FITNESS-TO-FLY AND THE SAFETY ROLE OF AIR CABIN CREW: PERSONAL, SOCIAL AND MANAGERIAL CHALLENGES

PhD Thesis submitted by

Andrea Sander-Grout

MSc Public Health, London School of Hygiene and Tropical Medicine

Independent Public Health Consultant

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For the Degree of Doctor of Philosophy

College of Business, Law and Governance

James Cook University

Townsville, Queensland 4811

Australia

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I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been duly acknowledged in the text and a list of references is given.

Andrea Sander-Grout
Digitally signed by Andrea Sander-Grout
Date: 2021.03.15 07:59:06 +11'00'

Signature, Andrea Sander-Grout

Date

STATEMENT OF CONTRIBUTION OF OTHERS

Stipend:

Higher Degree Research Scholarship, James Cook University, 2016 – 2021.

Supervision:

Distinguished Professor Philip L. Pearce, College of Business, Law and Governance

A/Prof Anna Blackman, College of Business, Law and Governance

A/Prof Richard Franklin, College of Public Health, Medical & Veterinary Sciences

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2. Speakman, E.M., Flear, M., Grout, A. (2020). COVID-19: A Mandate for a New International Governance Framework for Global Public Health Threats in Commercial Aviation.

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Conference presentations:

Grout, A. (2018). *Plane Safe*? Cabin Crew Hand Hygiene and Food Handling Practices. Paper presented at the Aviation Health Conference, 25-26 September 2018, London, England.

Contribution as invited expert at the World Health Organization (WHO):

1. WHO consultation on aircraft disinsection and vector-borne diseases spread via air travel, 05-06 July 2018, Geneva, Switzerland

2. Member of the WHO Guidelines Development Group (GDG) to revise the WHO International Travel and Health (ITH) book, 26-27 February 2019, Geneva, Switzerland

3. Selected expert of the WHO Guidelines Development Group (GDG) to work on COVID-19 guidance as it relates to aviation and maritime traffic, 28-30 October 2020, weekly meetings ongoing.

ABSTRACT

Cabin crew serve an essential role in aviation, where good health and fitness are important prerequisites to ensure safe flight operations. Cabin crew are exposed to a range of occupational hazards that can negatively affect their health and in turn influence their task performance. In aviation medicine, fitness-to-fly is a measure of current health status. The narrow discourse of the term fitness-to-fly reasserts that the assessment parameters for fitness-to-fly have a conflicting effect on the overall performance of cabin crew work.

In an industry characterised by dynamic processes, this project reveals two key aspects that formulate the research questions: intensification of work in the context of organisational and operational changes, and increasing concern about exposure to occupational hazards. The identification of the specific activities cabin crew perform, and the factors affecting their performance, have historically received little attention in the occupational health and human resources literature.

To address this knowledge gap, I combine secondary data with online blog material from two sources: first, a literature review that draws on occupational and environmental science; and second, a corpus of 890 online blog posts that illuminate cabin crew perspectives on health and safety in crewmembers' own words. Rather than exploring fitness-to-fly as prerequisite of employment in the form of point-in-time assessment, this work has turned fitness-to-fly into the central object of inquiry; that is, conceiving fitness-to-fly as the outcome of a changing set of operational, environmental, and individual processes. Throughout the blog analysis, a new cycle of concerns became apparent, and cross-disciplinary fields became prominent. Emerging topics allowed for the pre-determined research questions to evolve organically, leading to seven topical publications between 2017 and 2021, with five articles currently in preparation, undergoing review, or being revised. In addition, relevant theory underpins the pivotal features that are inclusive of the cabin crew safety role.

The data reveal how fitness-to-fly is contextually related and situationally constructed; how it depends on professional practice and performance; and how it encompasses the hidden imprints of global air travel at a variety of individual health scales. Analysing occupational risks and hazards not only by their final effects, but also by the complex interactions that are involved when performing the dual role of safety and service, this project aims to deliver a more operational definition of fitness-to-fly. Through exploring the mechanisms that enable the often divergent interpretations of fitness-to-fly and flight safety, I offer an original contribution to the existing body of scholarship by building the conceptual components of fitness-to-fly. The aim is not to suggest a sharply demarcated research agenda, but instead to propose a set of anchor points for others to expand upon and modify. As such, this thesis has a discovery focus that is foundational to future quantitative or qualitative studies. My contribution should be understood as a non-exhaustive attempt to encourage future dialogues.

The COVID-19 pandemic - ongoing during the last stages of writing this thesis - highlights the complexity of the cabin crew role, which must be considered on a personal, social, and managerial level. In this way, COVID-19 offers the unintended opportunity to draw attention to occupational health approaches and modes of social organisation previously ignored.

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ABBREVIATIONS AND ACRONYMS

AFA
Association of Flight Attendants, a flight attendant-specific trade union in the U.S.

ASHS
Air Safety Health and Security

BfR
Bundesinstitut für Risikobewertung (Germany, Federal Institute for Risk Assessment)

CAA
Civil Aviation Authority (UK)

CAPSCA
Cooperative Arrangements for the Prevention of Spread of Communicable Disease

CASA
Civil Aviation Safety Authority (Australia)

CDC
Centers for Disease Control and Prevention (USA)

CRM
Crew Resource Management. A method of communication and interaction implemented to enhance inflight safety, mandated by the Joint Aviation Requirement for the Operation of Commercial Air Transport (JAR-OPS), and consistently taught and reiterated to cabin crew and pilots

DOT
Department of Transport (United States)

EASA
European Aviation Safety Agency

EPA
Environmental Protection Agency (USA)

EU
European Union

EUAC
European Union Aviation Commission

FAA
Federal Aviation Administration, a US government agency charged with regulating all aspects of aviation in the US

HSE
Health and Safety Executive (UK)

IATA
International Air Transport Association, an international industry trade group of airlines, headquartered in Montreal, Canada

ICAO
International Civil Aviation Organization, a UN specialized agency, established by states in 1944 to manage the administration and governance of the Convention on International Civil Aviation (Chicago Convention)

IHR
International Health Regulations published by the World Health Organization (WHO)

IPCS
International Programme on Chemical Safety, a WHO initiative to establish the scientific basis for the sound management of chemicals, and to strengthen national capabilities and capacities for chemical safety

LCC
Low Cost Carrier

OHMP
Occupational Health Medical Practitioner

OSHA
Occupational Safety and Health Administration

ULH
Ultra-long haul. Any non-stop flight carrying an economically meaningful payload of passengers and air cargo over more than 7,000 nautical miles (nm) (12,964 km). Ultra-long-haul operations are flight operations involving any sector between a specific city pair in which the planned flight time exceeds 16 hours, taking into account mean wind conditions and seasonal changes

USDA
United States Department of Agriculture

USDOT
United States Department of Transport

WHO
World Health Organization

INTERCHANGEABLE USE OF TERMS

Aircraft disinsection / pesticide spraying

Blog forum / group forum / weblog

Private blog / personal blog / online diary

Blog entry / blog post / comment / commentary

Blogger/ author/ respondent / contributor

Cabin crew (plural) / crew (plural) / crewmember (singular) / flight attendant / stewardess / air hostess

Pesticides / insecticides / chemicals

Schedule / roster

Trip / pairing / line / sectors

EXPLANATION OF TERMS

Aeromedical examiner / Aviation medical examiner

A physician designated by the national aviation authority and given the authority to perform physical examinations for fitness-to-fly, and issue aviation medical certificates.

Aircraft disinsection

International air travel carries the risk of inadvertent transport of mosquito vectors (and the diseases they transmit) into countries where they were not previously found. Aircraft disinsection is the procedure whereby health measures are taken to control or kill the insect vectors of human disease present in baggage, cargo, containers, conveyances, goods, and postal parcels.

Airline Deregulation Act

The Airline Deregulation Act of 1978 phased out the U.S. government’s control over fares and service, relying instead on market forces to decide the price and quality of domestic air service.

Cabin crew

In this thesis, the term cabin crew is synonymous with cabin attendants, flight attendants or crewmembers as part of an aircrew. Cabin crew are personnel carried on board an aircraft in accordance with the requirements of Chapter 12 of Annex 6 to the Convention on International Civil Aviation. According to the European Aviation Safety Agency (EASA) Commission Regulation (EU) No 290/2012 (Article 11) ‘cabin crew member’ means an appropriately qualified crew member, other than a flight crew or technical crew member, who is assigned by an operator to perform duties related to the safety of passengers and flight during operations.

Crewmember

For reasons of practicality, in this thesis ‘crewmember’ relates to a cabin crewmember and excludes pilots.

