared punitive action such as cancellation of medical certificates.
- The fear of punitive actions creates a barrier to reporting any health-related issues to the authorities.
- Mental health stigma among the pilot community.

Summary

The underlying result of the literature review was that limited studies are conducted on the health and safety of aircrew operating the ULH routes, with sparse correlated research found or combinations of effects that could support the analysis of aircrew health impact factors. Despite this slow progress, current literature on the topic suggested:

1. Most studies, including the efforts of aviation regulators, have been centered on cabin environments and their effects, such as noise, air quality, humidity, and its effects. The only in-flight job-related factor that has received much attention and has been researched extensively is fatigue and its cumulative effect.
2. Fatigue and its association with ULH operations have been mainly studied from a pilot perspective. Only sparse studies have focused on the effects of fatigue on flight attendants' operation of ULH flights.

3. The health and safety studies in aviation have been inconsistent, either focused on general flight experience or specific flight experience. Only sparse studies have focused on ULH flight impact factors on aircrew.

One distinct study on health and safety impact factors for cabin crew operating ULH flights (Haines, 2006) identified various physiological and psychological factors affecting flight attendant performance. The study identified several gaps in regulatory standards, for instance, mandating FRMS for these operations, setting specific duty time limitations and rest periods for the crew, and providing ULH operational training for aircrew. In the current regulatory framework, these stated gaps are translated into regulations by most aviation regulators (FAA, 2022; EASA, 2022; CAAS, 2022). However, this study was conducted 16 years back. In the current aviation dynamics, in which ULH operations are progressively gaining attention, there is a requirement for a well-controlled baseline knowledge of various regulatory health and safety standards and best practices established for pilots and flight attendants operating ULH routes.

Methodology

Studies on ULH and its impact factor on the aircrew have been inconsistent and sparse in the last decade. The issues regarding varied occupational safety and health are significantly increasing (ALPA, 2022). Thus far, very few specific aviation regulations concerning these issues have been introduced. Based on this understanding from the current literature, this study has adopted a mixed methodology. This method allows combining the approaches from qualitative and quantitative paradigms (Patten and Newhart, 2018) that will help devise an understanding of the current impact factors and subjective experiences of ULH aircrew operating these routes. The following subsections provide applicability and reasoning for the selected method, including ethical consideration, research methods and design, study participants, instrument, procedures, measurements and analysis method.

Ethical Considerations

The risks to the participants of this study were minimal because the data being collected posed little or no risk to participants' personal or professional activities. The participants for this research were recruited through different channels, such as emails and social network platforms. The recruitment email and messages were intended for passive recruitment and the study's explanation. The interested participants who volunteered to participate in this survey research were presented with an Informed Consent Form (See Appendix B) which provided a detailed explanation and criteria for participation involvement. The participants were required to provide their consent prior to starting the survey. The participant's responses were anonymous, and no personal information was collected other than age, gender, or demographic descriptor.

In order to ensure that the survey questionnaire complies with the ethical considerations set forth by the Belmont Report (National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979), prior to distributing the survey to participants, approval was applied and granted through Embry Riddle Aeronautical University Institutional Review Board (IRB) (See Appendix A).

Research Methods and Design

A mixed methods approach is best suited for studies that focus on physiological and psychological determinants of health and the human aspects, requiring the data results to be explained or generalized (Lingard, 2008; Patten and Newhart, 2018). As discussed above, this thesis probes the current health and safety standards for aircrew operating ULH operations; a mixed methodology approach is considered the most appropriate choice. The effectiveness of a mixed-method approach study is contingent on the strategic relationship between the qualitative and quantitative methods to ensure the data triangulation produces a greater understanding of the study (Lingard, 2008). Since one information area can rely upon various sources of evidence (Hatch,2002) triangulation design technique was used to gain optimum results. The triangulation design is the most common research design for a mixed-method approach that supports obtaining different but complementary quantitative and qualitative data on the same topic (Morse, 1991, p.121). The study of health and safety in aviation cannot be solely analyzed based on quantitative results. The aircrew's subjective experiences play a pivotal role that strongly correlates with the current perception of these operations. Making deductive assumptions based on a single research technique is ineffective, especially when researching health and the human aspect.

Study Participants

The sample for this research is drawn from a population of aircrew who currently operate ULH operations. The aircrew sought to participate in this research survey required to meet the following two criteria:

- Employed (in last 24 months) by an air carrier operating scheduled ULH/ULR flights (>16hrs);
- Qualified as an aircrew member to operate ULH/ULR flight.

Instrument

The survey was the primary data collection method to gather current impact factors and subjective experiences of ULH aircrew operating these routes. This survey was developed on an internet-based website SurveyMonkey.com (See Appendix D). The reason for choosing this web-based platform was its efficient nature in gaining participants' data and analyzing the data. In addition, the web-based survey tool helped secure the participants' data, avoiding any compromise and cyber threat to the data. The survey questions consisted of a mix of open-ended qualitative questions and close-ended quantitative questions. Concurrently, this design strategy helped target five different operational parameters to identify and understand relevant impact factors experienced by aircrew on ULH flights. These parameters are discussed in detail in the following subsection.

Procedure

The primary data collection method for this research involved human participants. The survey questions were designed to collect information about the participants' opinions, perceptions, and choices. In order to ensure the survey questionnaire complies with the ethical considerations set forth by the Belmont Report (National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979), prior to distributing the survey to participants, approval was applied and granted through Embry Riddle Aeronautical University Institutional Review Board (IRB) (See Appendix A).

Following the IRB approval, the recruitment process was initiated. The participants for this research were sent the survey recruitment email/message (See Appendix C) through different channels listed below:

- The researcher's existing professional network contact was sent the survey recruitment email.
- Curt Lewis and Associates, a U.S. research consulting firm, was contacted to distribute the survey in its daily aviation newsletter.
- The researcher is a student member of the International Society of Air Safety Investigators (ISASI). As a member, the researcher had access to the email details of other members. The survey recruitment email was sent to the majority of members of ISASI.

- Pilots, flight attendants, and other established aviation social media groups on Facebook were reached out to and requested to share survey recruitment messages.
- A LinkedIn post with the survey recruitment message was posted on the researcher's profile.

The above-stated channels were sent follow-up emails and messages two weeks before the survey deadline date.

Measurement and Analysis

One of the most critical areas to be considered by research adopting mixed methodology is using different types of procedures for collecting data to augment the validity and reliability of the data and their interpretation (Zoharabi, 2013). Zoharabi (2013) noted the steadiness and stability of the data collected using a mixed approach are variable to the investigator's efforts through data triangulation to corroborate the research question.

To ensure the steadiness and stability of this research, the initial research questions were linked to developing and designing survey questionnaires. As stated in the previous section above, this design strategy helped target five different operational parameters, which complemented the process of identifying and understanding relevant impact factors experienced by aircrew on ULH flights. Based on these five parameters, the survey questionnaire was deduced. These parameters are discussed below:

1. **Personal and organizational profile** – Questions 3 to 10 focus on gathering data relevant to participants' demographic information and subjective opinions on the current safety approach practiced at their airline.
2. **Airline training for ULH operation** – Questions 11 to 15 focus on gathering data relevant to participants' airline's training programs and current operational procedures relative to ULH flights.
3. **Cabin environment in ULH flights** – Questions 16 to 20 focus on gathering data relevant to participants' experience with the cabin environment and its impacts on health, safety, and performance.
4. **Health and safety focused** – Questions 21 to 27 focus on gathering objective and subjective data relevant to participants' experience with various health and safety impact factors experienced while operating ULH flights.
5. **Airline's outlook on aircrew health & safety** – Questions 28 to 30 focus on gaining subjective opinions/experiences from participants on their airline's approach to aircrew's health and safety practices. The purpose of gathering this data is to identify if the concept of health culture exists.

The 30-survey questions were designed using two psychometric scales, open-ended qualitative questions, close-ended quantitative questions, ranking questions, and subjective/objective experience questions to assess participants' responses. A systematic review of the questionnaire allowed the selection of appropriate descriptive and inferential statistical analysis tests. These have been discussed below in specific contexts with various question types.

- **Demographic and close-ended**: To gather participants' demographic background information such as region, age, gender, job role (Flight Attendant or Flight Crew), and current ULH training approaches, close-ended multiple-choice and dichotomous items questions were administered in the survey. Since closed-ended survey questions have discreet responses, these have been analyzed using the descriptive analysis method.
- **Visual Analogue Scale (VAS):** The VAS question design was used to evaluate participants' subjective impressions of their satisfaction concerning current regulations developed for ULH flights. An adjective was placed over the numeric rating scale, with the words "most dissatisfied" appearing on the far left and "most satisfied" on the right. Each VAS question required participants to move the arrow to the point of their level of satisfaction. The VAS question provided a range of scores from 0-100 for analysis. Given the scope of this study to probe current health and safety standards, it was decided to compare the survey responses of pilots and flight crew. Analysis using a two-sample t-test was conducted to determine if there is a difference in the subjective impressions' responses to VAS survey questions.
- **Matrix/Likert Scale:** A close-ended matrix question required participants to evaluate one or more row items using the five-level Likert-type scale of subjective opinion ranging from "Level 1 = Strongly Agree" to "Level 5= Strongly Disagree". The participants were asked to present their

opinion/satisfaction level about their airline's safety culture, different cabin environment factors, and airline approach to the safety level. Studies have identified that parametric statistical tests provide unbiased results compared to the non-parametric test when analyzing Likert scale responses. However, there is an exception for studies that primarily measure participants' satisfaction levels. Thus, in this scenario, either of the tests can provide unbiased results (Dexter and Chestnut, 1995; Sullivan and Artino, 2013). To test the significance of the response's chi-square statistical test was selected to examine the differences between categorical variables from the sample.

- **Ranking:** The forced choice ranking question required participants to arrange nine in-flight health-related impact factors based on their personal opinion and experience. The arrangements for these factors were from most (Rank 1) to least preferred (Rank 9). Since ranking questions result in ordinal or categorical data, the Friedman two-way analysis of variance by rank was selected to analyze this data. The Friedman ranking analysis will help determine if there is a statistically significant difference between the flight crew and flight attendant experiences of in-flight health-related impact factors while operating ULH flights.
- **Open Ended:** The open-ended questions in the survey were designed to gather relevant qualitative data from the participants. The main focus of these questions was to comprehend various health-related factors that can be experienced during the different phases of ULH flight. The

collected response was characterized by inductive rather than deductive information (Hatch, 2002). The content analysis approach is the most appropriate technique for deidentifying qualitative responses. Content analysis is an interpretive and naturalistic approach to formulating inferences by systematically manifesting message characteristics (Holsti, 1968). The aircrew responses are analyzed by focusing on specific repeated responses or words. These are further translated to complement the quantitative data.

Limitations and Delimitations

The limitations of this study are listed below:

1. The research design of this study incorporated non-probability sampling methods. Thus, the results of this study are only applicable to the aircrew currently operating ULH flights and cannot be generalized to other operations, i.e., short-haul and long-haul operations.
2. This study's self-administered survey questionnaire had 30 questions. This posed an inherent risk of participant fatigue and missing data due to respondent withdrawal from completing the survey.
3. Reaching the participants (ULH aircrew) to complete the survey was challenging. This was mainly due to the strict nature of employee protection at the airline and their employee union representation. Several rules and regulations established by the airline and unions limit the aircrew to provide

qualitative information despite knowing that their responses will be anonymous.

4. By comparison, the number of pilot participants who agreed to participate in the survey questionnaire was significantly more than the number of flight attendant participants. This limited the findings on health and safety impact factors experienced by the flight attendant population while operating ULH flights.

The delimitations of this study are listed below:

1. The research objective of this study was to probe the health and safety standards and best practices currently prescribed for ULH flights. This has only been researched with the main focus of the commercial operation. The cargo operations and their prescriptive regulations were excluded from this research objective.

Results and Discussion

Results

A total of 50 responses were obtained from the online survey instrument. Out of the 50 responses, 48 participants meet the criteria for survey participation. However, out of the 48 responses, 36 participants completed the survey. These 36 responses are considered the most accurate objective and subjective representation of participation responses. The participants for this survey were from four different regions. Thus, each response to the survey played a vital role in understanding the ULH operation, its impact factors, and current standard practices towards health and safety adopted by participants airlines operating these routes.

The survey results are presented based on the five parameters discussed in previous section. This approach was selected to help investigate the responses in a thematic manner that will support answering the study's research questions. Lastly, the number of respondents is shown under each parameter’s subsection heading.

Personal and organizational profile

The first 10 questions of the survey focused on the demographics of the participants and a mix of objective and subjective experience questions targeted to investigate the current safety approach practiced at the participants' airline.

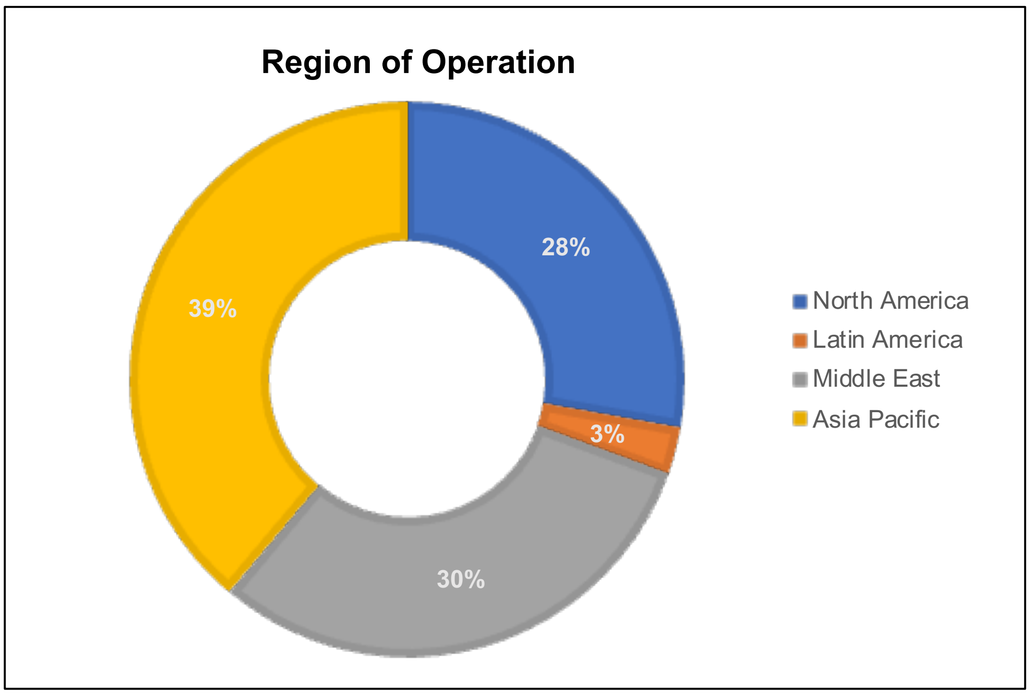
Region of Operation

(n=36)

The pie graph (Figure 3) presents survey participants' region of operation. The majority of participants were from Asia Pacific 39% the Middle East 30%, and North America 28% region. The remaining 3% of participants represented of Latin American region.

Figure 487

Participant region of operation



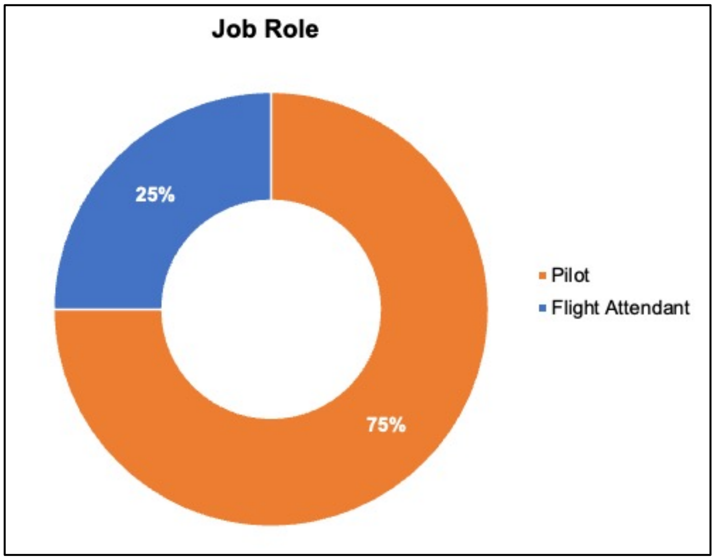
Job Roles

(n=36)

The pie graph (Figure 4) presents survey participants' job roles. The majority of participants in this survey were pilots (75%). In comparison, only 25% of participants were flight attendants.

Figure 730

Participant job role



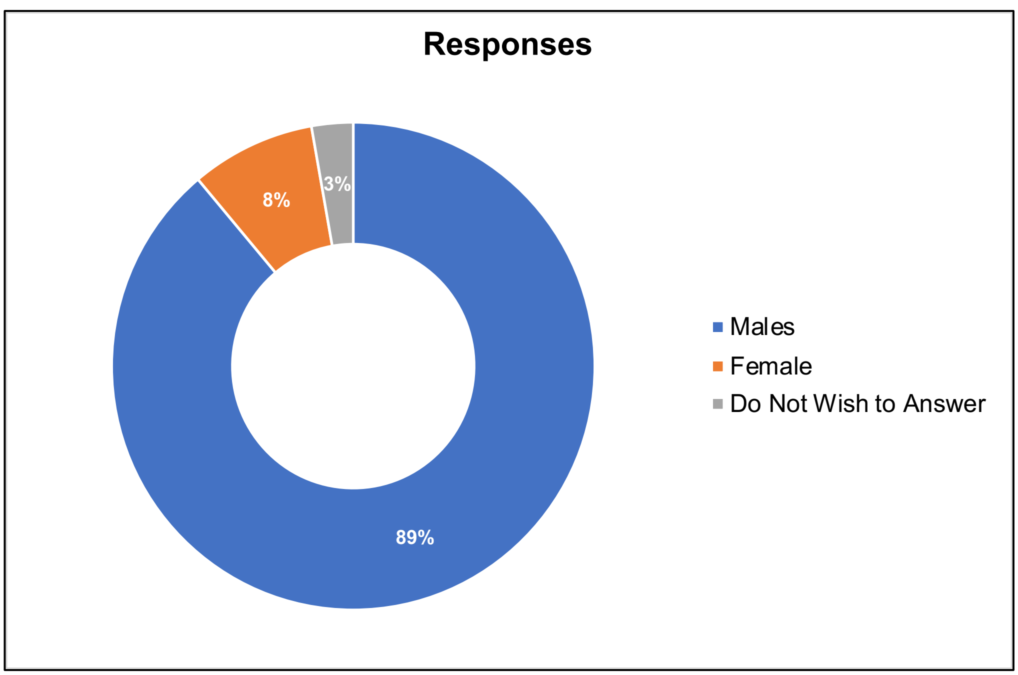
Gender Ratio

(n=36)

The pie graph (Figure 5) presents survey participants' gender ratio. Approximately 89% of the total participants were male, 8% were female, and 3% elected not to answer.