Circadian rhythm

Circadian ('about-a-day') rhythms govern all physiological activities including sleep. They are synchronised with exposures during daylight and activity levels. Shifts in time zones will disrupt circadian rhythms, and require time to resynchronise.

Crew pairing

A sequence of flight segments beginning and ending at the same crew hub.

Crew rostering / Scheduling

The process of constructing sequences of duties that are assigned to a crewmember. These sequences consist of a set of flight rotations separated by time off that covers a given time frame. In this thesis, the term schedule or roster refers to a monthly schedule.

Cross contamination

Cross contamination occurs when one object becomes contaminated by either direct or indirect contact with another object which is already contaminated.

Deadheading

Cabin crew 're-positioning' to a duty station or to a home base. While 'deadheading' is part of a duty assignment, cabin crew are not considered working crew members and are not assigned to duty in an aircraft. This implies they are not obligated to help serve and assist passengers, but they would still be required to help in an on-board emergency.

Duty period

A period that starts when a crewmember is required to report for a duty and ends when that crewmember is free from all duties.

Effectiveness

Producing the intended or expected results ("doing the right thing"). Effectiveness trials measure the degree of effect under "real world" settings.

Efficiency

Completing tasks in the least amount of time, with the least amount of resources. In economic considerations, efficiency is the ability to achieve a result intended per unit cost.

Efficacy

The ability to produce an intended, measurable effect under clinical conditions.

Hand hygiene

Hand hygiene relates to any action of hand cleaning, including the removal of visible soil and removal or killing of transient microorganisms from the hands. Hand hygiene may be accomplished using soap and running water or an alcohol-based hand sanitiser.

Hand washing

The physical removal of microorganisms from the hands using plain or antimicrobial soap and running water.

Hazard

Hazards are an inherent property of a substance, agent, source of energy or situation that has the potential of causing undesirable consequences or harm to a person. Hazards at work may include noise, chemicals, electricity, working at heights, a repetitive job, or bullying at the workplace.

Healthy worker effect (HWE)

HWE refers to the consistent tendency of the actively employed to have a more favourable mortality experience than the population at large. Because the severely ill and chronically disabled are typically excluded from employment, HWE is a phenomenon explaining why a working population usually exhibits lower overall mortality rates than the general population.

Jet lag

Also known as syndrome or desynchronosis that results from rapid travel across time zones in combination with sleep deprivation due to circadian rhythm disruption.

‘May’

Indicates an optional course of action.

‘Must’

Indicates a legal requirement exists that must be complied with.

Occupational health and safety

Preventive and therapeutic services and oversight provided in the workplace by trained occupational health and safety professionals, e.g., medical doctors, hygienists, safety technicians.

Risk

Risk is the possibility that harm (e.g. injury, illness or death) may occur when exposed to a hazard. Occupational hazards refer to workplace activities that have the potential to cause or increase the risk of injury or ill health.

Standard

Standards are authoritative statements that reflect the expectations, values and priorities of a profession.

‘Should’

Indicates a recommended course of action.

Toxic fume events

In this thesis, toxic fume events refer to the potential exposure to organophosphate compounds, particularly the chemical tricresyl phosphate (TCP). TCP is present in engine oil and hydraulic fluids and may contaminate the cabin air during the air circulation process. TCP is known to be highly toxic.

Trip

A trip is a collection of flights that a cabin crew member will be operating over the course of one day or several days and sometimes up to two to three weeks. The word "trip" can be substituted for the word "pairing," "line," or "sectors" depending on the airline or country in which cabin crew work.

INTRODUCTION

One of the fundamental questions pertaining to safety in commercial aviation is: “How does a crewmember’s good health benefit flight safety?”, and in turn, “what aspects of the cabin crew workspace may impact a crewmember’s physical and psychological health?” These questions can be approached through the concept of fitness-to-fly. While not yet conceptualised in a formal academic sense, fitness-to-fly encompasses the wider context of good individual health and flight safety.

This topic was chosen as the relevance of cabin crew health to the safety of airline operations has been increasingly challenged (Air Safety Health and Security [ASHS], 2016; Griffiths & Powell, 2012). The personal connection with the topic stems from my long-standing employment as cabin crewmember for two international airlines. It is the insight I gained throughout my flying career that acted as catalyst to produce this work.

Aviation is a dynamic and highly regulated industry, subject to significant legal requirements, and many types of oversight by government agencies (Ferguson & Nelson, 2012, p.26). As a result, cabin crew are affected by regulations and compliance issues that require good health and ad-hoc safety responses. The threshold for making conclusions on individual fitness-to-work is thus slightly different in the aviation context. By illustrating several themes relevant to applied health and safety principles in aviation, I have structured the thesis in a manner that connects the theoretical to the practical in no binding order. Rather than adhering to pre-set and rigid a priori planning, I remained open to questions emerging from the various stages of data analysis. This approach gave the thesis authentic momentum with a strong focus on end user applicability. Given the degree of scientific uncertainty that still surrounds cabin crew health issues, my overall aims are to enable access to real-world operational experiences, enhance the existing knowledge base, and to proactively support research opportunities in this field.

This work brings together two important approaches to understanding occupational health risks: contested illness and risk perceptions. Drawing on previous work on cabin health and occupational hazards, I offer a framework for analysing how cabin crew assess potential occupational risks, and that can ultimately be applied as a self-assessment tool. I clarify the idea of fitness-to-fly and its relationship to the safety role, and highlight the influential factors likely to guide cabin crew as they develop their risk assessments in light of scientific uncertainty.

The problems with conventional assessments of fitness-to-fly can be summarised in three oversimplifications about the nature of such assessments:

- Fitness-to-fly assessment is most useful for initial medical examination for new recruits;
- Recurrent fitness-to-fly assessment contains a bias towards verification, that is, a tendency to confirm the examiner’s preconceived notions;
- It is difficult to develop general propositions based on specific environmental factors that carry inherent uncertainty of risk.

Epistemological background

Challenging questions arose about the most appropriate approach to study cabin crew. Seeking better understanding of the ways perception, place and practice intersect, this thesis exemplifies a constructivist paradigm, which aims to “gain understanding by interpreting subject perceptions” (Lincoln, Lynham & Guba, 2011, p. 102). This work takes the stance that neither positivism nor relativism satisfy the epistemological requirements of research based on phenomena, and that a ‘pragmatic constructivism’ (Hammersley 1992) or ‘interpretivism’ (Bhaskar 1997) are more appropriate. Pragmatic constructivism is characterised by the quest for measures that are contained in, or inferred by, a policy, such as procedures, norms or mechanisms. This position suggests there is a role for methods that are contributing to the evidence base by understanding different perspectives rather than focusing on common meaning (Green & Thorogood 2018, p.32-33). This approach encouraged a recognition of subjectivities and reflexivities not as epistemological differences, but as core characteristics and even opportunities.

The fundamental basis of interpretive and critical approaches is that they propose multiple constructed realities, because different people are likely to experience the world in differing ways (Lincoln & Guba 2000). Such beliefs support a health and safety-focused approach. As cabin crew work in a global environment, their workspace is contextually and theoretically rich, and populated with multiple perspectives and ideologies. Not allowing a multi-narrative approach would lose this unique nature.

Problem Statement

Fitness-to-fly cannot be easily defined. To understand why the conventional fitness-to-fly assessment is problematic, we need to grasp the role of management control and operational realities in airline organisations. For flight safety, the closeness of fitness-to-fly to real-flight situations and its details are important in two respects: First, it is important for the development of a differentiated view of operational reality, including the view that fitness-to-fly cannot be meaningfully understood as simply a rule-governed act; and second, continuous fitness-to-fly assessments are important for the medical professional's own learning process in developing the skill needed to carry out thorough assessments. Concrete outcomes can be achieved via continued proximity to operational reality and via feedback from cabin crew. From both an understanding-oriented and occupational health-oriented perspective, I argue that it is more important to clarify the deeper causes behind a given health problem and its potential consequences than to describe the symptoms of the problem and how frequently they occur.

Opportunities for researchers to study the cabin crew workforce are limited, especially because of limited access to real-life operations. Studies on difficult to reach populations raise a number of specific methodological questions usually absent from traditional research approaches (Faugier & Sargeant, 1997). Initially, a research design using qualitative and quantitative methods had been set up for this PhD, when access to study participants was denied last minute. The difficulties encountered have thus prompted me to access cabin crew via a netnographical framework. The obstacles that presented further demonstrate the limitations of collaborative work.

I first conducted a literature review to determine what is known about the phenomenon of health, safety, and fitness-to-fly in the cabin crew workspace, clarifying the attention on this phenomenon by:

1. Using scientific sources to find out what is known about fitness-to-fly and possible health impacts of the workspace;
2. Describing the operational context of the service role which could lead to safety concerns;
3. Analysing online blog discussions on cabin crew concerns about health and fitness-to-fly;
4. Illustrating the cabin crew role in infectious disease control and related health concerns that evolved from the blog analysis in terms of aircraft disinsection;
5. Illustrating the cabin crew role in infectious disease control and related health concerns that evolved from the blog analysis in terms of inflight food safety; and
6. Discussing the importance of the fitness-to-fly phenomenon and its extent of attention indicated in the results from the blog analysis.

Overall research aims

In this project I address two specific research aims: First, to identify environmental and occupational hazards and risks that may impact cabin crew fitness-to-fly, and how cabin crew assess these risks; and second, what impact certain health states may have on job performance, and ultimately on flight safety. To understand how differences in perceptions shape personal conflicts, both questions require attention to the processes underlying the formation of risk perceptions. I will focus on a range of sub-questions to elicit the personal, social, and managerial challenges inherent in the cabin crew safety role. These sub-aims are specified in the relevant chapter overviews.

Methodology

This PhD thesis is a blended thesis. Chapters 2, 3, 4, and 5 were developed and prepared as separate research papers and then connected with additional information. Chapters 1 is very close to, and extends the developed papers, while chapter 6 combines one paper and additional conceptual analysis.

For this project, I utilise a qualitative facilitation approach, that is the literature review and blog analysis (chapters 1 and 3 respectively) provide a research basis and inform the writing of subsequent chapters. The literature review was conducted in a scoping format, and illustrates how thoughtful application of secondary data can provide new insights into challenging problems such as cabin crew health. Indeed, drawing together data and ideas from a range of disciplines harmonises with arguments about the need for flexible, intuitive, practice-led approaches to research (Webb & Brien 2011).

In line with Chang (2013), I posit that whilst memory and recall might encapsulate autobiographic data, self-reflection upon such data is likely to echo my current perceptions and attitudes, which might uncover for cabin crew online engagement habits. Netnography as research method foregrounds my personal experience as a former cabin crewmember, for which my insights provide a timely and accessible memoir. Using a subjective lens, netnography gives crewmembers the opportunity to voice experiences that would otherwise not be heard. This type of research involves a laying bare of the self to gain new insights and understandings, and offers the potential for management to learn from the experiences and reflections of their staff. In turn, netnography provides for cabin crew to reflect critically upon their professional experiences. In examining the voices of cabin crew, netnography has achieved its goal if it results in new insights and a better understanding in health and safety practices, and if it promotes broader reflection amongst organisations about their safety culture and training practices.

Thesis structure and chapter overview

Chapter 1: The Role of Air Cabin Crew: Literature Review

Chapter 2: The Role of Cabin Crew: Service Aspects

Chapter 3: Online Blog Analysis: Cabin Crew Health, Safety, and Fitness-to-fly

Chapter 4: The Cabin Crew Role and Infectious Disease Control: Aircraft Disinsection

Chapter 5: The Cabin Crew Role and Infectious Disease Control: Aviation Food Safety

Chapter 6: Conceptualisation of Fitness-to-fly

Figure 1. Thesis structure

Chapter overview:

Each chapter contains the relevant references in APA (7th edition) format. In adhering to publishing ethics, different referencing styles have not been altered to suit APA format for chapters containing publications. This also applies to differences in American and British English spelling as per journal or publisher instructions.

Chapter 1 provides an overview of literature relevant to the cabin crew function and comprises the foundation for subsequent publications. Two manuscripts relating to the literature review are currently in progress.

Chapter 2 presents a publication using critical incident technique and autoethnography to highlight challenging elements of the service role. This serves to illustrate service demands that may conflict with the safety role, and sets the context for chapters 4 and 5.

Chapter 3 offers an analysis of cabin crew online blogs to investigate three thesis sub-aims:

1. To evaluate cabin crew's motivation to write blogs and report on the personal health and fitness to fly concerns;
2. To investigate and report the content of the blog writer's concerns about being fit to fly; and
3. To examine risk and perceived responsibility in the context of being fit-to-fly.

By using netnography as analytical tool, I examine cabin crew through subjective narratives and the interaction between those narratives to explore notions of commonness, companionship, engagement, and motivation. In addition, the crewmember perspectives on risk aim to stimulate the existing organisational frameworks, as these may have consequences for fitness-to-fly assessment and the performance of the cabin crew safety role. Supported by the scientific evidence presented in chapter 1, the blog analysis informs thesis aims 1 and 2, and forms the basis for chapters 4 and 5.

The focus of chapters 4 and 5 is on central aspects such as probability, harm, and uncertainty. In particular, the question of how fitness-to-fly can be inferred from these aspects.

Chapter 4 consists of two publications that developed as themes became apparent from the blog analysis. Stemming from the disconnects in aviation guidelines, law and governance, publication 1 relates to the difficulties cabin crew encounter from policy and regulations as part of performing their safety role. Illustrating the role of cabin crew in vector-borne disease control, publication 2 focuses on the controversies surrounding pesticide spraying in aircraft (termed ‘aircraft disinsection’). Both publications inform thesis aims 1 and 2.

Chapter 5 presents 3 publications which further investigate the role of cabin crew in infectious disease prevention. Solidified by the literature in chapter 1, the papers discuss two prominent topics that emerged during the online blog analysis: the role of cabin role in food handling and food hygiene. These works aim to illuminate covert hazards that may exist inflight, and related difficulties in spurring foodborne disease outbreaks. The publications inform thesis aims 1 and 2.

Chapter 6 consists of one publication, one manuscript currently in progress, and offers a concept framework for fitness-to-fly. I present recommendations for future research aimed at fostering a better understanding of required research processes that facilitate analysis of the interdependence between fitness-to-fly and flight safety. The chapter informs thesis questions 1 and 2.

Summary: This section synthesises the previous chapters, and summarises challenges of the cabin crew role on the personal, social, and managerial level.

Early into the candidature, I was offered two internships at the occupational health and safety department of an international airline. The internships focused on completing a statutory risk assessment for cabin crew, as well as participating in research on pandemic preparedness and updating safety-relevant features in operations by conducting a systematic literature review. Lastly, I was involved in the preparation of a three-day workshop on health communication, which assembled a diverse group of stakeholders, including from national health authorities, aviation departments, occupational health, and academia. While these tasks and research efforts did not form part of the thesis, they have aided the development of research questions and methodology. Additionally, involvement in the research project provided me with insights into organisational planning and helped to establish initial contact with stakeholders, which assisted with the conduct of the thesis research.

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CHAPTER 1

The Role of Air Cabin Crew: Literature Review

Thesis structure

- **Chapter 1: The Role of Air Cabin Crew: Literature Review**
- Chapter 2: The Role of Cabin Crew: Service Aspects
- Chapter 3: Online Blog Analysis: Cabin Crew Health, Safety, and Fitness-to-fly
- Chapter 4: The Cabin Crew Role and Infectious Disease Control: Aircraft Disinsection
- Chapter 5: The Cabin Crew Role and Infectious Disease Control: Aviation Food Safety
- Chapter 6: Conceptualisation of Fitness-to-fly

Overview

First, an introductory section outlines the leading academic literature and ideas that are important for understanding the requirements for cabin crew to successfully perform their duties. Next, a historical background on the commercial airline industry sets the context for the cabin crew job profile by describing how changes within the industry impacted on the requirements of the cabin crew profession. With a view to how airline organisations have responded to these new stimuli, subsequent sections then discuss the following key themes:

1. Safety culture
2. The role of cabin crew
3. Training
4. Crew phraseology and bonding
5. Health systems, duty of care, and fitness-to-fly
6. Scheduling
7. Exposure to environmental and occupational hazards during operations
    - Fatigue
    - Cosmic Ionising Radiation
    - Cabin Air Quality and Fume Events

  - Oxidative Stress
  - Mental Health Disorders
  - Infectious Disease Control: Exposure to Pesticides and Inflight Food Hygiene

8. Risk perception: Risk from a cabin crew perspective
9. Compliance with rules and regulations
10. Safety versus service: Role conflicts

I reviewed the literature with the goal of moving from the root causes of occupational conditions to practical solutions in daily operations. The selection of themes is not a random one. From a topical perspective there are important developments and dynamics which are ongoing as aviation evolves. The empirical evidence has not always supported themes such as the role of cabin crew in infectious disease control, or the practicality of fitness-to-fly assessments, in turn leading onto questions of optimal scheduling, training and regulatory regimes, and the trade-offs which cabin crew must make between the health implications of flight operations and those which accompany regulation. There are possible lessons to be learned for those bodies framing regulatory and operational codes, which have set the pace in policy. Ideally, in this context, one would seek to cover all in such an analysis, but topicality and pragmatism lead me to focus primarily on those issues with a potential direct or indirect impact on flight safety and public health. Each of these themes sets out the development of the cabin crew role, the specific reasons behind subsequent health-related factors, and comments on the impacts of these changes. There is also some forward thinking as to where the changes are likely to lead in the future of air travel.