Figure 973

Participant gender ratio



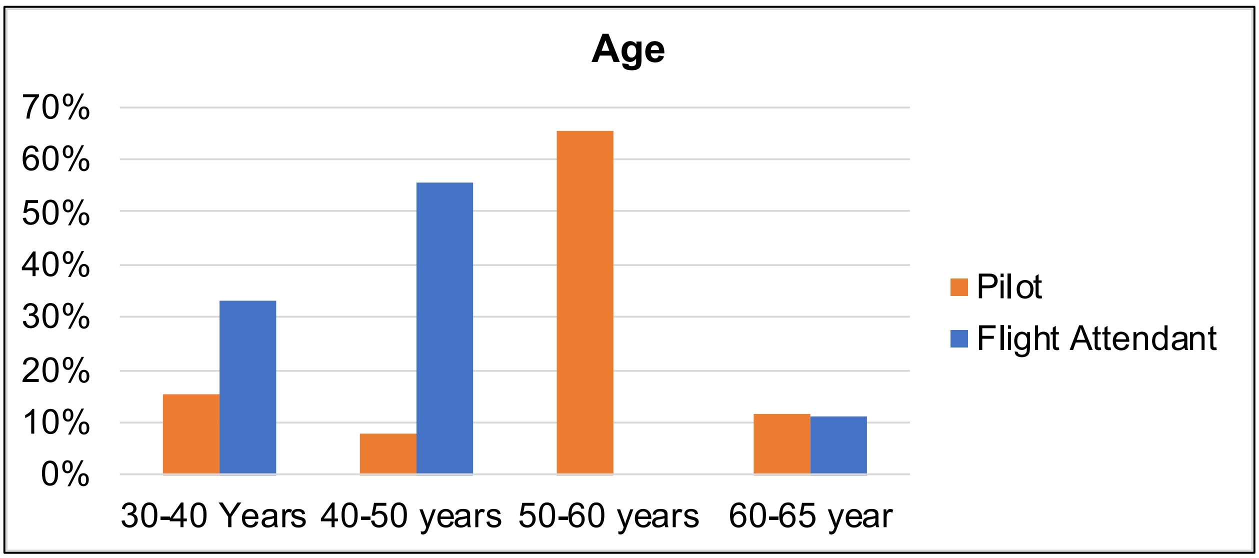
Age

(n=36)

The bar graph (Figure 6) presents the breakdown of the age groups of the participants. The participants' age ranged from 23 to 65 years (*M=48.6, SD =10.1).* In comparison, the majority of the pilot population (65%) fell in the age group of 50-60 years, whereas the majority of the flight attendant population (56%) fell in the age group of 40-50 years.

Figure 1216

Participant age



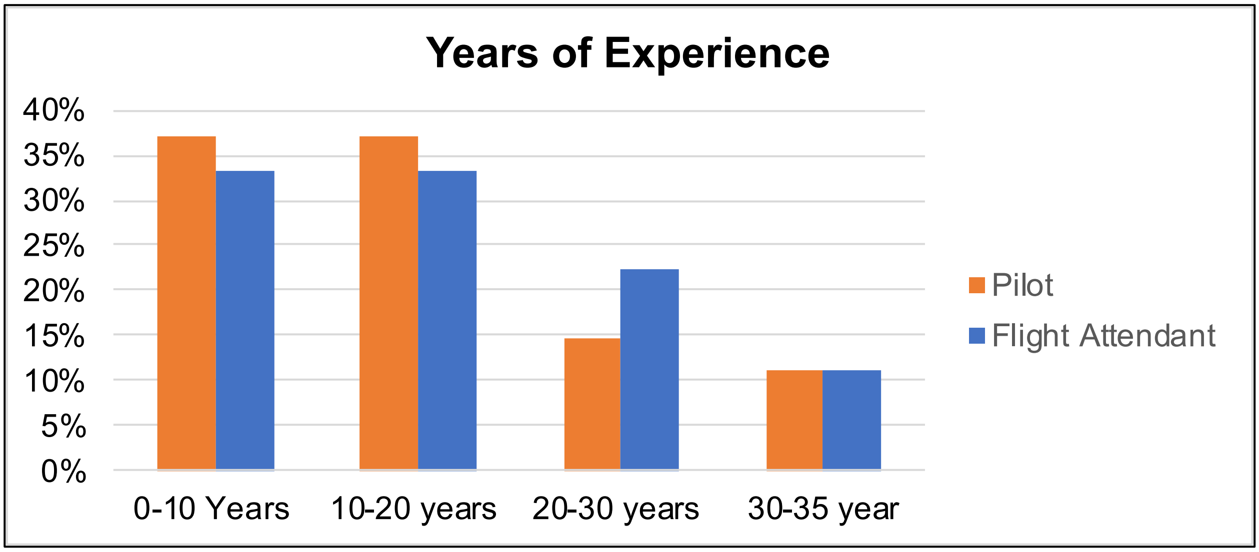
Years of Experience

(n=36)

The bar graph (Figure 7) presents the sub-categorical breakdown of the participants' years of experience in their current job roles. The participants' years of experience range from 1 to 34 years *(M=10.7, SD= 9.7).* Most of the pilot and flight attendant population experience was ≤ 20 years. The pilots with experience between 20-30 years were 15%, whereas 22% accounted for flight attendants. Only 11% of the pilot and flight attendants had experience falling between 30 and 35 years.

Figure 1459

Participant years of experience



Current Workplace Environment

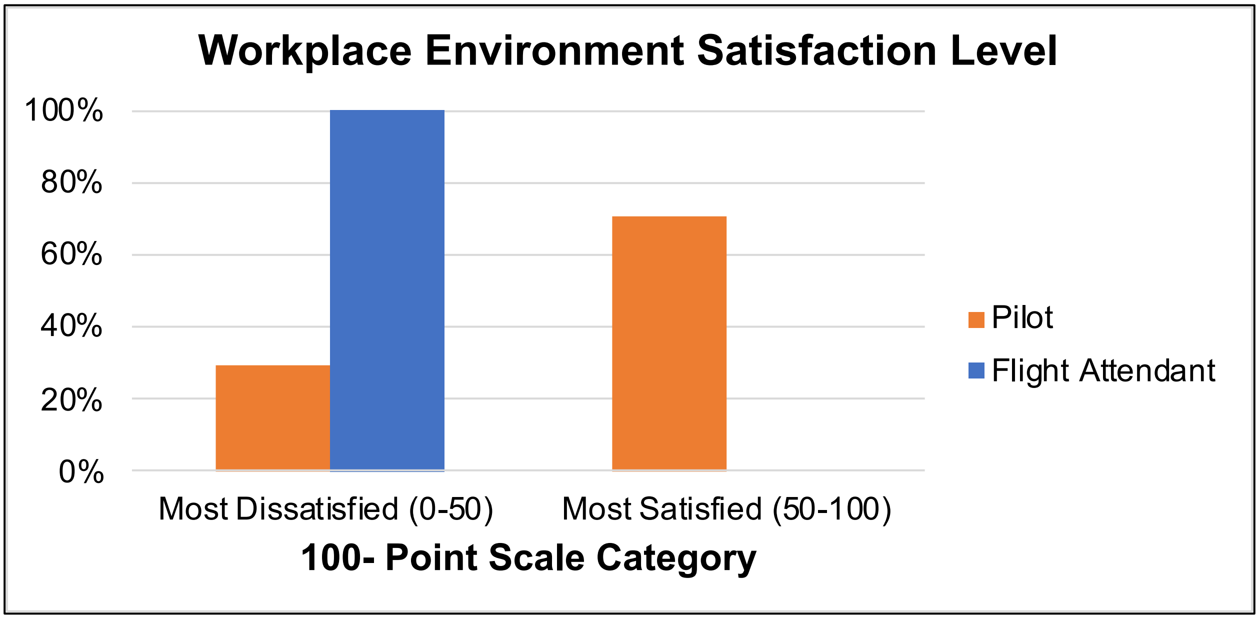
(n=36)

The bar graph (Figure 8) presents survey participants' satisfaction level with the current workplace environment. The participants were required to use the VAS psychometric scale (0-100 numeric rating scale) to respond. The adjective was placed over the numeric rating scale, with the words "most dissatisfied" (0-50 rating) appearing on the far left and "most satisfied" (50-100 rating) on the right.

All the flight attendants' population responded "most dissatisfied," whereas 70% of the pilot population responded "most satisfied" with the current workplace environment. Analysis using a t-test presented a statistically significant difference (T_{34}= 2.0322, $p>0.05$) between the group mean of the pilot population (M=61.6, SD= 29.3) and the group mean of flight attendant population (M= 32.1, SD=18.6).

Figure 1702

Participant's satisfaction level with workplace environment



Safety Culture

(n=35)

Participants' responses to safety culture practices at their airlines are presented in Table 6. The participants were required to answer 6 questions using a five-level Likert- scale ranging from "Level 1 = Strongly Agree" to "Level 5= Strongly Disagree."

The responses of pilots and flight attendants to most questions were similar, i.e., they strongly agree with various safety culture practices at their airline. However, for Question 4, the flight attendants and pilots responded with different experiences. Analysis using the Chi-square test presented a result of $\chi^2 = 0.069550$, $p>0.05$, which presented a statistically significant difference between the response frequencies.

Table 6

Participant responses to safety culture practices at their airline

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	χ^2 Test
New recruitment (crew) quickly learn that they are expected to follow practices	43%	37%	6%	9%	6%	χ^2 (4, *N=35*) = *0.0262, p<0.05*
There are no significant compromises or shortcuts taken when worker safety is at stake	23%	43%	20%	9%	6%	χ^2 (4, *N=35*) = *0.000497, p<0.05*
Where I work, crew and line managers or top management work together to ensure the safest possible working condition	26%	37%	11%	9%	17%	χ^2 (4, *N=35*) = *0.009118, p<0.05*
Crew Members are addressed when they do not follow good safety practices without any punitive actions	20%	40%	6%	17%	17%	χ^2 (4, *N=35*) = ***0.069550,*** *p>0.05*
The safety of crew members is a priority to management	17%	43%	14%	20%	6%	χ^2 (4, *N=35*) = *0.009118, p<0.05*
I feel free to report safety related violations/errors where I work	29%	40%	3%	23%	6%	χ^2 (4, *N=35*) = *0.009118, p<0.05*

Airline's Safety Practices

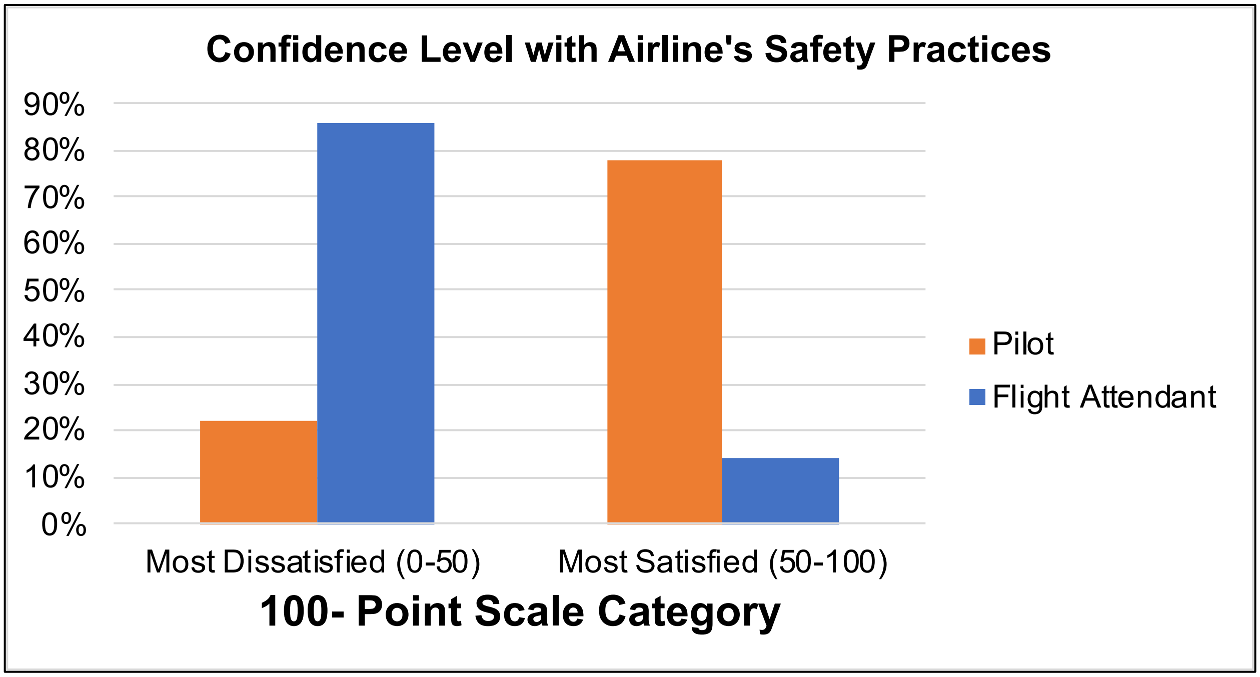
(n=34)

The bar graph (Figure 9) presents survey participants' confidence level to their airline safety practices. The participants were required to use the VAS psychometric scale (0-100 numeric rating scale) to respond.

The majority of the flight attendants' population (86%) responded "most dissatisfied," whereas 78% of the pilot population responded "most satisfied" with the current workplace environment. Analysis using a t-test presented a statistically significant difference (T_{32}= 2.0369, *p> 0.05*) between the group mean of the pilots' population (*M=68.7, SD= 22.4*) and the group mean of flight attendants' population (*M= 37.3, SD=14.2*).

Figure 1945

Participant confidence level to their airline safety practices



Airline training for ULH operation

Survey questions 11 to 15 focused on gathering data relevant to the participant's airline's training programs and current operational procedures relative to ULH flights.

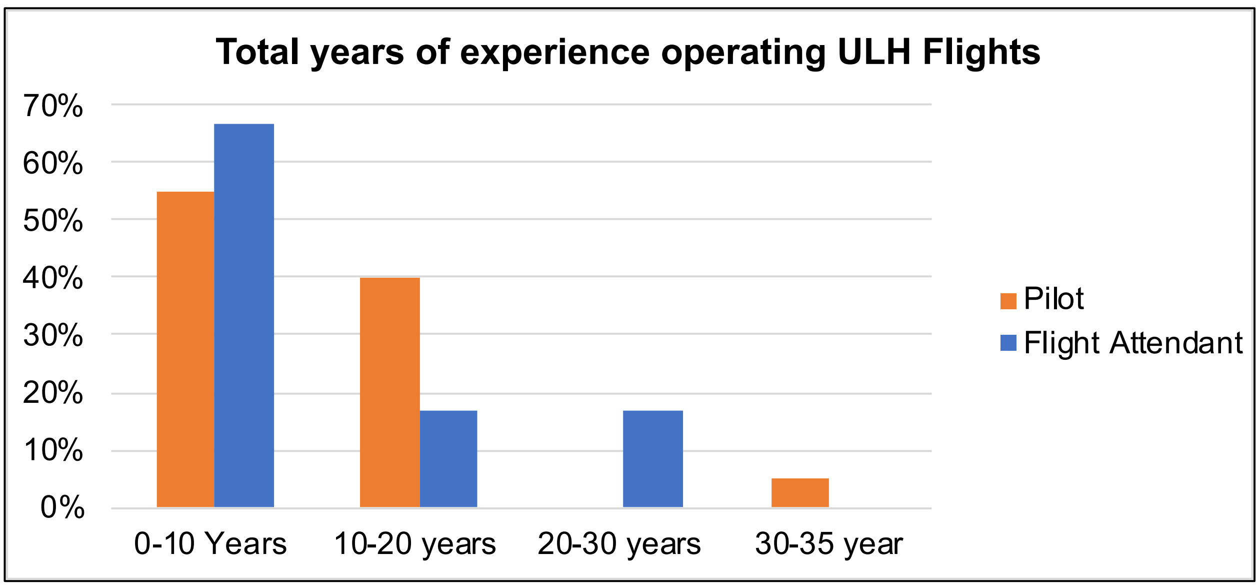
Years of Experience operating ULH Flights

(n=26)

The bar graph (Figure 10) presents the sub-categorical breakdown of the participants' years of experience operating ULH flights. The participants' years of experience range from 1 to 34 years *(M=9.8, SD= 8.18).* Most of the pilot and flight attendant population experience was ≤ 20 years. Only 17% of the flight attendant fell into the experience category between 20-30 years, and 5% of pilots fell into the experience category between 30-35 years.

Figure 2188

Participant years of experience operating ULH flight



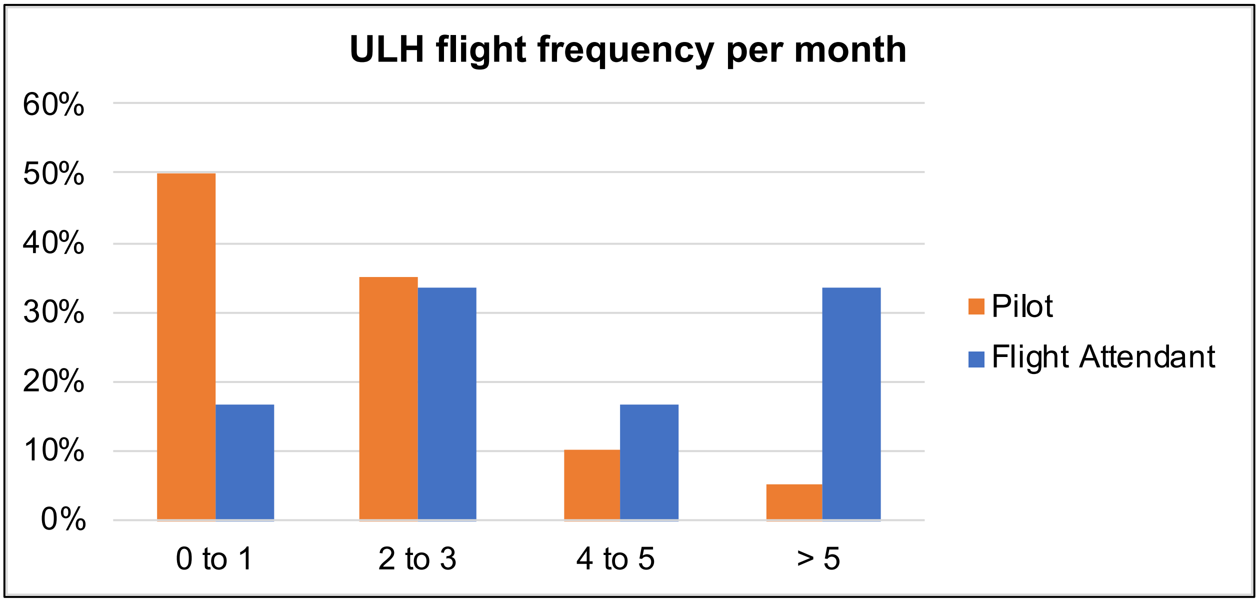
ULH flight Frequency per month

(n=26)

The bar graph (Figure 11) presents the sub-categorical breakdown of the participants' ULH flight frequency per month. The participants' flight frequency ranged from 1 to 7 flights per month *(M= 2.3, SD= 1.8).* About half of the pilot population operates 0 to 1 ULH flight per month. In comparison, 33% of the flight attendant population operates 2 to 3 and > 5 ULH flights per month.