Purpose of the literature review in relation to my research question

- To provide an authoritative up to date overview of available evidence;
- To formulate key research questions to guide the online blog analysis and future research;
- To promote the development of a theoretical framework for a fitness-to-fly self-assessment tool.

Introduction

The airline industry is a large and fast-growing sector in tourism, with an increase of flights at both global and regional level. The International Air Transport Association (IATA) expects nearly eight billion people to travel each year by 2036, with Asia and Africa alone doubling in size each decade (International Air Transport Association, 2017). Flight safety is of fundamental importance to airline operations. Safety permeates all levels of an airline organisation, and the concept of professionalism is tightly woven into all levels of an airline business. In commercial air travel, cabin crew have the important function to ensure passenger safety. The literature on flight safety identifies the pivotal role of cabin crew in the implementation of effective skill-, and knowledge-dependent features to ensure cabin safety, and to protect the health and safety of passengers. While the level of service provision is an important consideration on which customers base their choice, an airline's safety record remains a decisive factor for customer preference (Koo et al., 2018; The Economist, 2015). Global studies of travel perceptions and behavioural trends have revealed that safety and security were the key deciding factors in travellers' decision-making process when choosing a destination (Singleton & Wand, 2014; CNN, 2013). Customers thus need to be confident in airline operations.

Historically, little attention has been paid to the work role of cabin crew when compared to pilots or air traffic controllers. Although they share the same work space and are connected through interlinking roles, cabin crew remain an understudied field in the tourism and occupational health and safety literature (Cano, 1998; Griffiths & Powell, 2012; McNeely et al., 2014; McNeely et al. 2018a, 2018b). Air cabin crew work in dual roles: as front-line customer service representatives and in the key position as 'safety agents' to ensure cabin safety. Safety duties not only relate to emergencies such as following evacuation procedures, but also include First Aid training to respond to medical emergencies, knowledge about infectious disease handling and prevention, and awareness of their extended role as inflight food handlers.

The individual health of cabin crew is a crucial determinant in carrying out safety-related duties. For the protection of passengers and the safety of the flight, airline operators are required to have a medical clearance procedure in place that is consistent and based on accepted physiological principles (IATA, 2018d). To ensure equal application of medical standards to new recruits and existing staff, cabin crew must declare any new medical problem, which develops during the period of employment, with potential safety ramifications (Griffiths & Powell, 2012). While annual medical checks provide some form of assurance for general fitness-to-fly, it is unclear to what extent occupational and environmental factors affect cabin crew health in day-to-day operations, and how this may in turn impact on cabin crew to adequately perform their safety role.

The analysis of the cabin crew safety role has focused predominantly on avoiding the negative outcomes of incidents, accidents, or abnormal procedures. However, cabin crew are exposed to numerous hazards with a high risk of occupational injury (Boyd & Bain, 1998; Livingston, 1992; McNeely et al., 2014; McNeely et al., 2018b; Tvaryanas, 2003). Injury and illness rates are significantly higher than those of other commercial aviation workers (van Drongelen et al., 2013). Cabin crew also experience unique mental and physical stress during their work, as well as exposure to environmental hazards such as cosmic radiation, communicable disease, and pesticides (Centers for Disease Control and Prevention, 2017a). Changes in operational procedures, as well as concomitant changes in occupational hazards, have brought about new challenges to the cabin crew role (Baruah & Patrick, 2014; McNeely et al., 2018b). For example, Taylor and Moore (2015) describe how decades of cost reduction have eroded working conditions, introduced inferior contracts for new recruits, and intensified work among the workforce. Concerns for the health and safety of air quality in aircraft cabins, too, have received increased attention (Global Cabin Air Quality Executive, 2019; Harrison & Mackenzie Ross, 2016; Michaelis et al., 2017; Spengler & Wilson, 2003). While acute and chronic symptoms from toxic engine fumes have been linked to the occupational environment of cabin crew (Michaelis, 2016; Michaelis et al., 2017), reports also point to the exposure of cabin crew to pesticides sprayed in aircraft cabins (a procedure termed ‘aircraft disinsection’) to prevent the introduction of disease-carrying mosquitoes (Sutton et al., 2007; WHO 2018). Similarly, accidents and safety-critical incidents result from the combined effect of long standing conditions, such as safety culture, working practices, health-related behaviours and isolated unsafe acts by individuals (Andersen et al., 1990; Maurino, 1992).

Cabin crew have expressed concern about performing their job safely under current operating conditions (Avers et al., 2011; McNeely et al., 2014). Moreover, increasing threats of terrorism and the spread of infectious diseases - facilitated through air travel - will comprise an even larger proportion of the cabin crew role as more people will be travelling by air (IATA, 2017). Combined, these challenges present an extension of the safety role. For cabin crew, the retention and adaptation of safety standards and training will therefore be necessary to meet future skills and response requirements.

Given the lack of scientific knowledge in these fields, attention is drawn to the topicality of this research at a time when air travel, as well as infectious disease risks and security threats are increasing, yet little understanding of the working life of cabin crew exists. Through addressing issues such as the role of cabin crew in infectious disease control, or the impact of extended flight times on fatigue, the results can help build a research base for occupational health and tourism scholars, as well as provide guidance for airline managements and airline regulators. In addition, the results of this review may be applied to other professions in the service industry.

At the time of planning this study and reviewing the literature, the presence of COVID-19 was not on the horizon of problems for cabin crew and aviation. Its subsequent global effects bear out the points made in this review at an earlier time. The relevance of much of this thesis remains highly pertinent to pandemic issues and specific later chapters explain these immediate and contemporary links.

Historical Perspective: Airlines and the Role of Cabin Crew

The role of cabin crew first became known as an occupation when passenger air travel began in the early 1920s. In March 1912, Heinrich Kubis became the first ‘air steward’ in history, serving passengers on the German airline DELAG (Aerotime Hub, 2016). Kubis is credited with encouraging passengers to jump from the windows when the

Zeppelin ship 'Hindenburg' burst into flames at Lakehurst, New Jersey on 06 May 1937. Also called 'couriers' or 'cabin boys' (e.g., at British company Daimler Airways), the air steward job focused on handing out cotton earplugs or hot water bottles, and aiding passengers during the flight and upon disembarkation. In 1930, Boeing Air Transport hired eight trained nurses (see Figure 2), arguing that nurses would make an ideal addition to the flight crew in that they could care for sick passengers. Their duties also included winding the clock in the cockpit, preventing passengers from throwing cigarette stumps out of the windows, and killing flies after take-off (Filiepa, 2012). Although soon after stewardesses were no longer required to have a nursing degree, the nurturing character remained a key element in the profession.

Figure 2. The "Original Eight" flight attendants at Boeing Air Transport, 1930

Source: http://cdlifestylepremium.com/flair-in-the-air

By the 1950s, stewardesses had become an integral part of the airline industry. As the profession grew into a symbol of sophistication and glamour in the 1960s, airlines imposed tight restrictions on stewardesses (see Figure 3). For example, the average tenure of a stewardess was two to three years, largely due to age restrictions. They were generally underpaid, had few benefits and were 'grounded' at age 32 whilst male stewards could fly until they reached their sixties (Conde Nast Traveler, 2017). Some airlines accepted fewer than three percent of its applicants, indicating that being a stewardess had become a popular job.

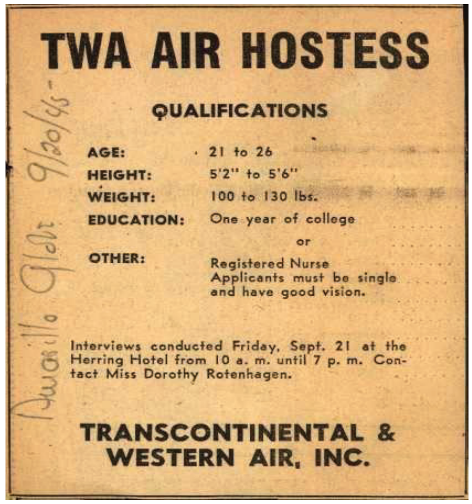

Figure 3. Job advertisement Trans World Airlines (TWA) in the 1960s

Source: https://www.pinterest.ch/pin/104216178860287313/

Flying still was an exotic and rare treat for most, and commercial aviation was highly regulated (Hunter, 2006). National governments and international agreements dictated flight routes, flight times, and pricing structures; even the amount of legroom and the number of courses that constitute a meal were prescribed by international agreement. There was little room for innovation, and for airlines to distinguish themselves. While many airlines had only hired male stewards until the 1940s, airlines realised that the very femaleness of ‘stewardesses’ was a valuable marketing tool (see Figure 4), and increasingly stressed the importance of hiring females (Whitelegg, 2007). Broad advertising promised “the end of routine travel with hostesses to match” (Vanity Fair, 2002), and cultural changes lifted air hostesses to their apex as icons of glamour (Forseth, 2017). Irrespective of the advertising rhetoric used, most commercial airlines considered flight attendants to be service workers.