Figure 2431

Participant ULH flight frequency per month



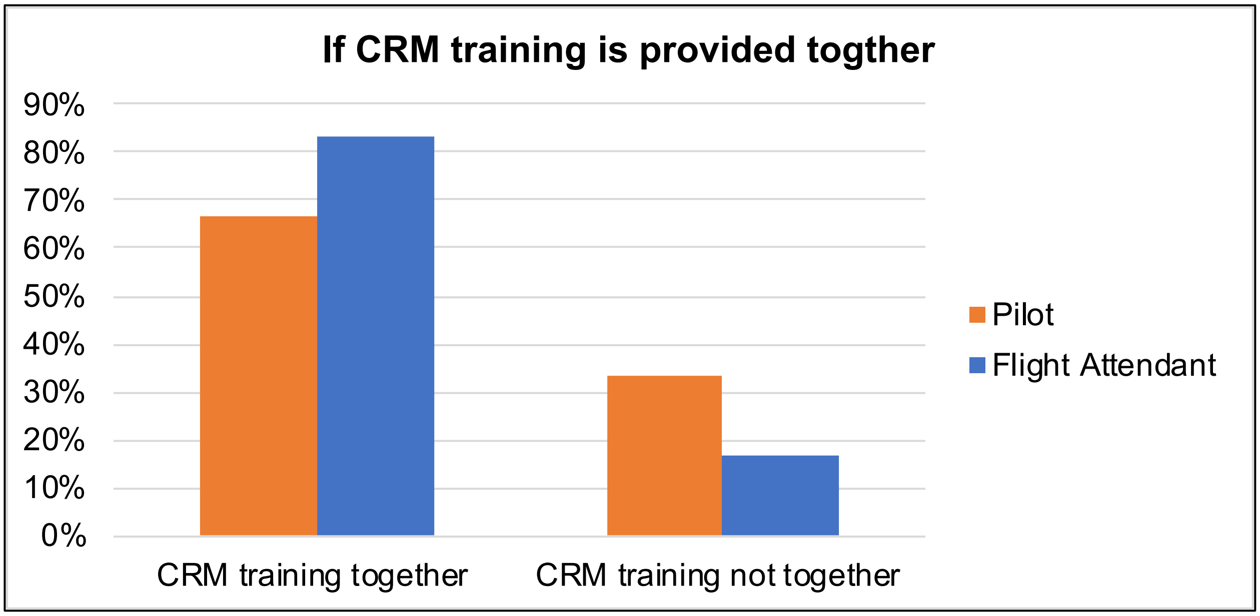
CRM Training

(n=27)

The bar graph (Figure 12) presents participants responses on whether the CRM training is inclusive, in which both flight attendants and pilots' groups are trained together. The majority of the pilot, 67%, and flight attendants, 87%, stated that their airline provided CRM training together. The question also provided an open-ended response option, allowing the participants to provide other information. Subsequently, 2 pilots stated that though the CRM training is provided together, it is conducted out of formality and not conducted yearly.

Figure 2673

Participant responses to CRM training



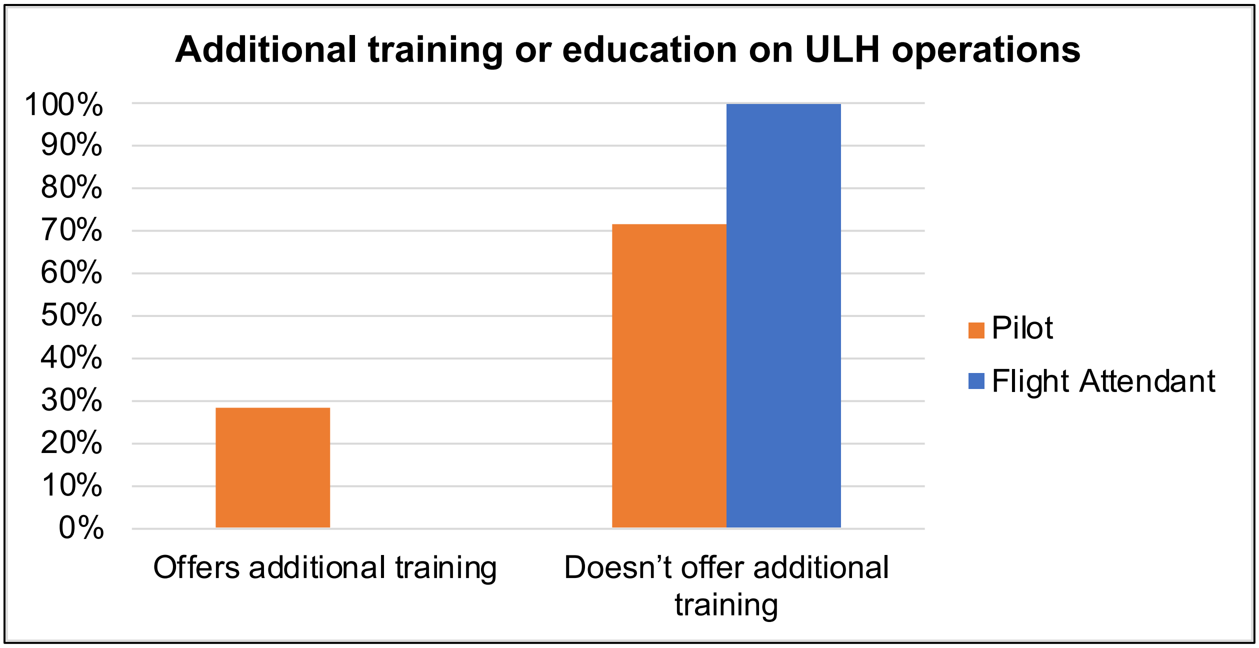
Additional Training on ULH operation

(n=27)

The bar graph (Figure 13) presents responses on if the participant's airline provides any additional training on the unique nature of ULH operation. The majority of the pilot, 71%, and almost all the flight attendants stated that their airline does not offer any additional training or educational session except what the regulation requires.

Figure 2905

Participant responses to additional training on ULH operation



Operational and Safety Procedures for ULH operation

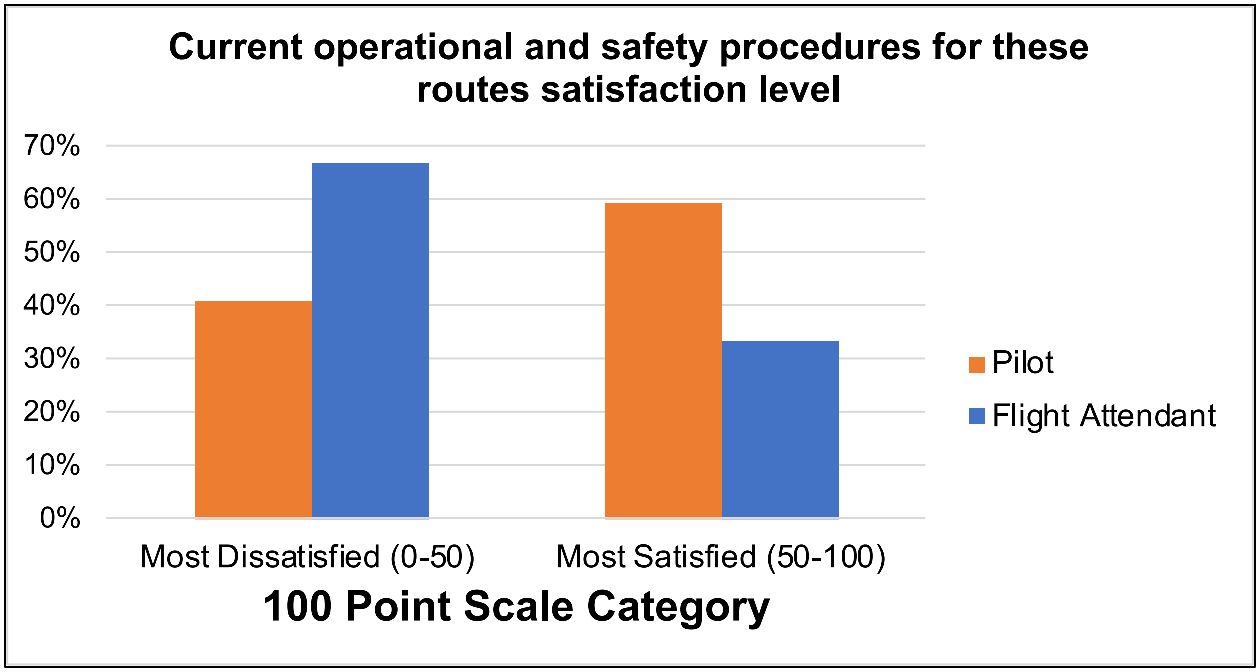
(n=27)

The bar graph (Figure 14) presents participants' satisfaction level with their airlines' current operational and safety procedures for ULH routes. The participants were required to use the VAS psychometric scale (0-100 numeric rating scale) to respond.

More than half of the flight attendants' population, 67%, responded "most dissatisfied," whereas 59% of the pilot population responded "most satisfied" with the current operational and safety procedures for ULH routes adopted by their airlines. Analysis using a t-test presented no statistically significant difference (T_{25}= 2.0595, *p<0.05*) between the group mean of the pilots' population (*M=57.2, SD= 25.6*) and the group mean of flight attendants' population (*M= 35, SD=25.9*).

Figure 3097

Participant satisfaction level on current operational safety procedure for ULH operation



Cabin environment in ULH flights

Survey Questions 16 to 20 focused on gathering data relevant to participants' experience with the cabin environment and its impacts on health, safety, and performance.

Rest Period Pattern on ULH flight

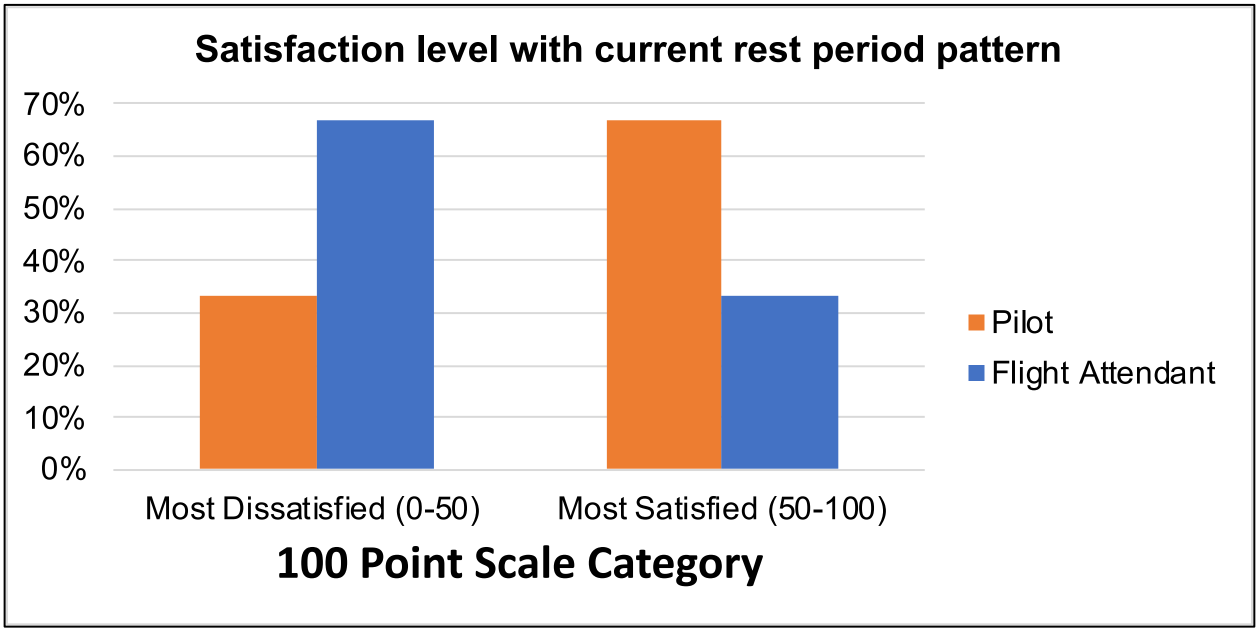
(n=27)

The bar graph (Figure 15) presents participants' satisfaction level with their airline's scheduled in-flight rest period pattern. The participants were required to use the VAS psychometric scale (0-100 numeric rating scale) to respond.

Approximately 67% of the flight attendants' population responded "most dissatisfied," whereas 67% of the pilot population responded "most satisfied" with the airline's rest period pattern for ULH routes. Analysis using a t-test presented statistically significant difference (T_{25}= 2.0595, *p>0.05*) between the group mean of the pilots' population (*M=63.6, SD= 28.2*) and the group mean of flight attendants' population (*M= 26.7, SD=23.4*).

Figure 3209

Participant satisfaction level with scheduled in-flight rest period pattern on ULH flight



Cabin Environment Factors

(n=27)

Participants' responses to the cabin environment and various impact factors are presented in Table 7. The participants were required to answer their experience using a five-level Likert- scale ranging from "Level 1 = Strongly Agree" to "Level 5= Strongly Disagree".

The responses of pilots and flight attendants to the first 3 impact factors differed. In comparison, most of the pilot population "Strongly Agree" that in-flight rest facilities, cabin air quality, and humidity and seating (jump seat) impact the aircrew while operating ULH flights. Whereas the majority of the flight attendant population responded either "Neutral" or "Disagree" with these impact factors. However, both populations responded "Strongly Agree" to the impacts of noise and vibration in ULH flight. Analysis using the Chi-square test presented a statistically significant difference between the first 3 impact factor response frequencies.

Table 7

Participant responses to cabin environment impact factors

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	χ^2 Test
In-flight rest facilities	48.1%	22.2%	14.81%	11.1%	3.7%	χ^2 (4, *N=27)* = ***0.0555***, *p>0.05*
Cabin Air Quality and Humidity	29.6%	33.3%	18.52%	14.8%	3.7%	χ^2 (4, *N=35)* = ***0.0644***, *p>0.05*
Seating (Jump Seats)	22.2%	29.63%	25.93%	18.5%	3.70%	χ^2 (4, *N=35)* = ***0.1394***, *p>0.05*
Noise and Vibration	33.3%	25.93%	18.52%	14.8%	7.41%	χ^2 (4, *N=35)* = *0.00090**,** p>0.05*

Rest Facilities and Cabin Environment Improvements

(n=27)

The participants were asked to subjectively provide three improvements concerning rest facilities and the cabin environment. The content analysis of the responses is presented in Table 8.

Table 8

Participant responses to three improvements concerning rest facilities and cabin environment

Aircrew	Improvements	
Rest Facility		
Flight Attendants	Quality of bunk mattress	50%
	Location and space for rest facility	33%
	Installation of humidifiers	17%
Pilots	Noise Reduction	50%
	Quality of bunk mattress	35%
	Installation of humidifiers	15%
Cabin Environment		
Flight Attendants	Allocated in-flight rest time	67%
	Air Quality / Installation of humidifiers	17%
	Noise Reduction	17%
Pilots	Noise Reduction	55%
	Air Quality/Installation of humidifiers	35%
	Rest area lighting control	10%

Health and Safety focused

Survey Questions 21 to 27 focused on gathering objective and subjective data relevant to participants' experience with various health and safety impact factors experienced while operating ULH flights.

Health related factors in different flight phase

(n=25)

The participants were asked to subjectively provide three health related factors that can be experienced in different phases of ULH flight. The content analysis of the responses is presented in Table 9.

Table 9

Participant responses to three health factors experienced during different flight phase

Aircrew	Health Related Factors during different flight phase	
Pre Flight		
Flight Attendants	Anxiety by in-flight sleep	40%
	Mental Fatigue	40%
	Dehydration	20%
Pilots	Sleep Loss	45%
	Improper food and nutrition consumption due to Gastrointestinal issues	30%
	Anxiety caused by in-flight sleep	25%
In-flight		
Flight Attendants	Stress caused by in-flight sleep	60%
	Dehydration	20%
	Mental Fatigue	20%
Pilots	Stress caused by in-flight sleep	40%
	DVT	35%
	Gastrointestinal issues caused by quality of meals provided	25%
Post Flight		
Flight Attendants	Chronic mental and physical fatigue	60%
	Dehydration	40%
Pilots	Circadian Dysrhythmia	45%
	Chronic mental and physical fatigue	30%
	Improper sleep recovery due to psychosocial issue (family commitments)	25%

In-flight Health Related Factors

(n=25)

Participants forced choice ranking on various in-flight health related factors are presented in bar graph (Figure 16 and 17). The participants were provided with nine in-flight health related factors.

The top three impact factors ranked by the pilot population were:

1. Dehydration
2. Improper Diet
3. Lower Backpain

Analysis using Friedman test presented a statistically significance difference (F_r= *36.33,* F_r *> 15.51 when N= 20 and* k*= 9*) between rank totals of dehydration, skin irritation, neck pain, psychosocial issues.

The top three impact factors ranked by the flight attendant population were:

1. Dehydration
2. Deep Vein Thrombosis
3. Neck Pain

Analysis using Friedman test presented no statistically significance difference (F_r*= 8.33,* F_r *< 15.51 when N= 4 and* k*= 9*) between the rank totals.