Figure 4. Southwest Airlines flight attendants, in hotpants worn during the 1970s

Source: https://www.cntraveler.com/story/a-timeline-from-stewardess-to-flight-attendant

In the late 1960s, being an airline stewardess was a prestigious but precarious profession. Employees could be dismissed for unreasonable barriers such as marrying, gaining weight, or reaching the age of thirty-two (Escolme-Schmidt, 2013). The resistance of stewardesses to such policies not only inspired a consciousness of gender inequality, but also the organisation of female labour unions, and the filing of lawsuits against workplace discrimination (Wade, 2017). Civil rights laws subsequently made it illegal for airlines to discriminate on the basis of age, sex, or race (Population Reference Bureau, 2009). Thus, the airline industry had to abandon its preference for hiring women as well as its no-marriage and no-pregnancy rules.

At the root of perceptions of glamour in airline employment was the fascinating nature of travel itself. Airlines used cabin crew as depiction of prestige ascendancy, “remote from an ordinary everyday life that most people experience” (Whitelegg, 2007). Compared to today’s ‘mass tourist’ experience, work in this exclusive environment spelled adventure, and also brought about opportunities that arose from travelling to far-away destinations. However, with the introduction of the low-cost business model, newly accessible tourist destinations and intensive marketing strategies, the glamour attached to the job gradually wore off (Baum, 2010).

The establishment of the ‘Airline Hostesses Association’ in Australia in the 1960s, or the U.S. ‘Association of Flight Attendants’ in the 1970s, transformed the cabin crew job from a temporary adventure into an actual career (Whitelegg, 2003). Taking an active interest in cabin crew working conditions, these unions professionalised the role of cabin crew in many ways, and the ‘stewardess’ or ‘air hostess’ became a ‘flight attendant’. Unions also began to highlight the difficult physical conditions of flying, as crewmembers and passengers began experiencing physiological problems due to crossing several time zones within a few hours (Air and Space, 2007). Later termed ‘jet lag’, this phenomenon was first experienced after long-distance trips on faster turboprop aircraft. At the same time, the very nature of commercial aviation was changing.

The US Airline Deregulation Act in 1978 heralded a new era of air travel. By removing government control over fares and market entry of new airlines, the airline industry could offer lower fares to ever more routes, leading to an increase in the number of flights and passengers (Button, 2017). Rather than focusing on which airline had the most attractive flight attendants, deregulation also offered airlines another way to ‘compete’. As an international industry, these changes were of international importance (Doganis, 1989; Hoekman, 1990). Rapid liberalisation of commercial aviation resulted in a significant increase in the demand for global air travel, causing intense competition among international carriers for profitable long-haul flights (Forbes, 2018; Kohl & Karisch, 2004). As a response, airlines formed multinational alliances to strengthen their international position. Combined, these alliances were in a strong position to influence regulatory standards for airline operations.

In contrast to the ‘era of the glamorous days’, the low-cost business model now acts as metaphor for contemporary air travel (Baum, 2012). The emergence of low-cost air travel has not only contributed to the decline of glamour, but has radically altered the work relations environment, forcing airline employees to adapt to a new and unfamiliar work environment. For example, low-cost carrier (LCC) campaigns tend to frame the role of cabin crew as being part of a young, trendy mindset, with images focusing on concepts of appearance rather than capacity. Accentuation of the safety role is therefore of considerable value for cabin crew today in that it holds an aspiration that far exceeds the work-related demands or financial rewards. Being cabin crew is not just a job, but a way of life; a system of order and stability (Baum, 2012).

The development of international standards and regulations to better define cabin crew performance requirements were first formalised by the International Civil Aviation Organization (ICAO) through the Chicago Convention of 1944 (International Civil Aviation Organization, 2006). Reflecting the multi-national nature of the ICAO based on an effort for harmonising regulatory processes, efforts to build global standards also occurred in collaboration with other international organisations such as the IATA (IATA, 2012). Layers of the airline operating context relevant to cabin crew are:

- National and international regulations governing aviation operations;
- Internal airline policies and procedures;
- Cabin crew manuals and medical requirements;
- Initial and recurrent training;

- Occupational hazards and respective risk management;
- Environmental hazards and respective risk management;
- International passengers and their cultural expectations.

The establishment of LCCs following the deregulation process created an enduring split in airline culture (Forbes, 2018; Kohl & Karisch, 2004). The basic features of the airline industry are that it has global dimensions, where profitability depends largely on maximising revenue in the face of variable demand (Jones, 2012). The combined pressure of aggressive marketing strategies and the inability to control disruptions such as weather conditions or security situations, explains why reducing operating costs reduction remains on the top of airline managements' priority lists (Eller & Moreira, 2014). Crew represent the second largest cost to airlines (Bayliss, 2016; Belobaba et al., 2015). While flight safety continues to be of paramount importance, the growth of international competition is increasingly forcing traditional airlines to adopt practices and policies of their low-cost competitors. This has led to significant changes in the industry's operating structures (Civil Aviation Safety Authority, 2012), and may generate the risk of reducing expenditure on training and maintenance and prioritise profit over employee health and safety (Boyd, 2001; Michaelis et al., 2017). For example, contract-based employee models have been criticised of harbouring potential safety risks. Such models are counterproductive to developing a safety culture and instead induce a culture of mistrust, which may ultimately undermine safety efforts (Flight Safety Australia, 2015).

While country-specific aviation regulatory systems define the parameters for cabin crew duty time (e.g. European Aviation Safety Agency, 2010), unions have increasingly expressed concerns about cost saving programmes due to commercial pressures, such as quicker turnaround times and service-intensive flight segments. These programmes not only extend the cabin crew service role, but contribute to neglect of safety duties and may ultimately compromise flight safety (Transport Workers Union, 2010). New approaches to cost-saving measures are thus likely to undermine consistency in cabin safety practice by dictating the option of meeting minimum regulation requirements rather than applying best safety practice.

Flight safety is embedded in an airline's organisational structure. Correspondingly, airlines have a duty of care for the health and safety of their workforce. The structured safety activities in all sectors of the air transportation system aim to ensure that complex risks to aviation safety are effectively controlled. The IATA verifies that most accidents and incidents result not from technical malfunction, but from the actions and decisions of crew associated with aircraft operation (IATA, 2018b). Safe air travel is thus not just about the proper functioning of aircraft. Within the tourism system, Cohen (2009) correspondingly highlights how airlines tend to avoid discussing matters of flight safety that harbour real threats of bodily harm or exposure to hazards. There is also silence about the darker side of inherent risks in a flight experience, obscured by a focus on the pleasure-enhancing aspects of travelling (Williams & Baláž, 2015). Optimal flight safety outcomes therefore largely depend on a risk-based approach to industry surveillance by both airlines and regulatory bodies.

Methodology: Literature search

The need to highlight the dominant public perceptions of relating cabin crew more with the service than the safety role has sparked an interpretive approach to synthesise complex literature. Such an approach allows for exploring the complex issues that surround the work space of this occupational group, and reflects the inherently contingent and intuitive realities of practice and experience (Dixon-Woods et al., 2006). Exploring the basis of different aspects and resulting knowledge allowed for identifying gaps and uncertainties that provide rationales for future research.

In addition, the review has drawn on the author's autoethnographic account and own work (Grout, 2015). The strength of this iterative approach is that it allows for covering interdisciplinary material that includes both quantitative and qualitative studies. Such an approach further offers possibilities to explore overlapping areas in the aviation, tourism and health literature that have been neglected in the past. Insights may be brought together in new ways by introducing a holistic approach to this complex field.

Search strategy

To retrieve the most comprehensive evidence and produce results that reflect the broad spectrum of topics, I used the keywords in Table 1 for title and abstract terms to search for papers published between 1975 and 2018 with no language restrictions. This timeframe was chosen for two reasons. First, to provide an historical overview from the inception of the cabin crew work in modern jet aircraft, and second, to reflect a balance between the need to include as much evidence as possible and maintaining relevance to contemporary conditions.

Table 1. Literature search: key terms and synonyms

Key search term	**Synonyms**
Cabin crew	Flight attendant, air hostess, stewardess, aircrew
Flight safety	Safety role, in-flight, performance, duties, emergency, cabin air
Aviation	Airline industry, aircraft, commercial, operations, low-cost
Health	Fitness to fly, unfit to fly, wellbeing, medical, physical, psychological, occupational, environmental
Disease	Infectious, food-borne, food hygiene, vector-borne, disinsection, pesticides, toxic air
Fatigue	Jet lag, shift work, sleep, rest,
Schedule	Roster, leg, flight sector, ultra long-haul

The search was conducted using the following sources:

- Cochrane Database of systematic reviews
- Key subject databases Google Scholar, AMED, Web of Science, SCOPUS
- Featured journals from ScienceDirect, Safety Science and Accident Analysis and Prevention databases
- Key journals for Occupational Health and Safety
- Multi-disciplinary databases Academic OneFile and ProQuest Central
- James Cook University library sources
- Manual searches of the references and retrieved literature

Inclusion and exclusion criteria

Papers were selected for analysis if they included any assessment of the cabin crew safety role and associated topics on flight safety and health, as described above. Literature was excluded based on anecdotal reports, and where only abstracts were available. Articles were excluded from analysis if the study population were pilots, unless they clearly addressed issues that could be translated to cabin crew or supported explanations of the common workspace. This exclusion prevented consideration of studies where health and safety issues reflect the pilot population's specific medical requirements which are naturally more stringent. Finally, using a snowball approach, I reviewed and evaluated references identified by the primary search for possible inclusion. Figure 5 illustrates the literature selection process.

Results

The findings are presented as an overview of the most critical factors which determine response performances, namely the characteristics of operational factors, occupational and environmental conditions, as well as determinants of individual health and work-life balance. Google Scholar identified an initial 3360 possible references, of which 421 were relevant to the cabin crew role and crewmember health and safety. Subsequent searches in the specified databases and libraries yielded a further 186 references for cross-referencing. The literature search was further refined by exploring key words for health issues as they were identified by the search, including occupational stress and sickness absence. Manual searching of identified papers provided a further 81 references. After removing duplicates and applying inclusion and exclusion criteria, I identified 70 articles as being relevant to the review.

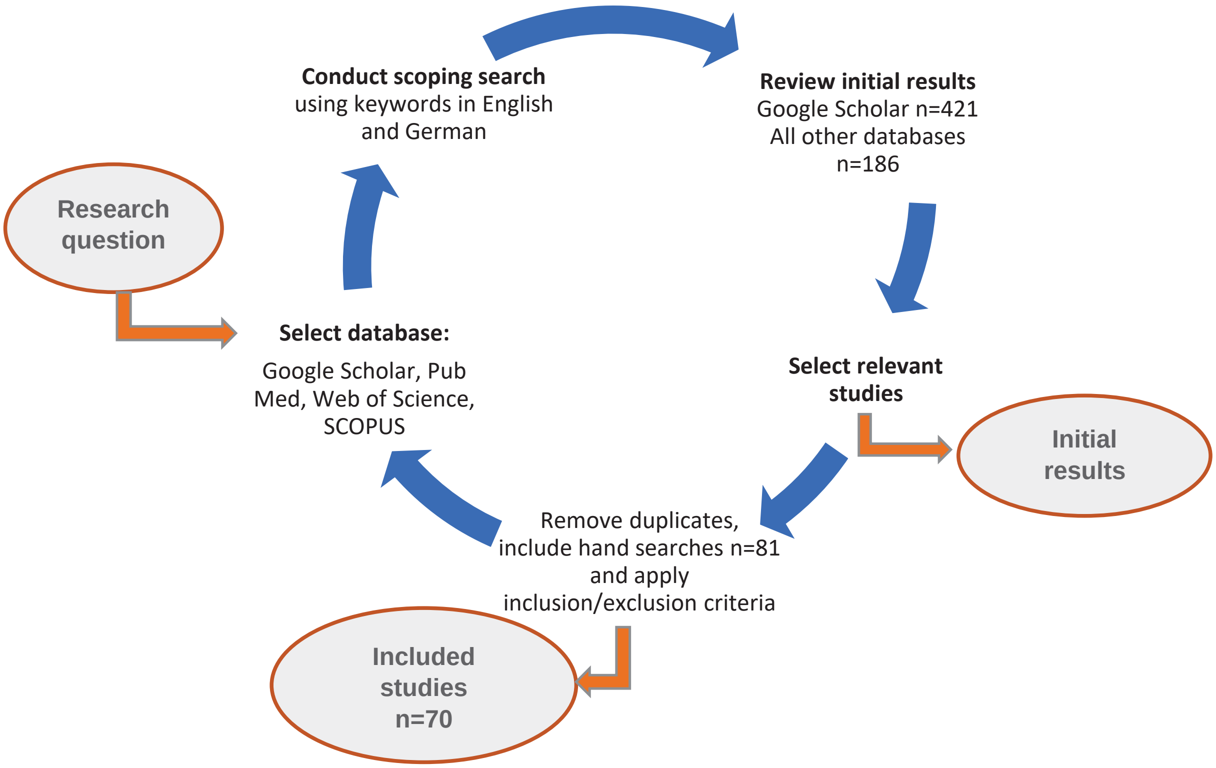

Figure 5. Literature selection process

The selected papers added to the number and to the content of themes developed at the outset of the research. The discussion of results in the next sections relates to the identified themes. Only the main themes are recorded in the literature review. Table 2 is a list of included papers.

Table 2. Composite table of relevant literature in alphabetical order

Nr	Author(s)	Title
1	Abeyratne (1998)	The regulatory management of safety in air transport
2	Air Safety Health and Security (ASHS) (2016)	FAA Flight Attendant Fatigue Studies
3	Al-Serkal (2006)	Stress, Emotional Labour and Cabin Crew: Does Emotional Labour Influence the Well-Being and Retention of Cabin Crew?
4	Archer et al. (2014)	Mistimed sleep disrupts circadian regulation of the human transcriptome
5	Avers et al. (2009)	Flight attendant fatigue, part I: national duty, rest, and fatigue survey
6	Avers et al. (2009).	Flight attendant fatigue, part VI: fatigue countermeasure training and potential benefits

7	Avers et al. (2011)	Flight Attendant Fatigue: A Quantitative Review of Flight Attendant Comments
8	Avis (2012)	The Social and Psychological Aspects Behind Flight
9	Bagshaw (2010)	Fitness to fly
10	Ballard et al. (2004)	Integrating qualitative methods into occupational health research: a study of women flight attendants
11	Ballard et al. (2006)	Self-perceived health and mental health among women flight attendants
12	Baruah & Patrick (2014)	Influence of Emotional Labour on General Health of Cabin Crew and Airline Ground Employees
13	Bergman & Gillberg (2015)	The Cabin Crew Blues: Middle-aged Cabin Attendants and Their Working Conditions
14	Baum (2012)	Working the skies: Changing representations of gendered work in the airline industry, 1930–2011
15	Buja et al. (2006)	Cancer Incidence among Female Flight Attendants: A Meta-Analysis of Published Data
16	Caldwell, J.A. (2005)	Fatigue in aviation
17	Cano (1999)	Passenger Airline Cabin Staff Stress Reduction Program
18	Chen, C.-F., & Chen, S.-C. (2012)	Burnout and Work Engagement Among Cabin Crew: Antecedents and Consequences
19	Chen, C.-F., & Chen, S.-C. (2014)	Investigating the Effects of Safety Management System Practice, Benevolent Leadership and Core Self-evaluations on Cabin Crew Safety Behavior.
20	Cho et al. (2000)	Chronic jet lag produces cognitive deficits
21	Chute & Wiener (1995)	Cockpit/Cabin Crew Performance: Recent Research
22	Cohen & Goessling (2015)	A darker side of hypermobility
23	Damos et al. (2014)	Safety Versus Passenger Service: The Flight Attendants' Dilemma
24	DeHart (2003)	Health issues of air travel
25	Edmonson (1996)	Learning from mistakes is easier said than done: group and organizational influences on the detection and correction of human error
26	Gander et al. (2011)	Fatigue risk management: organizational factors at the regulatory and industry / company level
27	Gill & Shergill (2004)	Perceptions of safety management and safety culture in the aviation industry in New Zealand
28	Griffiths & Powell (2012)	The Occupational Health and Safety of Flight Attendants
29	Hammer et al. (2012)	Cosmic radiation and mortality from cancer among male German airline pilots: extended cohort follow-up
30	Hammer et al. (2014)	Mortality from cancer and other causes in commercial airline crews: a joint analysis of cohorts from 10 countries.
31	Harrison et al. (2009)	Exposure to aircraft bleed air contaminants among airline workers. A guide for health care providers.
32	Holcomb et al. (2009)	Flight attendants fatigue, part IV: Analysis of incident reports
33	Houston et al. (2012)	Fatigue Reporting Among Aircrew: Incidence Rate and Primary Causes
34	Janic (2000)	An assessment of risk and safety in civil aviation