Figure 3241

Pilot responses to ranking inflight health related factors

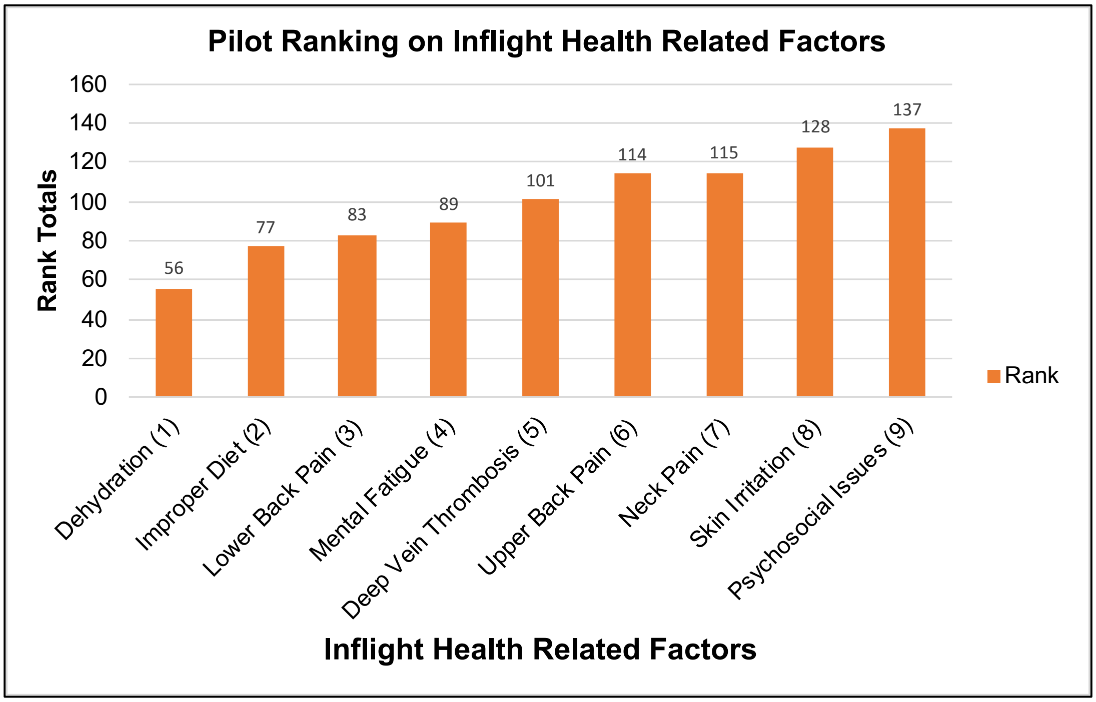
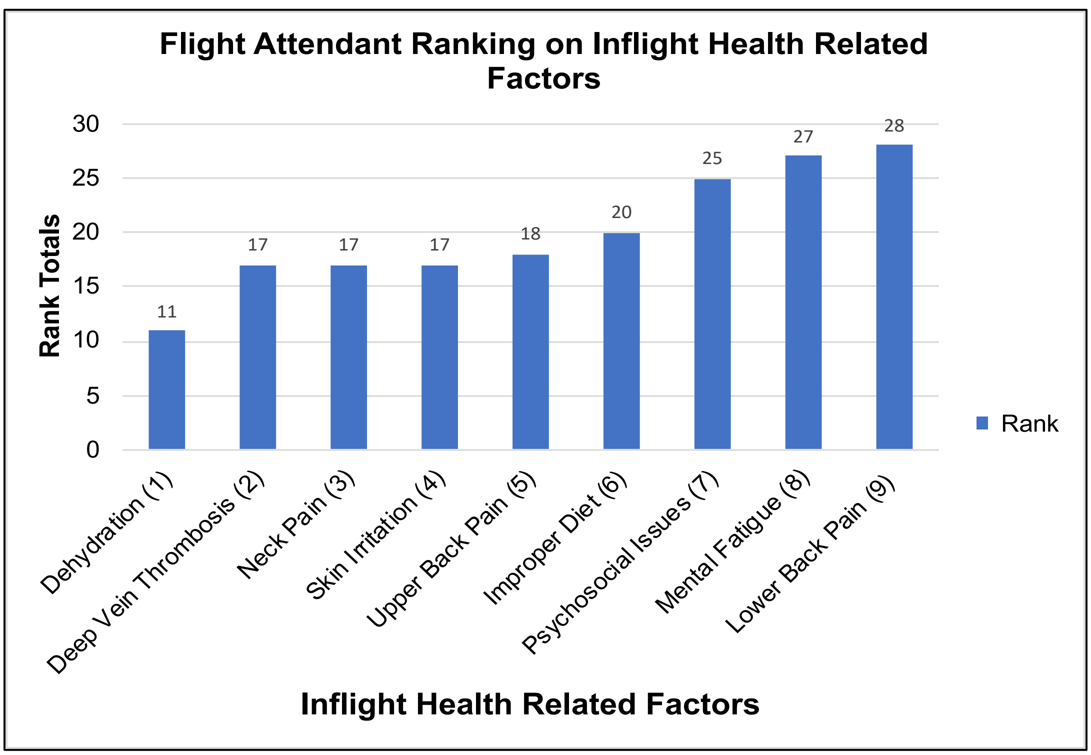


Figure 3273

Flight Attendants responses to ranking inflight health related factor



Airline Accommodation

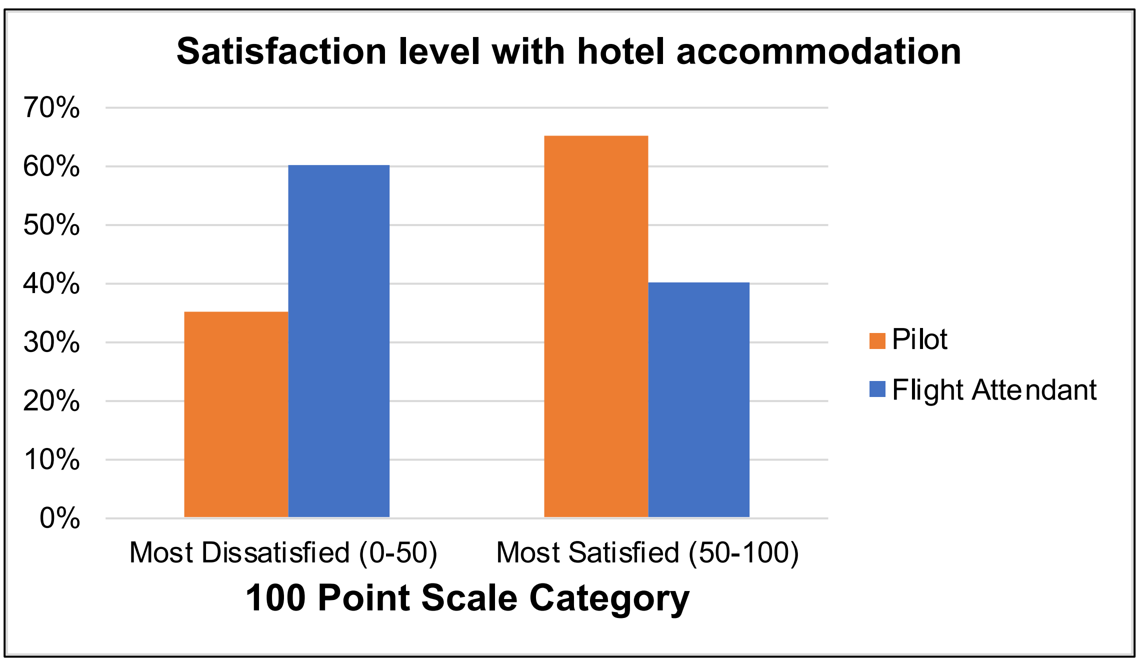
(n=25)

The bar graph (Figure 18) presents participants' satisfaction levels with airline provided accommodation (hotel) provided at the destination. The participants were required to use the VAS psychometric scale (0-100 numeric rating scale) to respond.

Approximately 60% of the flight attendants' population responded "most dissatisfied," whereas 65% of the pilot population responded "most satisfied" with the airline provided accommodation (hotel) to recover for the return flight. Analysis using a t-test presented statistically significant difference (T_{23}= 2.0687, *p>0.05*) between the group mean of the pilots' population (*M=67.2, SD= 24.3*) and the group mean of flight attendants' population (*M= 38.2, SD=24.3*).

Figure 3305

Participant satisfaction level with hotel accommodation at destination



Airline's outlook on aircrew health and safety

Survey Questions 28 to 30 focused on gaining subjective opinions/experiences from participants on their airline's approach to aircrew's health and safety practices. The purpose of gathering this data is to identify if the concept of health culture exists.

Health Culture

(n=24)

Participants' responses to the health culture are presented in Table 10. The participants were required to answer their experience using a five-level Likert- scale ranging from "Level 1 = Strongly Agree" to "Level 5= Strongly Disagree".

The responses of pilots and flight attendants for all 4 questions were consistent. By comparison, most pilot population responses were reported between "Neutral" and "Agree." In contrast, the flight attendant population either responded "Disagree" or "Neutral" to their respective airlines' different health culture practices. However, for Question 1, there was a trend (figure 19) for most of the pilot population, with 42% "Agree" In contrast, the majority of flight attendants, 60%, "Extremely Disagree" with their airline investment towards aircrew health while operating ULH flight. Analysis using the Chi-square test presented no statistically significant difference χ^2 = 0.0275, $p<0.05$, in the response frequencies.

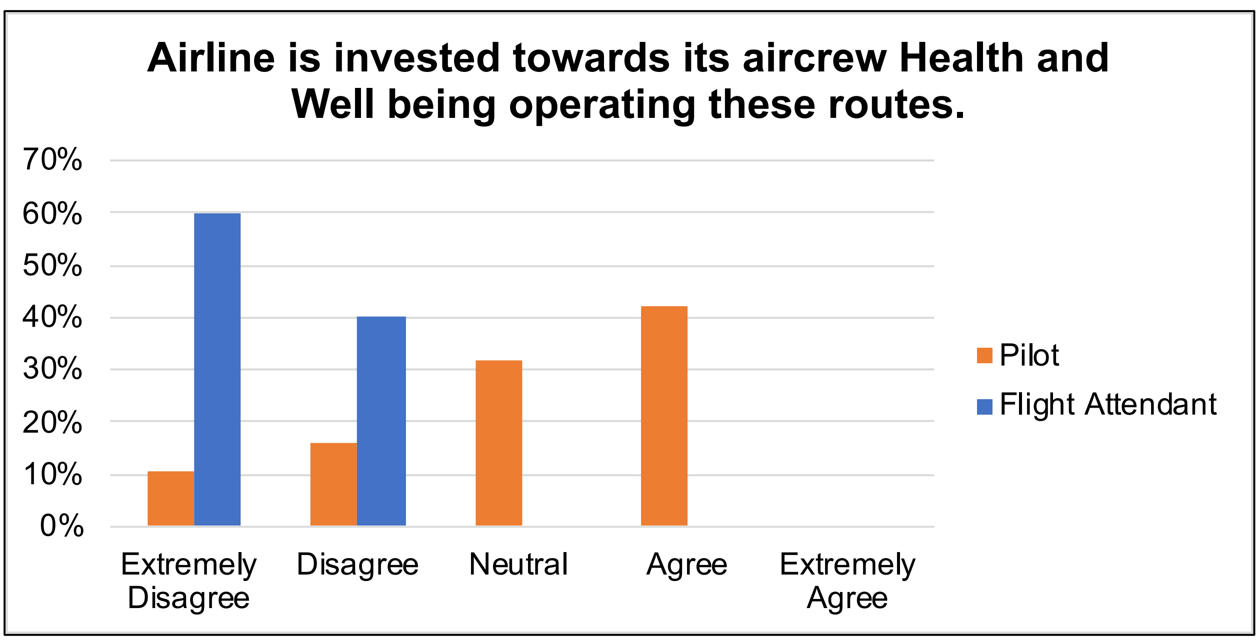
Table 10

Participant response to airlines' health culture practice

	Extremely Disagree	Disagree	Neutral	Agree	Extremely Agree	χ^2 Test
My airline is invested towards aircrew health and well-being operating these route	20.8%	20.8%	25%	33%	0%	χ^2 (4, *N=24*) = *0.0275, p<0.05*
My airline provides training and helps with different programs/resources towards well being	8.3%	29.1%	37.5%	25%	0%	χ^2 (4, *N=24*) = *0.0385, p<0.05*
My airline is proactive towards health and well-being of its crew	16.6%	20.8%	50%	12.5%	0%	χ^2 (4, *N=24*) = *0.00008, p<0.05*
I am satisfied with current health and safety practices of my airline for these routes	16.6%	29.1%	45.8%	8.3%	0%	χ^2 (4, *N=24*) = ***0.00001,** p<0.05*

Figure 3337

Participant responses to airlines' health culture practice #1



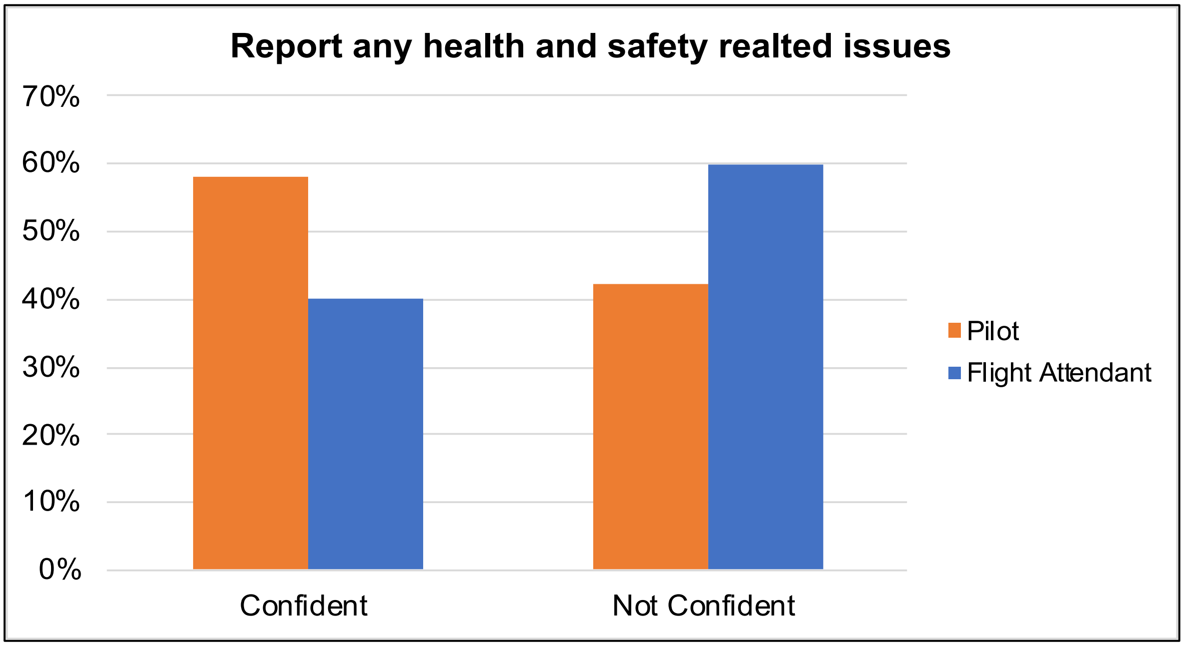
Reporting Health and Safety Related Issue

(n=24)

The bar graph (Figure 20) presents participants responses on confidence level to report any health and safety related issues. The majority of the pilot, 58% responded confident, whereas 60% of the flight attendants responded not confident to report any health and safety related issues.

Figure 3339

Participant confidence level to report any health and safety issues



Health and Safety Improvements

(n=24)

The participants were asked to subjectively provide three improvements in relation to health and safety for ULH operations. The content analysis of the responses is presented in Table 11.

Table 11

Participant response to three health and safety improvement for ULH operation

Aircrew	Improvements	
Flight Attendants	Increase rest period pre and post ULH flights	50%
	Equal in-flight rest period allocation as provided to Pilots	33%
	Better hotel accommodations and facilities	17%
Pilots	Establish regulation, policy, procedure and training material on circadian disruption and in-flight stretch time	42%
	Increase rest period pre and post ULH flights	32%
	Better hotel accommodation and facilities	26%

Discussion

The ULH flights have unlocked a new dimension to air travel for airlines, manufacturers, and aircrew. Since the commencement of the first ULH flight, these operations have presented steady growth in the past two decades. Considering the current commercial airlines' commitments to ULH operation, there is an expectation for these flights to grow substantially in the following year. In general, the issues regarding varied occupational safety and health are significantly increasing (ALPA, 2022). Therefore, the research objective of this thesis covers to probe the current health and safety standards and practices established for aircrew operation ULH operations. The research questions addressing this objective are:

1. From current studies on aircraft cabin environment and in-flight job-related health impact factors on aircrew, has the industry made improvements to mitigate adverse effects on aircrew health?
2. What are current health and safety-related prescriptive regulations, policies, and industry best practices adopted by commercial airliners operating ULH flights
3. A review of health culture and does it exist in the current aviation operational dynamic?

The 36 participants in this study shared their objective and subjective responses to survey questions targeted to find different health and safety impact factors and their airlines' operating standards and practices while conducting ULH flights. The responses also helped gain insights into participants' subjective responses to potential improvements concerning current health and safety standards for ULH operations. In general, the analyses of survey data presented significantly different response experiences between pilots and flight attendants to most questions.

The discussion is organized into four subsections drawing on the research questions and findings presented in the previous section of this thesis.

Cabin Environment and Rest Facilities

This study reports a higher prevalence of in-flight rest facilities, cabin air quality and humidity, seating, and noise and vibration impacting the pilot population (Table 7). These findings are consistent with previous studies focusing on cabin environment influences on pilots (NRC, 2002; ALPA, 2022). By contrast, the cabin environment impact factors cited by flight attendants substantially differed. The only consistent impact factor in previous studies reported was noise and vibration (NRC, 2002; Nagda and Koontz, 2003; Haines, 2006; Griffith and Powell, 2012). According to Nagda and Koontz (2003), such indication from general surveys may be instructive but should be interpreted as subjective or speculative. Since the in-flight targeted survey questions only offer insights on specific causative factors that may be related to reported outcomes.

Although the roles, responsibilities, and work environment differ between flight attendants and pilots, the cabin's internal and external environmental factors significantly impact their health and safety. Correspondingly, the subjective responses to three improvements to rest facilities and cabin environment presented (Table 8) common responses. For example, the quality of bunk mattresses and installation of humidifiers in the rest facility, and noise reduction and air quality/ installation of humidifiers in the cabin environment were among the common improvements suggested by both pilot and flight attendant. These reported impact factors are consistent with previous studies, especially air quality and its influence on aircrew (NRC, 2002; EASA, 2012). The striking differences between the subjective responses of pilots and flight attendants for rest facilities were noise reduction and location and enhanced space for rest facilities.

Most pilots also suggested improvements for current internal and external noise levels. The U.S. Government Accountability Office (GAO) (2017) reported a study on pilot and flight attendant exposure to noise aboard aircraft. The study conducted a meta-analysis of 10 studies that measured noise levels in aircraft published between 1994 and 2012. The analysis of this study found that the aircrew can experience high levels of sustained noise. However, the report concluded that the ambient noise levels "likely" do not exceed OSHA standards (GAO,2017).

On the contrary, 33% of flight attendants reported improvements required to the location and space for the rest facility. The current generation of ULH aircraft has separate rest areas variable to airlines' configuration demand and choices (Hardiman, 2021). Table 12 presents the different rest area locations in current generation ULH aircraft.

Table 12

Rest area location in current generation ULH aircraft

Aircraft Type	Rest Area Location
Airbus	
A350	Flight Attendant: The rest area is above the economy cabin's rear.
	Pilot: The rest area is in front of the plane, near the first-class cabin.
Boeing	
B777/787	Flight Attendant: The rest area is located at the very rear, near the economy class cabin.
	Pilot: The rest area is above the business class cabin in front of the plane.

Current Cabin Environment and Rest Facility Regulation

Over the past three decades, aviation industry regulators and stakeholders have extensively studied the cabin environment and its influences on aircrew. The regulatory requirements for in-flight rest facilities have significantly evolved with the aircraft's capabilities to travel longer routes. In the current regulatory structure, FAA, UK CAA, and EASA have similar aircraft and operation certifications for cabin environments and rest facilities to mitigate the adverse effects on aircrew health. These have been adopted and are consistent with ICAO Annex 6 standards and recommended practices (SARPs) (ICAO,2018). However, the difference remains in the current efforts that both regulators are involved in finding the regulatory solution and best standard operating practices concerning aircraft cabin air quality. Table 13 highlights FAA regulations requirements for cabin environment and rest facility for ULH flights.

Table 13

Current FAA regulation concerning Cabin Environment and Rest Facility

Scope	Regulation	
	Aircraft Airworthiness	**Commercial Operation**
	Cabin Environment	
Ventilation, Heating, and Air Quality	14 CFR Part 25 Subpart D • FAR 25.831 - Ventilation • FAR 25.832 - Cabin Ozone Concentration • FAR 25.841 - Pressurized Cabins • FAR 25.843 - Tests for Pressurized Cabins	14 CFR Part 121 Subpart J • FAR 121.219 - Ventilation 14 CFR Part 121 Subpart T • FAR 121.578 - Cabin Ozone Concentration AC 120-38 - Transport Category Airplanes Cabin Ozone Concentration
Noise	14 CFR Part 36 – Noise Standards Aircraft Type and Airworthiness Certification	-
	Rest Facility	
Rest Facility	Society of Automotive Engineers (SAE) Aerospace Recommend Practice (ARP) 4101/3A – Recommends criteria for designing and installing flight crew facilities on commercial transport category aircraft with the augmented flight crew.	14 CFR Part 117 – Flight and Duty Limitations and Rest Requirements: Flight Crew Members AC 117-1 Flight Crew Member Rest Facilities AC 121-31 - Flight Crew Sleeping Quarters and Rest Facilities
Classes of Rest Facility	• Class 1: Configuration of bunk or other surface, which allows for a flat sleeping position. The location of the rest facility should be separate from the flight deck and passenger cabin in a temperature-controlled area, allowing the flight crew member to control light, and providing isolation from noise and disturbance. • Class 2: Configuration of seat that allows for a flap or near flat sleeping position. It is separated from passengers by a minimum of a curtain to provide darkness and some sound mitigation; and is reasonably free from disturbance by passengers or flight crew members. • Class 3: Configuration of a seat in an aircraft cabin or flight deck that reclines at least 40 degrees and provides leg and foot support.	

Note: The regulation referenced in the table above provides operation, health, and safety regulatory guidelines for pilots and flight attendants. However, not all the regulations apply to ULH operations. Most of these regulations also apply to other commercial operations, i.e., short-haul and long-haul flight operations.

In addition to the above-stated prescriptive regulations concerning the cabin environment, the FAA and EASA have established independent informational websites on the cabin environment and its effects. This website provides guidance, studies, and research on health and safety medical topics, which include cabin air quality educational material, bleed air, radiation exposure and its effects, and noise and its impact (FAA, 2022; EASA, 2022). Concurrently, since 1985 the FAA, EASA, and industry experts have invested substantial resources to conduct several studies that help indicate the air quality of transport airline cabins. However, most of these studies have reported significantly lower potential health-related risks to human exposure to bleed air – contaminants (FAA, 2015; EASA, 2016). In 2017, EASA commissioned a larger-scale study focusing on primary oil contamination. This study aims to bridge the gap to enable advancement in the investigation of the exposure levels of the quality of air onboard commercial aircraft and its potential health impacts on crew and passengers (EASA, 2022). Whereas, as a part of the FAA reauthorization act of 2018, the FAA commissioned a study to help identify and develop techniques to monitor cabin bleed-air quality in transport airplane categories (FAA, 2020). The anticipated completion date for both studies is in the year 2023.

The SAE ARP 4101/3A is the most recent revision to the guidelines concerning rest facilities established for regulators (both FAA and EASA). These guidelines clearly state the requirements to make the rest facility conducive to recuperative sleep in an unnatural environment, i.e., an aircraft flight deck (IFALPA,2019). These require the crew rest facility should have:

- **Lighting:** A controllable (dimmable) general lighting and further provision to be made to limit light spill between resting seats and sleeping surfaces. The resting seat should also provide a controllable (direction, focus, and intensity) reading light.
- **Noise:** The background or ambient noise should not exceed 65dB(A). Sources of transient and percussive noise such as doors, stowage, bins, galleys, and stowage should not produce sound levels within the rest facility that exceeds more than 3dB(A).
- **Vibration:** The motion sickness generating potential areas of rest facilities should be assessed with particular regard to low-frequency z-axis oscillations in the range 0.1Hz to 0.63Hz.
- **Microclimate:** Air flow volume of 0.3 cubic meters per minute and occupants should be provided. The airflow should be draft free. The temperature should be within the range of 18°-23° C.

In-flight Job Related

Consistent with previous studies, this study also reports significantly different responses from flight attendants and pilots to various in-flight job-related impact factors (T Brown et al., 2001; Nagda and Koontz, 2003; Hains, 2006; Griffith and Powell, 2012; Van Dan Berg et al., 2015; Grout and Leggat, 2021). Counterintuitively this is mainly due to the different sets of job requirements and regulations governing the roles and responsibilities of both cohorts (Flight Safety Foundation, 2005). Therefore, for consistency, the in-flight job-related impact factors have been discussed separately for both groups in the following subsection.

Flight Attendant Experience on ULH Flight

The flight attendants made up 25% of the total participants for this study. Most of the flight attendant experience operating ULH flights was ≤ 20 years (Figure 7). In comparison to the pilots, the data presented that flight attendants of this study tend to work a higher frequency of ULH flights per month (Figure 11). The objective measures targeted to gather ULH operational insight suggested that almost all the flight attendants stated that their airline does not offer any additional ULH flight training or education guidance (Figure 13) except regulatorily prescribed training. Correspondingly, 67% of flight attendants shared dissatisfaction with the current operational and safety procedures (Figure 14) for these ULH routes.

This study found various types of subjective health effects experienced by flight attendants correlated with different phases of ULH flights (Table 9). The types of factors reported by flight attendants include anxiety, mental fatigue, dehydration, stress caused by in-flight sleep, and chronic mental and physical fatigue. Concurrently, the objective measure for in-flight-related factors from a force choice option (Figure 17) identified dehydration, deep vein thrombosis (DVT), and neck pain as the top three health factors impacting flight attendants in ULH flights. These findings are consistent with previous studies that reviewed different impact factors concerning ULH flight (Gander et al., 1993; Flight Safety Foundation, 2005; Hains, 2006; FAA, 2007; House of Lords, 2007; Griffith and Powell, 2012).

Dehydration

The subjective and objective measures concerning health factors for this study revealed dehydration as the most cited health factor by flight attendant participants. Dehydration presents severe medical risks such as kidney stones, heat stress, exhaustion, and stroke. However, dehydration is reported to be an underrated factor and is usually interpreted as another stress factor in performing aircrew jobs (Flight Safety Foundation, 2001). Correspondingly, most current studies have focused on dehydration's impact on the pilot. Few studies have focused on dehydration and its effects on the flight attendant. More specifically, dehydration is only evaluated as an associated factor of DVT and fatigue in flight attendants (Hains, 2006).

DVT

Physiological factors cited by flight attendants as possible causes of such problems were neck pain and DVT. The potential causal agents for DVT that can be interpreted from the survey data and previous studies are inadequate galley area space and rest facility, dehydration, and seat pitch configuration (Nagda and Koontz, 2003; Hains, 2006; House of Lords, 2007). The DVT has been linked with air travel since the 1950s. The archival document and current literature (House of Lords, 2007; Adi et al., 2015) presented that, in general, air travel increases the risk of DVT through:

- Release of nitric oxide into the aircraft cabin and decrease air pressure.
- Low humidity in the cabin and caffeine intake results in dehydration which is one of the leading causal factors of DVT.
- Prolonged sitting on flights causes pressure on the calves, which disrupts the blow flow in veins.

A study by Schwartz (2003) found a causal relationship between flights of eight hours or more and a substantial risk of DVT in cabin occupants. The study compared a control group with another group of people who traveled on a flight lasting eight hours or more. The study found that in the group that traveled on the flight, 2.1% were diagnosed with isolated calf muscle venous thrombosis (ICMVT, a percussor of DVT), compared to 0.8% in the control group. The study also found that the participants who developed DVT had other risk factors such as high body mass index or being of an older age group. This relation is consistent with the flight attendant survey participants of this study in which 56% fell in the age group of 40-50 years (Figure 6).

Musculoskeletal Discomfort

Musculoskeletal discomfort, such as neck pain, is highly associated with the flight attendant occupation (Chen et al., 2021). Studies have identified that although flight attendants can relieve fatigue and jetlag during flights by in-flight rest facility provision, they are forced to maintain poor postures in confined cabins and rest areas, significantly increasing musculoskeletal pain and discomfort (Parr, 2012). Survey research of flight attendants conducted by Saudi Airlines identified neck pain as a chronic health problem among flight attendants. The analysis of this research further identified a positive correlation between occupation and neck pain (Ezzat et al., 2015). Similarly, an earlier study investigated various musculoskeletal symptoms of flight attendants operating long-haul flights. The result presented lower back and neck pain as the most severe symptoms (Lee et al., 2006).

Fatigue and inflight rest period

One of the interesting findings in the survey data of this study was flight attendants' dissatisfaction with current in-flight rest period patterns offered by their airlines' on ULH flights. This response is correlated with their subjective responses to health factors during different phases of flight (Table 9). For example, 40% of flight attendant participants in this study reported they experienced anxiety caused by the pressure of in-flight sleep during the pre-flight phase. Correspondingly, 60% of the population reported stress caused by in-flight sleep during the in-flight phase. The subjective data suggested the primary cause of this psychological distress was due to the current allocated in-flight rest time to flight attendants. Although sleep physiology is similar for pilots and flight attendants, there remains an underlying difference in stress levels, work environments, and required levels of alertness between both groups. Thus, the current in-flight rest pattern for ULH flights significantly differs between pilots and flight attendants (Flight Safety Foundation, 2005). These in-flight rest patterns are prescribed by airlines using the FRMS methodology and can substantially differ from one commercial operator to another (Signal et al., 2014). However, most airlines have adopted rest schedules for flight attendants suggested by the FSF ULR crew alertness steering committee (Flight Safety Foundation, 2005):

> "A cabin crew typically is divided into group A and group B, each with a designated crewmember-in-charge (CIC) so that whenever the primary CIC is resting, the standby CIC is on duty. The patterns are planned so that, at all times, have at least one group on duty, and during the peak times of major meal services – as well as during takeoff and landing- both groups are on duty. In

single- rest pattern, group A goes on rest for four or five hours, depending on the flight sector, as group B goes on duty; then, with a 15-minute overlap and information handover, group A goes back on duty as group B goes on rest. Alternatives for some flights can include a split-rest pattern (3-2-2-3) and mixed-rest- pattern (3-5-2)."

In retrospect, the split or mixed rest pattern was successful for Singapore flight attendants that conducted the first ULH flights between Singapore and New York in 2004 (Flight Safety Foundation,2005). However, this study's participants presented dissatisfaction, and 33% suggested that the current in-flight rest period should equal what is provided to pilots. In addition, 50% of the participants indicated a requirement for an increased pre- and post-ULH flight rest period, which could help mitigate the flight's cumulative physiological and psychological effects.

The most common and consistently reported physiological and psychological impact factor by the flight attendants of this study was fatigue. Fatigue and its cumulative insidious effects on the crew have been cited in aviation since 1953 (Lindberg, 1953; Orlady, 1996; Wingelaar-Jagt, 2021). Substantial progress has been made in understanding fatigue and its contributing impact, such as job strain, extended duty periods, disrupted schedules, irregular hours of work, circadian rhythm disruption, workload, time zone differences, and layover duration. However, most archival and current studies on fatigue are pilot centric. This is evident in the ICAO FRMS SARPs (ICAO,2015), which clearly state that:

"The ICAO SARPs apply to both flight and cabin crew. However, to date, flight crew fatigue has received much more scientific, operational, and regulatory

> attention than cabin crew fatigue, so the examples in this manual focus on flight crew. The safety risks associated with fatigue-related impairment are different for flight and cabin crew members, and some mitigation strategies may be different. More specific advice on managing cabin crew fatigue will become possible as research and fatigue management experience with cabin crew increases".

In the case of ULH operations, the literature on flight attendant fatigue associated with ULH flights is sparse (Van Dan Berg et al., 2015). For example, current ULH scheduling and FRMS methodology and procedure for flight attendants are predominantly based on pilot data. The three health and safety-related improvements reported by participants of this study were relative to equal rest periods to pilot and increasing the rest periods for different phases of flight which directly contribute to fatigue. These responses were consistent with the field study conducted by Massey University (2015), which reported that despite the operational difference, the influence of fatigue on flight attendants is no different from what is experienced by pilots. The current rest periods are significantly less in comparison to pilots. Since all the flight attendants are required to be awake for meal services, takeoff, and landing, they have comparatively less time available for in-flight rest (Van Dan Berg et al., 2015; 2020).

Lastly, the data of this study also highlighted hotel accommodation as a causal agent of flight attendant fatigue. This was in reference to flight attendants' dissatisfaction with the hotel accommodation provided by the airline in the foreign destination to recover for the return flight (Figure 18). The participants' subjective responses suggested that the current airline offered hotel accommodation and its facilities and services contribute to sleep loss and improper recovery, eventually cumulating the effects of fatigue (Table 11).

Pilot Experience on ULH Flight

The majority of the participants of this study were pilots. Most of the pilot's experience operating ULH flights was ≤ 20 years (Figure 10). In comparison to the flight attendants' frequencies (2 to 3 and > 5), the data presented that most pilots operated between 0 to 3 frequencies of ULH flights per month (Figure 11). The objective measures targeted to gather ULH operational insight suggested that almost all the pilot participants' airlines did not offer any additional ULH flight training or education guidance (Figure 13) except regulatorily prescribed training. Concurrently, more than half of the pilot population shared satisfaction with the current operational and safety procedures for these ULH routes (Figure 14).

This study found various types of health effects experienced by pilots associated with different phases of ULH flight (Table 9). The variety of factors reported by pilots includes sleep loss, improper food and nutrition consumption, anxiety and stress caused by in-flight sleep, DVT, circadian dysrhythmia, and improper recovery due to psychosocial issues. Subsequently, the objective measures for in-flight-related factors from a force choice option (Figure 16) identified dehydration, improper diet, and lower back pain as the top three health factors impacting pilots in ULH flights. In a broad sense, these reported health issues can be categorized into four main health effects: improper food and nutrition consumption, fatigue experienced in different phases of flight, post-flight recovery and psychological effects, and musculoskeletal issues. These findings have been consistent with previous ULH flight studies on pilot health and impact factors (Flight Safety Foundation, 2005; Caldwell et al., 2006; Albermann, 2020; Signal et al., 2013; Williamson and Friswell, 2013; Demerouti et al., 2019; ALPA, 2022).

Dehydration and Nutrition

Similar to flight attendants, the pilot participants of this study also ranked dehydration as a top in-flight health factor experienced in ULH flights (Figure 16). However, in supplement to dehydration, the pilots also cited improper food and nutrition consumption due to gastrointestinal issues encountered in the preflight and in-flight phases of ULH flight. This factor was also ranked as the second in-flight health factor experienced in ULH flights. In a recent review of pilots' occupational health and safety protections, ALPA recognized that the safety of food served onboard to pilots on commercial aircraft poses a health and safety issue. This was identified based on numerous pilot reports to NASA's Aviation Safety Reporting System (ASRS) concerning in-flight incapacitation from crew meals (ALPA, 2021). The study recommended FAA, EPA, and FDA, in a coordinated effort, should develop a public website that publishes the findings of the U.S. government's ongoing food and potable water safety audits and inspections for all FAR part 121 airlines and all cargo operations.

Fatigue and In-flight sleep

In juxtaposition with previous studies, 40% of the pilots reported that they experienced stress caused by in-flight sleep and, in most cases, lapses in in-flight sleep (Table 9). Extended pilot flight duty periods, insufficient onboard rest, and short recovery times significantly cause a cumulative effect of fatigue on pilots (Williamson and Friswell, 2013; Bendak and Rashid, 2020). The pilot operational duty time approaches 20 hours during many ULH operations, which makes circadian dysrhythmia and extended wakefulness unavoidable. The conventional approach to managing fatigue accumulated by this duty time is to increase the duration of time flight crew members have available for sleep in the aircraft crew rest area (Flight Safety Foundation, 2005). However, sleep studies conducted during ULH flights presented that providing extended or more frequent bunk sleep opportunities during flight does not guarantee an increase in sleep duration (Ho et al., 2005). For example, in a study conducted by Massey University (year), each flight crew on an outbound ULH flight was allocated seven hours of crew rest period in the aircraft bunk. The flight crew bunk sleep was assessed using electroencephalographic (EEG) and presented sleep times average of only 3.27 hours (Signal et al., 2005). Thus, the results show that flight crew sleeps less than 50% of the time during scheduled rest periods, which is equivalent to a long nap more so than a consolidated daily sleep period. This reduction of sleep significantly increases sleep debt, especially when crossing multiple time zones.