35	Kanki & Palmer (1993)	Communication and crew, resource management
36	Kelleher & McGilloway (2005)	Survey Finds High Levels of Work-related Stress Among Flight Attendants.
37	Kim & Park (2014)	An Investigation of the Competencies Required of Airline Cabin Crew Members: The Case of a Korean Airline
38	Kohl & Kahrisch (2004)	Airline Crew Rostering: Problem Types, Modeling and Optimization
39	Kojo et al. (2013)	Risk factors for skin cancer among Finnish airline cabin crew
40	Lee et al. (2006)	Development of Utilities to Assess Airline Cabin Safety Culture
41	Liang & Hsieh (2005).	Individual's perception of career development and job burnout among flight attendants in Taiwan.
42	MacDonald et al. (2003)	Job Stress Among Female Flight Attendants
43	McKneely et al. (2014)	The self-reported health of U.S. flight attendants compared to the general population
44	McKneely et al. (2018)	Estimating the health consequences of flight attendant work: comparing flight attendant health to the general population in a cross-sectional study
45	McKneely et al. (2018)	Cancer prevalence among flight attendants compared to the general population
46	Morley-Kirk & Griffiths (2003)	Cabin Crew Work Stress International Research 2003
47	Nagda & Hodgson (2001)	Low relative humidity and aircraft cabin air quality
48	Nesthus et al. (2007).	Flight Attendant Fatigue
49	NIOSH (2012)	Health concerns for flight attendants
50	Omholt et al. (2017)	Subjective health complaints, work-related stress and self-efficacy in Norwegian aircrew
51	Pukkala et al. (2013)	Cancer incidence among Nordic airline cabin crew
52	Rhoden et al. (2008)	Cabin crew training to control disruptive airline passenger behavior: A cause for tourism concern?
53	Roma et al. (2010)	Flight Attendant Fatigue Recommendation 2: Flight Attendant Work/Rest Patterns, Alertness, and Performance Assessment
54	Roma et al. (2012)	Analysis of Commute Times and Neurobehavioral Performance Capacity in Aviation Cabin Crew
55	Sanlorenzo et al. (2015)	The risk of melanoma in airline pilots and cabin crew: a meta-analysis
56	Sharma, L. (2007).	Lifestyles, flying and associated health problems in flight attendants
57	Sharma & Shrivastava (2004)	Jet lag and cabin crew: Questionnaire Survey
58	Simpson et al. (2004)	Cabin crew expected safety behaviours
59	Sonnentag & Natter (2004)	Flight Attendants' Daily Recovery from Work: Is there no Place like Home?
60	Stoleroff & Correia (2009)	The place of health, safety and work conditions in the demand priorities of workers: the case of airline cabin crews
61	Striker, Dimberg & Liese (2000)	Stress and business travel: Individual, managerial and corporate concerns.
62	Suvanto et al. (1990)	Stress and strain in flight attendant work

63	Tashkin et al. (1983)	Respiratory symptoms of flight attendants during high-altitude flight: possible reaction to cabin ozone exposure
64	Tvaryanas (2003)	Epidemiology of turbulence-related injuries in airline cabin crew, 1992-2001
65	van den Berg et al. (2015)	Monitoring and Managing Cabin Crew Sleep and Fatigue During an Ultra-Long Range Trip
66	van Drongelen et al. (2015)	Sickness absence and flight type exposure in flight crew members
67	Wade (2014)	Mother, Sex Object, Worker: The Transformation of the Female Flight Attendant
69	Whitelegg (2007)	Working the skies: The fast-paced, disorienting world of the flight attendant
69	Winget et al. (1984)	A Review of Human Physiological and Performance Changes Associated with Desynchronosis of Biological Rhythms
70	Winter et al. (2014)	Prevalence of risk factors for breast cancer in German airline cabin crew: a cross-sectional study

Discussion

1. Safety Culture

The need for understanding the concept of safety culture in airline operations arises from three needs: first, to describe the factors underpinning safe behaviour in the cabin workplace; second, the need to define the corporate ‘ethos’ regarding safety in an airline organisation; and third, as important factor that will moderate changes in operational practice. Numerous studies have defined safety culture in various industries, yet little research has focused on measuring cabin safety culture in an airline context (Roelen & Klompstra, 2012; Lee et al., 2006). The question as to what constitutes ‘flight safety’ largely lies in the definition of the word ‘safety’. In addition, the meaning of the terms ‘safety’ and ‘security’ varies considerably from one context to another, leading to potential ambiguities in their use and coverage.

The expansion of international flights has launched a discussion about flight safety, but has failed to deal with the meaning of ‘safety’ and how it differs from ‘security’. The discussion concentrated on adding adjectives such as `inflight', or `environmental' to safety but has largely ignored the meaning of the noun `safety' itself. Damos et al. (2013) identified safety, security, and passenger service as the three different sets of cabin crew duties. In line with the organisational definitions the authors provide a workable distinction between 'safety' and 'security' and explain how 'safety' and 'security' differ in connotation, and that the context must be weighed when deciding which term to use. The ICAO (2013) defines safety as

> *"the state in which risks associated with aviation activities, related to, or in direct support of the operation of aircraft, are reduced and controlled to an acceptable level."* (Annex 19, Definitions)

Similarly, Boeing (2016) notes how aviation safety focuses on various components and efforts taken to ensure aircraft are free from potential hazards. The words 'high', 'medium' and 'low' are typically used for grading separations. However for safety, no acceptable level of safety exists, rendering the concept of safety a binary condition of either 'safe' and 'unsafe' (Maguire, 2006). Safety duties are concerned with measures taken to avoid injury or harm within the cabin space, so are more 'internal' and aim to 'enfold'. 'Security', in contrast, is defined as

> *"the safeguarding of civil aviation against acts of unlawful interference, achieved by a combination of measures as well as human and material resources"* (ICAO, 2017a, Annex 17).

Aviation security is only one component of many that may affect crew and passenger safety. Primarily concerned with external objects or activities that could interfere with safe flight operations, security relates more to surrounding factors or conditions that could pose a risk to flight safety. Examples include airport security systems, pre-boarding procedures and intelligence gathering. Buzan et al. (1998) further conceptualised 'security' as lifting an issue out of normal politics and into a different area of operation. The introduction of extraordinary security measures by the US following the 9/11 event is a pertinent example of such a logic of exception. Characterised by an environment of increased threats, the aftermath of 9/11 further underscores the real potential for cabin crews to be directly exposed to violence in their workspace (Macdonald et al., 2003).

'Flight safety' in its generic use thus has several components. Making their respective meanings more explicit can help ensure a more consistent and complete risk coverage. A composite of existing definitions is employed in this review, hence, safety can be considered as the condition where all aspects and actors in the aircraft operating environment are protected from hazards and risks.

Although safety culture is considered essential for an aviation safety management system, the constituents of a healthy safety culture are not entirely clear (Roelen & Klompstra, 2012). Little agreement exists among researchers on the dimensions that comprise safety culture, and the safety behaviours and competencies expected from cabin crew (Kim & Park, 2014; Simpson et al., 2004). Implicit in the airline industry is the message that employee wellbeing, morale and motivation are key to a supportive safety culture and the successful delivery of inflight duties (Kapur et al., 2015). According to Cox and Cheyne (2000), key factors of a strong safety culture for high-risk environments (such as aviation) include management commitment, involvement and actions; employee relationships and communication; priority of safety rules and procedures; and safety reporting culture. In the UK, similar key features have been identified and developed into a safety culture toolkit: leadership, two-way communication, employee involvement, learning culture and attitude towards blame (Health and Safety Executive, 2005). For cabin crew, the main building block of a safety culture is an organisational culture that recognises the safety role, and as such values their role in creating safety (Flight Safety Australia, 2015). Understanding the interaction of aviation safety management systems with, for example, environmental and occupation health and safety systems, is therefore a vital concern.