In addition to the distress experienced because of sleep, the subjective experiences of the pilot population of this study also suggested they experienced sleep loss in the pre-flight phase and improper recovery post-flight due to psychosocial issues. In the case of pre-flight sleep loss, 45% of the participants indicated the sleep loss was correlated to the ULH flight schedule and uncertainty of which pattern to expect for in-flight sleep. A study commissioned by NASA Ames Research Centre (2005) identified the effects of fatigue on pilots flying different flight schedules. This simulator-based study, in which 20 pilot participants were assessed, used various subjective, cognitive, physiological, operational, and behavioral tools to measure participants' simulator ULH flight day, and after recovery sleep. These participants were divided into two departure groups, AM and PM, and subsequent analysis was conducted on fatigue, alertness, and recovery sleep levels. The findings suggested fatigue caused by prolonged pilot wakefulness strongly correlates with the specific flight schedules operated. This was due to the combination of circadian and homeostatic factors. Pilots departing at night after being awake since the previous morning are at a significant disadvantage than to pilots who depart in the morning. However, the study also noted that the pilots scheduled for the morning shortly after being awakened could experience progressive deteriorations in levels of alertness and fatigue (Caldwell et al., 2006).

Fatigue and Post-flight phase

In the post-flight phase, the subjective measure suggested approximately 25% of the pilots reported they experienced improper sleep recovery due to psychosocial issues (family commitments) (Table 9). While some participants stated they prioritized sleep, the remainder indicated they would generally trade-off between sleep and family social responsibilities in the limited time available. Previous studies on sleep problems and their association with psychosocial factors have been conducted from a work environment context. For example, to find a relationship between sleeping problems and psychosocial work situations based on job strain, a survey study was undertaken among 350 Swedish commercial pilots. The findings suggested that the psychosocial climate at work, such as low social support, negatively affects sleep for both captains and first officers (Runeson et al., 2011). Correspondingly, other studies have investigated the sleep loss associated with pilot's work-related stress (Cahill et al., 2021; Cullen et al., 2020) or the pilot's mental health (O'Hagan et al., 2017). More recently, a study by Venus and Holtforth (2021) on duty rosters and stress related to fatigue and sleep problems of international pilots found a strong association of psychosocial stress with flight duties. The study also found a relationship between increased flight duty hours and accumulation of sleep, resulting in less leisure time for post-flight recovery and potentially enhancing psychosocial stress (Venus and Holtforth, 2021).

Musculoskeletal Discomfort

Lastly, musculoskeletal discomfort, such as lower back pain in pilots, is considered an imprecation in the pilot's profession (Albermann, 2020). The pilot participants ranked lower back pain as the third in-flight health effect experienced while operating a ULH flight. In one of the early studies, Scandinavian Airlines System, Norway researched working conditions and their influence on aircrew's health. The study identified 60% of the long-haul pilots pronounced lower back pain as a dominant problem operating the route (Haugli, 1994). Additionally, in a study to characterize lower back pain in commercial airline pilots, Rodrigues and Mayorga (2016) found the prevalence rate of lower back pain in Columbian pilot respondents was 71%. This study also suggested a strong association of chronic low back pain with the pilot’s occupational exposure to physical load and work time (Table 9 and 16).

Current Health and Safety Regulation

The findings and recommendations of the four scientific research workshops conducted by the FSF ULR crew alertness steering committee in collaboration with aviation regulators, manufacturers, and commercial operators between 2000 and 2006 helped developed the current ULH operating regulations and standard practices. However, the committee's efforts centered on the operational aspect, i.e., fatigue and its cumulative effects on pilot alertness, and consequently, the development of mathematical and scientific models for fatigue management (Flight Safety Foundation 2003). In the current regulatory structure, it was identified that no dedicated regulations addressing ULH health and safety for aircrew are established. Instead, the general aircrew operating rule prescribed for other operations, such as short-haul and long-haul flight operations, applies to ULH operations. However, there are regulatory requirements specifying no commercial operator can operate a ULH flight until an FRMS and its methodology have been adopted and ULH city pair approval is received from the operator's respective CAA (FAA, 2022; EASA, 2022). Subsequently, to manage fatigue, the regulatory authorities have established specific flight and duty limitations and rest requirements for the augmented aircrew that operate ULH flights. However, these regulations significantly differ for both groups (Van Dan Berg et al., 2015).

The FAA, UK CAA, and EASA regulations relating to ULH operations are consistent with ICAO standards and recommended practices (ICAO, 2018). More recently, two significant updates have been made to rules regulating the health and safety of both pilots and flight attendants, which are:

1. The current flight attendant rest periods are increased from 9 to 10 hours (FAA, 2022).
2. Psychological issues have gained significant attention, and following this, regulatory authorities have introduced new regulations and recommended practices on the mental fitness of pilots (EASA, 2018).

For consistency with the cabin environment and rest facility regulations section, Table 14 highlights current FAA regulations for aircrew concerning health and safety and required standard practices for ULH operations.

***Table* 14**

Current FAA regulations and advisory documents concerning aircrew health and safety for ULH operation

Aircrew	FAA Regulations and Advisory Documents
Flight and duty limitations and rest requirements for the augmented aircrew	
Pilot	14 CFR Part 117 Subpart G • FAR 117.17 - Flight Duty Period: Augmented Flight Crew • Table C to Part 118- Flight Duty Period: Augmented Operations based on rest facility and number of pilots
Flight Attendant	14 CFR Part 121 Subpart P • FAR 121.467 - Flight attendant duty period limitation and rest requirements: Domestic, flag and supplemental operations
Fatigue Related	
Pilot	14 CFR Part 117 Subpart G • FAR 117.7 - Fatigue Risk Management System 14 CFR Part 121 Subpart R • FAR 121.527 - Fatigue Risk Management System
Flight Attendant	AC 120-100 – Basics of Aviation Fatigue AC 120-103A – Fatigue Risk Management Systems for Aviation Safety
Fitness for Duty and Medical Certificate (Physiological)	
Pilot	14 CFR Part 67 Medical Standards and Certification 14 CFR Part 117 Subpart G • FAR Part 117.5 - Fitness for Duty 14 CFR Part 121 Subpart O FAR 121.434 - Operating experience, operating cycles, and consolidation of knowledge and skills.

<table>
<tr><td>Flight Attendant</td><td>InFO 08016

14 CFR Part 121 Subpart O
• FAR 121.434 - Operating experience, operating cycles, and consolidation of knowledge and skills.
Note: In most cases, the medical assessment of flight attendants' is conducted by the airline in the hiring process.</td></tr>
<tr><td colspan="2">Fitness for Duty and Medical Certificate (Psychological)</td></tr>
<tr><td>Pilot</td><td>In 2016, the Pilot Fitness Aviation Rulemaking Committee (ARC) provided several recommendations to the FAA about pilot medical fitness. The ARC was established to evaluate pilot mental health, after the German Wings 9525 accident. The FAA has acted on several of those recommendations, including:
• Expand training in mental health issues provided to Air Medical Examiners (AME) in the AME Basic and Refresher seminars. The FAA has done this.
• Encourage Pilot Peer Support programs organized by airlines and unions.</td></tr>
<tr><td>Flight Attendant</td><td>-</td></tr>
<tr><td colspan="2">Occupational Health and Safety on-board Aircraft</td></tr>
<tr><td>Pilot</td><td rowspan="2">14 CFR Part 25 Subpart D
• FAR 25.832- Cabin Ozone Concentration

14 CFR Part 121 Subpart T
• FAR 121.578- Cabin Ozone Concentration

In accordance to the 2014 Memorandum of understanding, OSHA has enforced its regulations pertaining to aircraft aircrew in 3 specific areas:
1. Hazard communication
2. Bloodborne pathogens exposure
3. Occupational noise
Note: FAA retains the authority and jurisdiction over the working condition of pilots and the flight attendants in flight deck environment.

21 CFR Food and Drugs, Part 1250 – Interstate Conveyance Subpart B, C, and D</td></tr>
<tr><td>Flight Attendant</td></tr>
<tr><td colspan="2">Training and other educational resources for ULH operation</td></tr>
</table>

Pilot	14 CFR Part 117 Subpart G • FAR 117.7- Fatigue education and awareness training program • 14 CFR 121 Subpart N Training Program • 14 CFR Appendix O to Part 121 Hazardous materials training records
Flight Attendant	Civil Aerospace Medical Institute is the medical certification, research, education, and occupational health wing of FAA's Office of Aerospace Medicine. The main aim of this institute is to research and study various factors that influence human performance in aerospace environments and find ways to comprehend, communicate, and share training guidance material with the aviation community.

Note: The regulation referenced in the table above provides operational, health, and safety regulatory guidelines for pilots and flight attendants. However, not all the regulations apply to ULH operations. Some of these regulations apply to other commercial operations, i.e., short-haul and long-haul flight operations.

Health Culture

Compared with Lamp's (2018) qualitative study to understand the notion of health culture in commercial airline pilots, 56% pilot population of this study who operate ULH operations reported they felt confident to report any health and safety-related issues to their airline. The pilots' responses to other questions targeted toward both health and safety culture practices at their airline were consistent with this. For example, 70% of pilot participant of this study were "Satisfied" with the current airline workplace environment and 78% had confident with their airline safety practices for ULH and other operations (Figure 8 and Figure 9). In regards to the subjective measure for various health culture practices of participants airlines (Table 10), pilots' responses were recorded between "Neutral" and "Agree." One reason for this difference in responses can be age. A study by O'Brien et al. (2005) identified that older male participants were more inclined to get routine checkups and seek out medical professionals if necessary. This is usually due to a "health-related scare" (O'Brien et al., 2005, pg. 510). Considering the pilot demographic, 65% (Figure 6) of the pilot participants for this ULH study ranged between 50-60 years.

On the contrary, the responses of the flight attendants to questions targeted toward health culture were significantly different from the pilot population. For all the four questions regarding the health culture practices, the data suggested the flight attendants' responses were recorded between "Extremely Disagree" and "Disagree" with their respective airline’s best practices on health and safety (Table 10). Lastly, approximately 60% of the flight attendant participants did not feel confident about reporting any health and safety-related issues to their airline (Figure 20).

Conclusion and Recommendation

There is no attribute of the airline pilots' and flight attendants' career longevity and earnings more significant than their health. The importance of the health and safety of aircrew in aviation was recognized in early 1975. The current literature on the topic suggests:

1. Most studies, including the efforts of aviation regulators, have been centered on cabin environments and their effects, such as noise, air quality, humidity, and its effects. The only in-flight job-related factor that has received much attention and has been researched extensively is fatigue and its cumulative effect.
2. Fatigue and its association with ULH operations have been mainly studied from a pilot perspective. Only sparse studies have focused on the effects of fatigue on flight attendants' operation of ULH flights.
3. The health and safety studies in aviation have been inconsistent, either focused on general flight experience or specific flight experience. Only sparse studies have focused on ULH flight impact factors on aircrew.

The study was intended to probe different health and safety standards for ULH operations and review the notion of health culture in aviation. This study also intended to identify and address gaps in the current health and safety regulatory structure that can help form a well-controlled baseline knowledge.

The result and findings of this study suggested very few specific regulations and advisory guidance concerning aircrew health and safety regulations for ULH operations have been established by the regulatory authorities. The majority of current regulations are prescribed for fatigue and its management, and only limited regulations have been established for other in-flight effects experienced by aircrew. Notably, most of these regulations are pilot-centric, and only a few specific regulations have been established for flight attendants.

The notion of health culture in aviation is still in its nascence. The survey results indicated a significant difference in pilot and flight attendant responses. The pilots felt more confident reporting any health-related issues compared to flight attendants. However, due to the small sample size of this study, presenting any conclusions on health culture would be difficult.

Future Industry Research

Given these results, in future studies the following examination should be considered:

- A large aircrew sample size study focusing on different health impacts in different flight phases experienced by aircrew operating ULH flights. However, this can only be achieved by collaboration with a commercial airline or a union representative.
- A comparative study of two or more commercial airlines' health and safety policies, procedures, and best practices to review the notion of health culture.
- The potential utility of pharmacological products to improve flight attendants' in-flight sleep.

Recommendations

As a result of this thesis examination of different health and safety impact factors and current regulatory standards for these impact factors, the author makes the following recommendations.

The aviation regulatory authorities should:

1. Enhance and improve the current regulations and advisory guidance material on occupational health and safety for aircrew operating ULH flights. These should be separate and developed with a particular reference to the unique nature of ULH flights.
2. Require commercial operators to provide additional health and safety education and training to their aircrew on the unique nature of ULH flights. The current regulations have only focused on fatigue, its causes, and management. There is a requirement to focus on other impact factors such as (but not limited to):
    - Diet and Hydration
    - Different health and safety impact factors experienced in the different phases of ULH flight
    - Musculoskeletal Disorders and in-flight stretching
    - Ergonomics
    - Psychosocial Effects and its mitigation
    - Psychological Effects and its mitigation
3. Require in-flight rest facilities and sleeping compartments provided to the pilots and flight attendants to be of equal space and size.

4. Revise current regulation concerning in-flight Class 1 rest facility. This new revision should introduce a requirement for standardized mattresses for aircrew.
5. Authorize a study on in-flight rest period scheduling for flight attendants with a particular reference to fatigue. Since current ULH rest period for flight attendants' is scheduled based on pilot fatigue data. This is mainly due to the limited knowledge of flight attendant fatigue on ULH flights.
6. Revise current ozone-related regulations and guidance material since these were implemented in 1983 and reviewed literature indicated there are gaps in the regulations (Pottinger and Marcham, 2018).

The commercial airlines should:

1. Authorize a study on the hotel accommodation satisfaction level of their ULH flight attendants since hotel accommodation plays a pivotal role in mitigating the effects of fatigue and circadian dysrhythmia.
2. Adopt a proactive approach in providing vital information and educational material to its aircrew on the health impacts experienced while operating ULH flights.
3. Establish policies and procedures on in-flight stretch time to mitigate the effects of DVT and other musculoskeletal disorders for its aircrew operating ULH.
4. Consider psychosocial factors such as family and social commitments while allocating pre- and post-flight rest periods, for aircrew.

5. Conduct a study using various subjective, cognitive, physiological, and behavioral tools to assess the health and safety impact factors experienced by aircrew in the different phases of ULH flight.

References

Adi, Y., Bayliss, S., Rouse, A., & Taylor, R. S. (2004). The association between air travel and deep vein thrombosis: systematic review & meta-analysis. *BMC cardiovascular disorders*, *4*, 7. https://doi.org/10.1186/1471-2261-4-7

Airline Pilot Association. (2022). *Enhancing Pilots Occupational Health and Safety Protection.* ALPA. Retrieved October 16, 2022, from https://www.alpa.org/-/media/ALPA/Files/pdfs/news-events/white-papers/occupational-safety-health.pdf?la=en

Airbus. (2018, February 28). *First Ultra Long Range A350 XWB makes its debut*. Airbus. Retrieved March 20, 2022, from https://www.airbus.com/en/newsroom/press-releases/2018-02-first-ultra-long-range-a350-xwb-makes-its-debut

Airbus. (2022, May 02). *Qantas confirms future Airbus Fleet.* Airbus. Retrieved October 16, 2022, from https://www.airbus.com/en/newsroom/press-releases/2022-05-qantas-confirms-future-airbus-fleet

Airbus. (2022). Commercial *Aircraft History: 1967 to today.* Airbus. Retrieved October 16, 2022, from https://www.airbus.com/en/who-we-are/our-history/commercial-aircraft-history

Airbus. (2004). *Going global (2001-2004).* Airbus. Retrieved October 16, 2022, from https://www.airbus.com/en/who-we-are/our-history/commercial-aircraft-history/going-global-2001-2004

Air New Zealand. (2022). *Air New Zealand Touches down in the Big Apple- Media Release.* Air New Zealand. https://www.airnewzealand.com/press-release-2022-air-new-zealand-touches-down-in-the-big-apple

Albermann, M., Lehmann, M., Eiche, C., Schmidt, J., & Prottengeier, J. (2020). Low Back Pain in Commercial Airline Pilots. *Aerospace medicine and human performance*, *91*(12), 940–947. https://doi.org/10.3357/AMHP.5656.2020

Avers, K., & Johnson, W. B. (2011). A review of Federal Aviation Administration fatigue research: Transitioning scientific results to the aviation industry. Aviation Psychology and Applied Human Factors, 1(2), 87–98. https://doi.org/10.1027/2192-0923/a000016

Bauer, L. B., Bloch, D., & Merkert, R. (2020). Ultra-Long-Haul: An Emerging Business Model accelerated by COVID-19. *Journal of Air Transport Management*, *89*, 101901. https://doi.org/10.1016/j.jairtraman.2020.101901

Baxter, G. S., & Bardell, N. S. (2018). Can the renewed interest in ultra-long-range passenger flights be satisfied by the current generation of civil aircraft? *Aviation*, *21*(2), 42–54. https://doi.org/10.3846/16487788.2017.1336485

Belyavin, A. J., & Spencer, M. B. (2004). Modeling performance and alertness: the QinetiQ approach. Aviation, space, and environmental medicine, 75(3 Suppl), A93–106.

Bendak, S., & Rashid, H. S. J. (2020). Fatigue in aviation: A systematic review of the literature. *International Journal of Industrial Ergonomics, 76*, 102928. doi:10.1016/j.ergon.2020.102928

Bennett, S. A. (2022). *Safety in aviation and astronautics: A socio-technical approach*. Routledge.

Boeing. (1998). *Boeing 747 celebrates 30 years' proven success, Strong Future*. MediaRoom. Retrieved March 20, 2022, from https://boeing.mediaroom.com/1998-09-30-Boeing-747-Celebrates-30-Years-Proven-Success-Strong-Future

Blakemore, E. (2019). *The first nonstop flight across the Atlantic lasted 16 harrowing hours*. History.com. Retrieved March 20, 2022, from https://www.history.com/news/first-transatlantic-flight-nonstop-alcock-brown

Blettner, M., Grosche, B., & Zeeb, H. (1998). Occupational cancer risk in pilots and flight attendants: current epidemiological knowledge. *Radiation and environmental biophysics*, *37*(2), 75–80. https://doi.org/10.1007/s004110050097

Brown, T. P., Shuker, L. K., Rushton, L., Warren, F., & Stevens, J. (2001). The possible effects on health, comfort and safety of aircraft cabin environments. *The journal of the Royal Society for the Promotion of Health*, *121*(3), 177–184. https://doi.org/10.1177/146642400112100315

Cahill, J., Cullen, P., Anwer, S., Wilson, S., & Gaynor, K. (2021). Pilot Work Related Stress (WRS), Effects on Wellbeing and Mental Health, and Coping Methods. The International Journal of Aerospace Psychology, 00(00), 1–23.

https://doi.org/10.1080/24721840.2020.1858714

Chen, P. H., Liu, X., Dong, L., & Rau, P. P. (2021). Prevalence of musculoskeletal discomfort among female cabin crew in Taiwan. *Journal of occupational health*, *63*(1), e12286. https://doi.org/10.1002/1348-9585.12286

Civil Aviation Authority. (2004). *CAA Paper 2004/04 – Cabin Air Quality.* CAA. Retrieved October 16, 2022, https://publicapps.caa.co.uk/docs/33/CAPAP2004_04.PDF

Dexter, F., & Chestnut, D. H. (1995). Analysis of statistical tests to compare visual analog scale measurements among groups. *Anesthesiology*, *82*(4), 896–902. https://doi.org/10.1097/00000542-199504000-00012

DeHart R. L. (2003). Health issues of air travel. Annual review of public health, 24, 133–151. https://doi.org/10.1146/annurev.publhealth.24.100901.140853

Demerouti, E., Veldhuis, W., Coombes, C., & Hunter, R. (2019). Burnout among pilots: Psychosocial factors related to happiness and performance at simulator training. *Ergonomics, 62*(2), 233-245. doi:10.1080/00140139.2018.1464667

Değer, V. B. (2018). Transcultural Nursing. In (Ed.), Nursing. IntechOpen. https://doi.org/10.5772/intechopen.74990

Dedmon, D (1968). Physiological and psychological deficiencies of the airline flight attendant induced by the employment environment. Unpublished Paper. Airline Stewards and Stewardesses Association.

European Aviation Safety Agency. (2022). *Air passengers' safety & wellbeing*. EASA. Retrieved October 16, 2022, from https://www.easa.europa.eu/en/light/topics/air-passengers-safety-wellbeing

European Aviation Safety Agency. (2011). *Comment Response Document (CRD) to Advance Notice of Proposed Amendment (A-NPA) 2009-10 – Cabin Air Quality Onboard Large Aeroplanes.* EASA. Retrieved October 16, 2022, from https://www.easa.europa.eu/sites/default/files/dfu/CRD%20to%20A-NPA%202009-10.pdf

European Aviation Safety Agency. (2017). *EASA publishes two studies on cabin air quality.* EASA. Retrieved October 16, 2022, from https://www.easa.europa.eu/en/newsroom-and-events/press-releases/easa-publishes-two-studies-cabin-air-quality

European Aviation Safety Agency. (2017). *Characterization of the toxicity of aviation turbine engine oils after pyrolysis (AVOIL) (Technical Report ASA.2015.HVP.23).* EASA. Retrieved October 16, 2022, from https://www.easa.europa.eu/en/downloads/22224/en

European Aviation Safety Agency. (2017). *Preliminary cabin air quality measurement campaign (CAQ) (Technical Report EASA. 2014.C15.SU01).* EASA. Retrieved October 16, 2022, from https://www.easa.europa.eu/en/downloads/22219/en

European Aviation Safety Agency. (2018). *EASA welcomes new rules on Mental Fitness of Air Crew*. EASA. Retrieved March 20, 2022, from https://www.easa.europa.eu/newsroom-andevents/news/easa-welcomes-new-rules-mental-fitness-air-crew

European Aviation Safety Agency. (2022). *Cabin Air Quality Assessment of Long Term Effects of Contaminants.* EASA. Retrieved October 16, 2022, from https://www.easa.europa.eu/en/research-projects/cabin-air-quality-assessment-long-term-effects-contaminants

Ebbert, J. O., Croghan, I. T., Schroeder, D. R., Murawski, J., & Hurt, R. D. (2007). Association between respiratory tract diseases and secondhand smoke exposure among never smoking flight attendants: a cross-sectional survey. *Environmental health : a global access science source*, *6*, 28. https://doi.org/10.1186/1476-069X-6-28

Federal Aviation Administration. (1980). Advisory Circular 120-38, Transport Category Airplanes Cabin Ozone Concentration. FAA. Retrieved October 16, 2022, from https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/22760

Federal Aviation Administration. (2010). Advisory Circular 120-100, Basics of Aviation Fatigue. FAA. Retrieved October 16, 2022, from https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentid/244560

Federal Aviation Administration. (2013). Advisory Circular 120-103A, Fatigue Risk Management Systems for Aviation Safety. FAA. Retrieved October 16, 2022, from https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentid/1021088

Federal Aviation Administration. (2008). InFO 08016, Flight attendant certificate of demonstrated proficiency Information on the Web. FAA. Retrieved October 16, 2022, from https://www.faa.gov/sites/faa.gov/files/other_visit/aviation_industry/airline_operators/airline_safety/inFO08016.pdf

Federal Aviation Administration. (2012). Advisory Circular 117-1, Flightcrew Member Rest Facilities. FAA. Retrieved October 16, 2022, from https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1020336

Federal Aviation Administration. (1994). Advisory Circular 121-31, Flight Crew Sleeping Quarters and Rest Facilities. FAA. Retrieved October 16, 2022, from https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentid/22511

Federal Aviation Administration. (2012). *FAA Modernization and Reform Act 2012 – Section 917 Research and development of equipment to clean and monitor the engine and auxiliary power unit (APU) Bleed Air Supplied on Pressurized Aircraft - Report to Congress.* FAA. Retrieved October 16, 2022, from https://www.faa.gov/about/plans_reports/congress/media/Report_to_Congress_on_Engine_and_APU_Bleed_Air_Supplied_on_Pressurized_Aircraft.pdf

Federal Aviation Administration. (2012). *Memorandum of Understanding between the Federal Aviation Administration U.S. Department of Transport and The Occupation Safety and Health Administration U.S. Department of Labor.* FAA. Retrieved October 16, 2022, from https://www.faa.gov/about/initiatives/ashp/media/FAA_OSHA_MOU_2014.pdf

Federal Aviation Administration. (2002). *Management of passengers who may be sensitive to allergens* (Advisory Circular 121-36*).* FAA. Retrieved October 16, 2022, https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC121-36.pdf

Federal Aviation Administration. (2020). *Cabin Air Quality.* FAA. Retrieved October 16, 2022, https://www.faa.gov/newsroom/cabin-air-quality

Federal Aviation Administration. (2003). *Management of Passengers During Ground Operations Without Cabin Ventilation (Advisory Circular 121-35).* FAA. Retrieved October 16, 2022, https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC121-35.pdf

Federal Aviation Administration. (2018). *Airliner Cabin Environment Research.* FAA. Retrieved October 16, 2022, from https://www.faa.gov/data_research/research/med_humanfacs/cer

Federal Aviation Administration. (2022). *Aircrew Health and Safety Medical Topics.* FAA. Retrieved October 16, 2022, from https://www.faa.gov/travelers/fly_safe/health/aircrew

Federal Aviation Administration. (2022). *Aircraft Cabin Bleed Air Contaminants: A Review (Technical Report DOT/FAA/AM-15/20).* Oklahoma City. FAA. Retrieved October 16, 2022, from https://www.faa.gov/data_research/research/med_humanfacs/oamtechreports/2010s/media/201520.pdf

Federal Aviation Administration. (2022). *Pilot mental fitness*. Federal Aviation Administration. Retrieved November 20, 2022, from https://www.faa.gov/pilot-mental-fitness

Flynn, D. (2022, September 23). *Air New Zealand's next-gen 787 gets a big boost to business*. Executive Traveller. Retrieved October 16, 2022, from https://www.executivetraveller.com/news/air-new-zealand-boeing-787-ultra-long-range

Flight Safety Foundation. (2001). *Dehydration Presents Unique Risks for Pilots: Flight Safety Digest, July–August 2001*. Flight Safety Foundation. Retrieved March 20, 2022, from https://flightsafety.org/hf/hf_jul-aug01.pdf

Flight Safety Foundation. (2003). *Consensus emerges from international focus on crew alertness in Ultra-Long*-Range *Operations: Flight Safety Digest, May–June 2003*. Flight Safety Foundation. Retrieved March 20, 2022, from https://flightsafety.org/fsd_may-june03-2/

Flight Safety Foundation. (2005). *Lessons from the dawn of ultra-long-range flight: Flight safety digest August–September 2005*. Flight Safety Foundation. Retrieved March 20, 2022, from https://flightsafety.org/fsd_aug-sept05/

Freed, J., & Hepher, T. (2018, June 3). *Jetmakers race to meet Sydney-London non-stop challenge*. Reuters. Retrieved March 20, 2022, from https://www.reuters.com/article/airlines-iata-long-haul/jetmakers-race-to-meet-sydneylondon-non-stop-challenge-idINKCN1IZ0A1

Grimme, W. (2011). Going the long way – an analysis of the world's ultra long-haul non-stop air routes, *Proceedings of the Air Transport Research Society World Conference.*

Grimme, W., Bingemer, S., & Maertens, S. (2020). An analysis of the prospects of ultra-long-haul airline operations using passenger demand data. *Transportation Research Procedia*, *51*, 208–216. https://doi.org/10.1016/j.trpro.2020.11.023

Government Accountability Office. (2017). Aviation Safety: More Research Needed on the Effects of Air Quality on Airliner Cabin Occupants. (GAO Publication No. 04-54). Washington, D.C.: U.S. Government Printing Office. Retrieved October 17, 2022, from https://www.gao.gov/products/gao-04-54

Government Accountability Office. (2017). Commercial Aviation: Pilots' and Flight Attendants' Exposure to Noise aboard Aircraft. (GAO Publication No. 19-109R). Washington, D.C.: U.S. Government Printing Office. Retrieved October 17, 2022, from https://www.gao.gov/products/gao-18-109r

Grout, A., & Leggat, P. A. (2021). Cabin crew health and fitness-to-fly: Opportunities for re-evaluation amid COVID-19. *Travel medicine and infectious disease*, *40*, 101973. https://doi.org/10.1016/j.tmaid.2021.101973

Hardiman, J. (2021). Where Do Crew Sleep During a Flight? Simply Flying. https://simpleflying.com/crew-rest-areas/

Haugli, L., Skogstad, A., & Hellesøy, O. H. (1994). Health, sleep, and mood perceptions reported by airline crews flying short and long hauls. *Aviation, space, and environmental medicine*, *65*(1), 27–34.

Haines, M. J. (2006). *Impact factors of Ultra Long Range flights on cabin crew and passengers: "pushing the plane-- pushing the people", Massey University, Palmerston North, New Zealand* (thesis).

Hatch, J. A. (2002). Doing qualitative research in education settings. Albany, NY: State University of New York.

Ho, P., Landsberger, S., Signal, L., Singh, J., & Stone, B. (2005). The Singapore experience: Task force studies scientific data to assess flights. Flight Safety Digest, 20 – 40.

Holsti, O.R. (1968). Holsti, O. R., "Content Analysis," in Gardner Lindzey and E. Aronson, eds., Handbook of Social Psychology, Vol 2 . Reading, MA: Addison-Wesley, 1968.

House of Lords. (2007). *Air Travel and Health: An Update.* Authority of the Hourse of Lords UK. Retrieved October 16, 2022, from https://publications.parliament.uk/pa/ld200708/ldselect/ldsctech/7/7.pdf

IFALPA. (2019). *In Flight Crew Rest Facilities.* IFALPA. Retrieved November 22, 2022, from https://www.ifalpa.org/media/3423/19pos09-in-flight-flight-crew-rest-facilities.pdf

International Air Transport Association. (2019). *Aircraft Technology Roadmap to 2050.* IATA. Retrieved October 17, 2022, from https://www.iata.org/contentassets/8d19e716636a47c184e7221c77563c93/Technology-roadmap-2050.pdf

International Air Transport Association. (2022). *Air Passenger Numbers to Recover in 2024.* IATA. Retrieved October 17, 2022, from https://www.iata.org/en/pressroom/2022-releases/2022-03-01-01/

International Civil Aviation Organization. (2004). Assembly — 35th session - ICAO.int. ICAO. Retrieved March 20, 2022, from https://www.icao.int/Meetings/AMC/MA/Assembly%2035th%20Session/wp161_en.pdf

International Civil Aviation Organization. (2012). Doc 8984 Manual of Civil Aviation Medicine. Retrieved March 20, 2022, from https://www.icao.int/publications/pages/publication.aspx?docnum=8984

International Civil Aviation Organization. (2015). Fatigue Management Guide for Airline Operators (2nd Ed). Retrieved March 20, 2022, from https://www.icao.int/safety/fatiguemanagement/FRMS%20Tools/FMG%20for%20Airline%20Operators%202nd%20Ed%20(Final)%20EN.pdf

International Civil Aviation Organization. (2015). Cir 344-AN/202 Guidelines on Education, Training and Reporting Practices related to Fume Events. Retrieved March 20, 2022, from https://www.beca.be/images/safety/pdf/ICAOcircular344.pdf

International Civil Aviation Organization. (2017). Doc 10085 Extended Diversion Time Operations (EDTO) Manual (1st Ed). Retrieved March 21, 2022, from https://www.icao.int/MID/Documents/2020/EDTO%20Workshop/10085_cons_en.pdf

International Civil Aviation Organization (2019). Annex 6 Operation of Aircraft (10th Ed). Retrieved March 20, 2022, from https://store.icao.int/en/annexes/annex-6

International Civil Aviation Organization (2019). The World of Air Transport in 2019. Retrieved March 20, 2022, from https://www.icao.int/annual-report-2019/Pages/the-world-of-air-transport-in-2019.aspx

Lamp, A. (2018). *Health and Safety in Commercial Aviation* (Order No. 10784931) (Doctoral dissertation, Washington State University). ProQuest Dissertations and Thesis global. https://rex.libraries.wsu.edu/esploro/outputs/doctoral/Health-and-Safety-in-Commercial-Aviation/99900581714301842#files_and_links

Lee, H., Wilbur, J., Conrad, K. M., & Mokadam, D. (2006). Work-related musculoskeletal symptoms reported by female flight attendants on long-haul flights. *Aviation, space, and environmental medicine*, *77*(12), 1283–1287.

Limb, L. (2022). *The rise of ultra-long haul flights: Could you stomach 19 hours onboard?* Euronews.travel. Retrieved October 16, 2022, from https://www.euronews.com/travel/2022/03/24/the-rise-of-ultra-long-haul-flights-could-you-stomach-18-hours-onboard

Lingard, L., Albert, M., & Levinson, W. (2008). Grounded theory, mixed methods, and action research. BMJ (Clinical research ed.), 337, a567. https://doi.org/10.1136/bmj.39602.690162.47

Lindbergh, C. A. 1. (1953). The Spirit of St. Louis . Scribner.

Lombardi, M. (2008). *Seventh Heaven- 50 years ago, Boeing and Pan AM revolutionized travel with the 707*. Boeing Frontier. Retrieved October 17, 2022, from https://www.boeing.com/news/frontiers/archive/2008/july/i_history.pdf

Long, T. (2012). *May 2,1952: First Commericial Jet Flies From London to Joannesburg.* Wired. Retrieved October 17, 2022, from https://www.wired.com/2012/05/may-2-1952-first-commercial-jet-flies-from-london-to-johannesburg/

Kara, M. (2019, August 16). *Retrospective: The beginning of the end of Airbus A340*. Aero Time Hub. Retrieved March 20, 2022, from https://www.aerotime.aero/articles/23817-a340-retrospective

Michaelis S. (2019). EASA and FAA research findings and actions – Cabin air quality. In Conference proceedings: 2017 International Aircraft Cabin Air Conference. *Journal of Health and Pollution: Vol. 9, No. 24, pp. S1-S142.* Retrieved October 16, 2022, from https://www.susanmichaelis.com/about

Morse, J. M. (1991). Evaluating qualitative research. *Qual Health Res, 1*(3), 283-286. doi:10.1177/104973239100100301

National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. (1979). *The Belmont report: Ethical principles and guidelines for the protection of human subjects of research*. U.S. Department of

Health and Human Services. https://www.hhs.gov/ohrp/regulations-and-policy/belmont-report/read-the-belmont-report/index.html

National Academies of Sciences, Engineering, and Medicine. (2002). The Airliner Cabin Environment and the Health of Passengers and Crew. Washington, DC: The National Academies Press. https://doi.org/10.17226/10238."

Nagda, N. L., & Koontz, M. D. (2003). Review of studies on flight attendant health and comfort in airliner cabins. *Aviation, space, and environmental medicine*, *74*(2), 101–109.

O'Brien, R., Hunt, K., & Hart, G. (2005). 'It's caveman stuff, but that is to a certain extent how guys still operate': men's accounts of masculinity and help seeking. *Social science & medicine (1982)*, *61*(3), 503–516. https://doi.org/10.1016/j.socscimed.2004.12.008

O'Hagan, A. D., Issartel, J., Nevill, A., & Warrington, G. (2017). Flying Into Depression. *Workplace health &* safety, *65*(3), 109–117. https://doi.org/10.1177/2165079916659506

Orlady, H. W., Orlady, L. M., & Lauber, J. K. (1999). *Human factors in multi-crew flight operations*. Aldershot, England: Ashgate.

Patten, M. L., & Newhart, M. (2018). Understanding research methods: An overview of the essentials (10 Ed.). Routledge.

Parr, A. T., Manchikanti, L., Hameed, H., Conn, A., Manchikanti, K. N., Benyamin, R. M., Diwan, S., Singh, V., & Abdi, S. (2012). Caudal epidural injections in the management of chronic low back pain: a systematic appraisal of the literature. *Pain physician*, *15*(3), E159–E198.

Pottinger, T. L., & Marcham, C. L. (2018). An Analysis of Cabin Ozone Regulations. Collegiate Aviation Review International, 36(2). Retrieved October 16, 2022, from, https://commons.erau.edu/publication/1024

Qantas. (2019). *Project Sunrise Overview – news room.* Qantas. https://www.qantasnewsroom.com.au/wp-content/uploads/2022/05/Project-Sunrise-Overview_A4-FINAL.pdf

Quest, N., & Neild, B. (2019). *London to Sydney flight breaks world record.* CNN. https://www.cnn.com/travel/article/qantas-test-flight-london-sydney-nonstop/index.html

Rayman R. B. (1997). Passenger safety, health, and comfort: a review. *Aviation, space, and environmental medicine*, *68*(5), 432–440.

Ranabhat, S. (2022, March 27). *Biman Bangladesh B787 Flew 18 hours on Dhaka-Toronto non-stop Flight.* SamChui.com. https://samchui.com/2022/03/27/biman-bangladesh-b787-flew-18-hours-on-dhaka-toronto-non-stop-flight/

Reardon, J. (1992, April 1). *Safety and health experience of pilots and flight attendants: Monthly Labor Review: U.S. Bureau of Labor Statistics*. Retrieved October 16, 2022, from https://www.bls.gov/opub/mlr/1992/article/safety-and-health-experience-of-pilots-and-flight-attendants.htm

Repace J. (2004). Flying the smoky skies: secondhand smoke exposure of flight attendants. *Tobacco control*, *13 Suppl 1*(Suppl 1), i8–i19. https://doi.org/10.1136/tc.2003.003111

Runeson, R., Lindgren, T., & Wahlstedt, K. (2011). Sleep problems and psychosocial work environment among swedish commercial pilots. American Journal of Industrial Medicine, 54(7), 545-551. doi:10.1002/ajim.20943

Russell, E. (2022, May 2). *Qantas Plans World's Longest Flights With Project Sunrise Airbus A350 Order.* Airline Weekly. https://airlineweekly.com/2022/05/qantas-plans-worlds-longest-flights-with-project-sunrise-airbus-a350-order/

Salas, E., & Dan, M. (2010). *Human factors in aviation* (2nd ed.). Academic Press.

Science and Industry Museum. (2022). *Alcock, Brown and the first non-stop transatlantic flight*. Science and Industry Museum. Retrieved October 16, 2022, from https://www.scienceandindustrymuseum.org.uk/objects-and-stories/alcock-and-brown

Signal, T. L., Gander, P. H., van den Berg, M. J., & Graeber, R. C. (2013). In-flight sleep of flight crew during a 7-hour rest break: implications for research and flight safety. *Sleep*, *36*(1), 109–115. https://doi.org/10.5665/sleep.2312

Signal, T. L., Mulrine, H. M., van den Berg, M. J., Smith, A. A., Gander, P. H., & Serfontein, W. (2014). Mitigating and monitoring flight crew fatigue on a westward ultra-long-range flight. *Aviation, space, and environmental medicine*, *85*(12), 1199–1208. https://doi.org/10.3357/ASEM.4034.2014

Simons, S. M. (1997). Aviation Alliances: Implication for the Qantas-Ba Alliance in the Asia Pacific Region. Journal of Air Law and Commerce, 62(3), 842-867. https://scholar.smu.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1444&context=jalc

Slotnick, D. (2022, September 20). *Air New Zealand completes first 17-hour nonstop flight from New York to Auckland: Here's a sneak peek.* The Points Guy. https://thepointsguy.com/news/air-new-zealand-new-york-to-auckland-nonstop-lands/

Spencer, M. B. (2002). *Modeliing of aircrew alertness in future ultra-long range schedules, based on city pair.* Qinetiq Report No. CHS/P&D/CR0200471/1.1. http://www.cockpitseeker.com/wp-content/uploads/goodies/fi/JAA%20operations/Public%20Area/QinetiQ.PDF

Stackhouse, J. (1997). *The Longest Hop: Celebrating 50 Years of the QANTAS Kangaroo Route, 1947-1997*. Van Haren Publishing.

Sullivan, G. M., & Artino, A. R., Jr (2013). Analyzing and interpreting data from Likert-type scales. *Journal of graduate medical education*, *5*(4), 541–542. https://doi.org/10.4300/JGME-5-4-18

United Kingdom Civil Aviation Authority. (2004). *Cabin Air Quality (CAA Paper 2004/04).* West Sussex. UKCAA. Retrieved October 16, 2022, from https://publicapps.caa.co.uk/docs/33/CAPAP2004_04.PDF

United Kingdome Civil Aviation Authority. (2017). *CAA/HSE/HSENI Memorandum of Understanding guidance (CAP 1484).* West Sussex. UKCAA. Retrieved October 16, 2022, from https://publicapps.caa.co.uk/docs/33/CAP%201484%20MAR17.pdf

Van Den Berg, M. J., Signal, T. L., & Gander, P. H. (2020). Fatigue risk management for cabin crew: the importance of company support and sufficient rest for work-life balance-a qualitative study. *Industrial health*, *58*(1), 2–14. https://doi.org/10.2486/indhealth.2018-0233

Van Den Berg, M. J., Signal, T. L., Mulrine, H. M., Smith, A. A., Gander, P. H., & Serfontein, W. (2015). Monitoring and Managing Cabin Crew Sleep and Fatigue During an Ultra-Long Range Trip. *Aerospace medicine and human performance*, *86*(8), 705–713. https://doi.org/10.3357/AMHP.4268.2015

Venus, M., & grosse Holtforth, M. (2021). How Duty Rosters and Stress Relate to Sleep Problems and Fatigue of International Pilots. International Journal of Aviation, Aeronautics, and Aerospace, 8(3). Retrieved from https://commons.erau.edu/ijaaa/vol8/iss3/5

Wu, A. C., Donnelly-McLay, D., Weisskopf, M. G., McNeely, E., Betancourt, T. S., & Allen, J. G. (2016). Airplane pilot mental health and suicidal thoughts: a cross-sectional descriptive study via anonymous web-based survey. Environmental health : a global access science source, 15(1), 121. https://doi.org/10.1186/s12940-016-0200-6

Wignall, A. (2022). *A brief history of long-haul flights.* Aerotime Hub. Retrieved October 16, 2022, from https://www.aerotime.aero/articles/31506-a-brief-history-of-long-haul-flights

Williamson, A., & Friswell, R. (2013). Fatigue in the workplace: Causes and countermeasures. Fatigue: Biomedicine, Health & Behavior, 1(1-2), 81-98. doi:10.1080/21641846.2012.744581

Wingelaar-Jagt, Y. Q., Wingelaar, T. T., Riedel, W. J., & Ramaekers, J. G. (2021). Fatigue in Aviation: Safety Risks, Preventive Strategies and Pharmacological Interventions. *Frontiers in physiology*, *12*, 712628. https://doi.org/10.3389/fphys.2021.712628

Zohrabi, Mohammad. (2013). Mixed Method Research: Instruments, Validity, Reliability, and Reporting Findings. Theory and Practice in Language Studies. 3. 10.4304/tpls.3.2.254-262.

Appendixes

APPENDIX A: ERAU INSTITUIONAL REVIEW BOARD (IRB) APPROVAL

Embry-Riddle Aeronautical University
Application for IRB Approval
EXEMPT Determination Form

Principal Investigator: Aditya Rathi

Other Investigators: Brian Roggow

Role: Student **Campus:** Prescott **College:** Aviation/Aeronautics

Project Title: Ultra Long – Range Commercial Operations: An Assessment of current Health & Safety Standard

Review Board Use Only

Initial Reviewer: Teri Gabriel **Date:** 09/07/2022 **Approval #:** 23-020

Determination: Exempt

Dr. Beth Blickensderfer
IRB Chair Signature: Elizabeth L. Blickensderfer Digitally signed by Elizabeth L. Blickensderfer Date: 2022.09.14 14:54:43 -04'00'

Brief Description:

The study aims to review current Health & Safety International and National Regulations and best practices for operating Ultra Long-Range (ULR) Routes. Participants will be asked to complete a survey via SurveyMonkey.

This research falls under the **EXEMPT** category as per 45 CFR 46.104:

☑ (2) Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met: (Applies to Subpart B [Pregnant Women, Human Fetuses and Neonates] and does not apply for Subpart C [Prisoners] except for research aimed at involving a broader subject population that only incidentally includes prisoners.)

APPENDIX B: INFORMED CONSENT FORM

Ultra-Long–Range Commercial Operations: An Assessment of Current Health & Safety Standard
Survey Informed Consent Form

Please read this carefully so that you understand what your participation involves.

Purpose of this Research: You have been invited to participate in a survey as a part of a research study. The study aims to review current Health & Safety International and National Regulations and best practices for operating Ultra Long-Range (ULR) Routes. ULR operations refer to "An operation involving any sector between a specific city pair (A-B-A) in which the planned flight time exceeds 16 hours, taking into account mean wind conditions and seasonal changes." **The scope of this study is to identify different health-related factors affecting Aircrew (Pilots & Flight Attendants) who operate these routes.** During this study, you will be asked to complete a brief online survey about your opinions concerning health-related issues while operating ULR routes. You will answer several questions about different health-related factors and how it affects your lifestyle, including any prominent experiences you have encountered. The completion of the survey will take approximately 15-20 minutes.
Aircrew sought to participate in this study needs to meet the following criteria:

- **Employed (in the last 24 months) by an air carrier operating scheduled ULR flights (>16hrs);**
- **Qualified as an aircrew member to operate ULR flights.**

Risks or Discomforts: The risks of participating in this study are no more significant than what is experienced in daily life.

Benefits: While there are no benefits to you as a participant, your assistance in this research will help gauge current health-related impact factors operating this route.

Confidentiality of Records: Your individual information will be protected in all data resulting from this study. Your responses to this survey will be anonymous. No personal information will be collected other than age, gender, and demographic descriptors. The online survey system will not save IP address or any other identifying information. In order to protect the anonymity of your responses, I will keep your responses in a password–protected file on a password–protected computer. No one other than the researcher will have access to any of the responses. Information collected as part of this research will not be used or distributed for future studies.

Compensation: There is no compensation offered for taking part in this study.

Contact: If you have any questions or want additional information about this study, please contact **Aditya Rathi**, **rathia@my.erau.edu**, or the faculty member overseeing this project, **Prof. Brian Roggow, roggo234@erau.edu**. For any concerns or questions as a participant in this research, contact the ERAU Institutional Review Board (IRB) at **386-226-7179** or via email at **teri.gabriel@erau.edu**.

Voluntary Participation: Participation in this research is voluntary. You may withdraw at any time. If you decide to withdraw from the study, no information collected will be used, and it will be destroyed.

Consent: By checking AGREE below, I understand the information on this form, meet the above-stated participation criteria, and voluntarily agree to participate in the study.
If you do not wish to participate in the survey, close the browser or check to DISAGREE, which will direct you out of the study.
Please print a copy of this form for your records. A copy of this form can also be requested from Aditya Rathi, rathia@my.erau.edu.

APPENDIX C: RECRUITMENT EMAIL/MESSAGES

Dear Pilots and Flight Attendants,

Did you know that the difference between a 14-hour flight time and an 18-hour flight time is 28%, which means 28% more exposure by occupants to the cabin environment and other aircraft influences.

Keeping this in mind, I am working on a new research study that aims to review current Health & Safety International and National Regulations and best practices for operating Ultra-Long-Range Routes (ULR). ULR operations refer to "An operation involving any sector between a specific city pair (A-B-A) in which the planned flight time exceeds 16 hours, taking into account mean wind conditions and seasonal changes. The scope of this study is to identify different health-related factors affecting Aircrew (Pilots & Flight Attendants) who operate these routes. Based on this review, a gap analysis will be conducted, and recommendations will be presented to mitigate health and safety-related impact factors on Aircrew. As a part of this study, a survey is designed for Aircrew (Pilots and Flight Attendants) who operate on ULR flights. This survey aims to learn about different health and safety impact factors that Aircrew experiences while operating these routes.

Aircrew sought to participate in this study needs to meet the following criteria:

- **Employed (in the last 24 months) by an air carrier operating scheduled ULR flights (>16hrs);**
- **Qualified as an aircrew member to operate ULR flights.**

During this study, you will be asked to complete a brief online survey about your opinions concerning health-related issues while operating ULR routes. You will answer several questions about different health-related factors and how it affects your lifestyle, including any prominent experiences you have encountered. Your participation in the survey is **anonymous**. The completion of the survey will take approximately 15-20 minutes.

If you meet the criteria and are interested in helping, sign up for the study by clicking the link - https://www.surveymonkey.com/r/SV2D9KT
You can also sign up by scanning the QR code below.

Please let me know if you have any questions I can answer. Thank you for your participation

APPENDIX D: SURVEY QUESTIONNAIRE

Ultra Long-Range Commercial Operations: An Assessment of Current Health & Safety Standard

Informed Consent Form

Please read this carefully so that you understand what your participation involves.

Purpose of this Research: You have been invited to participate in a survey as a part of a research study. The study aims to review current Health & Safety International and National Regulations and best practices for operating Ultra Long-Range (ULR) Routes. ULR operations refer to "An operation involving any sector between a specific city pair (A-B-A) in which the planned flight time exceeds 16 hours, taking into account mean wind conditions and seasonal changes." The scope of this study is to identify different health-related factors affecting Aircrew (Pilots & Flight Attendants) who operate these routes. During this study, you will be asked to complete a brief online survey about your opinions concerning health-related issues while operating ULR routes. You will answer several questions about different health-related factors and how it affects your lifestyle, including any prominent experiences you have encountered. The completion of the survey will take approximately 15-20 minutes.

Aircrew sought to participate in this study needs to meet the following criteria:

- **Employed (in the last 24 months) by an air carrier operating scheduled ULR flights (>16hrs);**
- **Qualified as an aircrew member to operate ULR flights;**

Risks or Discomforts: The risks of participating in this study are no more significant than what is experienced in daily life.

Benefits: While there are no benefits to you as a participant, your assistance in this research will help gauge current health-related impact factors operating this route.

Confidentiality of Records: Your individual information will be protected in all data resulting from this study. Your responses to this survey will be anonymous. No personal information will be collected other than age, gender, and demographic descriptors. The online survey system will not save IP address or any other identifying information. In order to protect the anonymity of your responses, I will keep your responses in a password-protected file on a password-protected computer. No one other than the researcher will have access to any of the responses. Information collected as part of this research will not be used or distributed for future studies.

Compensation: There is no compensation offered for taking part in this study.

Contact: If you have any questions or want additional information about this study, please contact Aditya Rathi, rathia@my.erau.edu, or the faculty member overseeing this project, Prof. Brian Roggow, roggo234@erau.edu. For any

concerns or questions as a participant in this research, contact the ERAU Institutional Review Board (IRB) at 386-226-7179 or via email at teri.gabriel@erau.edu.

Voluntary Participation: Participation in this research is voluntary. You may withdraw at any time. If you decide to withdraw from the study, no information collected will be used, and it will be destroyed.

Consent: By checking AGREE below, I understand the information on this form, meet the above-stated participation criteria, and voluntarily agree to participate in the study.

If you do not wish to participate in the survey, close the browser or check to DISAGREE, which will direct you out of the study.

Please print a copy of this form for your records. A copy of this form can also be requested from Aditya Rathi, rathia@my.erau.edu.

* 1. Do you meet the participation criteria of this survey?

◯ Yes

◯ No

* 2. Do you agree to take part in this survey?

◯ Agree

◯ Disagree

Ultra Long-Range Commercial Operations: An Assessment of Current Health & Safety Standard

* 3. In which region does your airline operate in?

- North America
- Latin America
- Europe
- Middle East
- Central Asia
- Asia Pacific

* 4. Are you a

- Pilot
- Flight Attendant

* 5. What's your age?

6. What's your Gender?

- Male
- Female
- Other
- Do not wish to answer

* 7. About how many years have you been in your current position?

* 8. How satisfied are you with your current airline workplace environment? Use the slider below, to indicate your answer.

Most Dissatisfied — Most Satisfied

* 9. About your Airline's "Safety Culture," please indicate your opinion/ experience to the following scenario's below.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
New recruitment (crew) quickly learn that they are expected to follow practices	○	○	○	○	○
There are no significant compromises or shortcuts taken when worker safety is at stake	○	○	○	○	○
Where I work, crew and line managers or top management work together to ensure the safest possible working condition	○	○	○	○	○
Crew Members are addressed when they do not follow good safety practices without any punitive actions	○	○	○	○	○
The safety of crew members is a priority to management	○	○	○	○	○
I feel free to report safety related violations/errors where I work	○	○	○	○	○

10. How confident do you feel about your organization's current safety practices? Use the slider below, to indicate your answer.

Not Confident Confident

Ultra Long-Range Commercial Operations: An Assessment of Current Health & Safety Standard

* 11. About how many years have you been crew on ULR Flights?

* 12. On average, how many Ultra Long Haul flights (+16hrs) do you complete per month?

* 13. Is your Airline's CRM program inclusive where both the Flight Attendant's group and Pilot's group provided the training together?

- Yes
- No

Other (please specify)

* 14. Does your airline offer any additional training or education sessions on the unique nature of ULR operations?

- Yes
- No
- Other (please specify)

15. How satisfied are you with the current operational and safety procedures for these routes? Use the slider below, to indicate your answer.

Most Dissatisfied | Most Satisfied

* 16. On the ULR Flights, it's a regulatory requirement to provide an adequate rest period to manage fatigue and flight time limitation. Are you satisfied with your Airline's rest period pattern? Use the slider below, to indicate your answer.

Most Dissatisfied | Most Satisfied

17. Do you believe the rest periods allocated for operations are adequate?

◯ Yes

◯ No

* 18. Previous studies have identified that different Cabin Environment factors impact the aircrew (Pilot and Cabin Crew). Answer the following if you agree or disagree with the following with current generation of aircraft.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
In Flight Rest Facilities	◯	◯	◯	◯	◯
Cabin Air Quality and Humidity	◯	◯	◯	◯	◯
Seating (Jump Seats)	◯	◯	◯	◯	◯
Noise and Vibration	◯	◯	◯	◯	◯

* 19. In your opinion, list the **top three improvements concerning rest facilities** onboard the aircraft?

* 20. In your opinion, list the **top three improvements concerning Cabin Environments** that you feel can reduce the impact on your Health & Safety.

Ultra Long-Range Commercial Operations: An Assessment of Current Health & Safety Standard

* 21. In your opinion, list the top three Health - Related (Physiological, Psychological, and Psychosocial) factors that can be experienced during **Pre- ULR flight preparation**.

* 22. In your opinion, list the top three Health- Related (Physiological, Psychological, and Psychosocial) factors that can be experienced **During - ULR Flight**.

* 23. While operating different routes (Short &Long-Range flights), prior studies have indicated various In-Flight health-related factors which directly impact aircrew members (Pilot and Flight Attendant). Please rank them in order of personal opinion while operating ULR routes. (Please rank them all)

- Dehydration
- Skin Irritation
- Deep Vein Thrombosis
- Neck Pain
- Upper Back Pain
- Lower Back Pain
- Improper Diet
- Mental Fatigue
- Psychosocial Issues

24. In Question 21 you ranked different health-related factors experienced in flight. If there are additional areas not listed above, please detail them below. You may list up to three.

25. In your experience with the ULR operations, do you adjust quickly to foreign destination environments? (For instance, time zone, weather, socio-cultural factors)

- Yes
- No
- Other (please specify)

26. How satisfied are you with the airline accommodation (Hotels) provided at the destination? Use the slider below, to indicate your answer.

Most Dissatisfied — Most Satisfied

* 27. In your opinion, list the top three Health - Related (Physiological, Psychological & Psychosocial) factors that can be experienced after completing a **ULR flight**.

Ultra Long-Range Commercial Operations: An Assessment of Current Health & Safety Standard

* 28. Answer the following questions based on your satisfaction level

	Extremely Disagree	Disagree	Neutral	Agree	Extremely Agree
My Airline is invested towards its aircrew (Pilot and Cabin Crew) Health and Well being operating these routes.	○	○	○	○	○
My Airline provides with proper training and helps with different programs/ resources towards well being	○	○	○	○	○
My airline is proactive towards Health & well being of its crew (both Pilot and Cabin Crew)	○	○	○	○	○
I am satisfied with current Health & Safety practices of my airline for these routes	○	○	○	○	○

* 29. Do you feel confident to report any Health & Safety Related issues that you experience to your Airline?

○ Yes

○ No

* 30. In your opinion, list the **top three improvements** in relation to health and safety you would like to see for ULR operations.