Safety climate and safety training, as well as management commitment to safety, have been widely recognised as major antecedents to predict employees' safety behaviour and actual performance (Cooper & Phillips, 2004; Marsh et al., 1998). For instance, the inflight manager plays an important role in shaping the safety culture within an airline organisation by motivating crew to complete safety tasks timely and diligently. Complicated by a climate of mutual suspicion between cabin crew unions and management, several authors have criticised the lack of recognition and support for crew on behalf of airline organisations (Omholt et al., 2017; Flin et al., 2000; Lee et al., 2006; Neal & Griffin, 2002). For example, tense labour relations and an employee model based on contracts may harbour a potential safety risk. Such contract-based models induce a 'culture of mistrust and discontent' and thus ultimately undermine the very same safety efforts (Flight Safety Australia, 2015). Perceptions on safety culture are further influenced by different cabin crew backgrounds (Lee et al., 2006). Figure 6 illustrates the essential components of an effective safety culture.

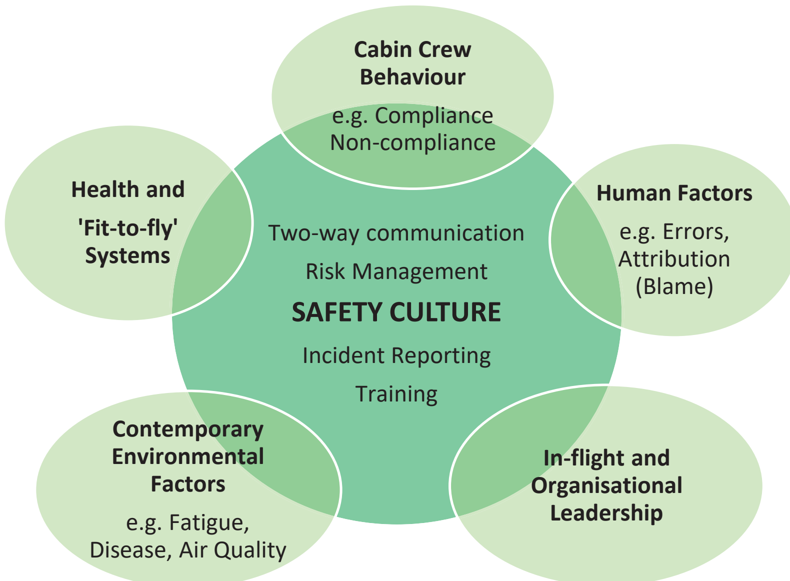

Figure 6. Elements of the Airline Safety Culture

Important preconditions for cabin crew to adequately perform their job are good health and emotional stability, as well as being empathic, adaptable, empathic, reliable, and self-sufficient (McNeely et al., 2014; Partridge & Goodman, 2006). Commonly, people who display these qualities require a degree of emotional nurturing from the organisation in turn. This often cultivates a strong dependency by crewmembers to where the organisation becomes more than an employer providing financial remuneration. Instead, the organisation is expected to be supportive across the board (Partridge & Goodman, 2006). In practice, however, it is unclear how these perceptions manifest in cabin crew's work performance and how they influence their compliance behaviour. Pointing to the lack of support perceived by cabin crew regarding exposure to risk factors and individual health, Stoleroff and Correia (2009) and Kelleher and McGilloway (2005) highlight the importance of formal support and appropriate recognition of safety duties for crew to adhere to prescribed practices. Consequently, understanding the factors that impact most on individual health is essential for bringing flight safety measures into line with cabin crew responses in the event of safety-critical incidents.

Aircraft-related incidents and accidents are usually complex and develop from multiple causes. By identifying effective communication as a fundamental vehicle for building a safety culture, Avis (2012) explains how the majority of commercial aviation accidents were caused by failure of communication and decision making. In an early study, Leventhal et al. (1965) demonstrated the importance of providing context in risk communication. Compliance with protocols and regulations is vital, but for fostering compliance the challenge is to create an open culture to ensure consistency in communication across the organisation. For example, based on the European Parliament Regulation, the European Aviation Safety Agency (EASA) encourages the reporting of incidents and occurrences in a non-punitive and protective environment (EASA, 2020). For cabin crew, safety awareness includes the ability to recognise the wide-ranging potential effects of one's actions or non-actions on the operational environment. This pertains to both service and safety tasks, and corresponds with the difficulty noted by Kanki and Palmer (1993) to fully control for differences in crew coherence and overall flight performance. These insights confirm that communication plays an important role for management to convey health and safety messages to crewmembers.

The quote by airline Captain Chesley B. “Sully” Sullenberger illustrates the importance of effectively translating safety culture into practice. Dedicated to the pursuit of safety throughout his career, Sullenberger became a source of inspiration for aviation safety specialists after he successfully executed an emergency water landing of a disabled aircraft in the Hudson River off Manhattan, New York City, on 15 January 2009 (see Figure 7). Widely praised for the decisiveness and dedication with which he handled the emergency, he noted:

> *‘Safety should be part and parcel of everything we do … Every decision that is made, whether it’s administrative, budgetary, or otherwise, should take safety implications into account because there is such an important business case for doing so … What we have right now, quite frankly… are islands – visible islands of excellence in a sea of invisible failures, with risk lurking just below the waterline. We need*

to widen those islands of excellence. We need to connect these islands with more dry land. We need to address these areas of risk. That is going to require transparency, it's going to require data, it's going to require personal story telling, and it's going to require effective use of health IT' (Sullenberger, 2013).

Figure 7. Emergency landing of US Airways Flight 1549 in the Hudson River, New York, January 15, 2009

Source:https://theconversation.com/why-the-miracle-on-the-hudson-in-the-new-movie-sully-was-no-crash-landing-64748

From a safety perspective, the important actors within aviation operations (i.e., the pilots, air traffic control, training instructors and cabin crew) worked in concert through their skills and competencies to land the aircraft safely on water. The ditching of US Airways flight 1549 illustrates the cabin crew's professionalism in that emergency assistance was critical to evacuate 150 passengers from the floating plane. While the pilots safely landed the aircraft, cabin crew initiated the evacuation and were a key factor in the successful evacuation of all passengers. For example, cabin crew were trained to calmly prepare the cabin and passengers for the emergency landing. By focusing on relevant safety procedures and conditions, cabin crew thus increased the probability of appropriate responses in the emergency. This example presents an optimal system response comprising both human and non-human input: Rather than depicting the landing as a 'miracle on the Hudson', the event is "rather evidence of a system that had all of the ingredients to operate safely" (The Conversation, 2016).

Summary: Human factors and cabin safety have become increasingly important to aviation, where numerous factors will shape future implications on flight safety. The lack of recognition among aviation agencies and airlines may be one aspect of neglect that resulted in incomplete coverage of cabin crew-related health and safety issues (Bergman & Gillberg, 2015). Conditions of increasing security threats mark significant shifts in the work environment of cabin crew that could have important implications for health and safety. The extent to which a responsive safety culture influences the cabin crew safety role will play a key role in realising its full potential in contemporary operational settings. Employee safety systems cannot be isolated from important issues such as occupational, environmental, and socio-organisational changes.

2. The Role of Cabin Crew

There are three aspects to the cabin crew role: First, the safety aspect demands that a specified number of cabin crew – the so-called crew complement - must be present to conform to national and international safety regulations (ICAO, 2017); Second, the service aspect requires cabin crew to act as ambassadors between the airline and its customers by making passengers feel comfortable and offering specialised service during the flight; Third, as frontline workers, cabin crew are the public face of an airline and thus a crucial aspect of the airline’s public image. For example, the uniform identity is the direct link to an airline’s exclusive brand (Whitelegg, 2007). Cabin crew are also effectively the administrative staff on board the aircraft, responsible for the reporting and inventory work that ensures smooth flight operations.

The safety responsibilities of cabin crew include, but are not limited to (IATA, 2019):

- Maintaining awareness for safety at all times in and around the aircraft;
- Performing pre-flight security checks for suspicious articles (e.g., weapons) or prohibited items
- Continuous awareness of passenger behaviour throughout the flight and reporting of suspicious behaviour;
- Lavatory inspections;
- Safety compliance check during turbulence and on descent and final approach;
- Cockpit guard duty;
- Handling medical cases and knowledge of infectious disease;

- Handling dangerous goods should these be discovered during flight;
- Firefighting duties;
- Managing unruly passengers inflight such as restraining passengers in the event of disruptive behaviour;
- Overseeing the carriage of persons in custody (e.g., deportees or unaccompanied minors);
- Responding to explosive device threats or attempted hijackings;
- Retaining control in emergency situations and managing aircraft evacuation (e.g., ditching)

Cabin crew also monitor passengers and are trained to detect suspicious behaviour or evidence of malicious intent (IATA, 2019). The safety role became apparent in real emergency situations such as described above in the Hudson River landing.

Cabin crew have traditionally been more closely identified with the service role (Chute & Wiener, 1996; Damos et al., 2013; Murphy, 2001), leading to assessments of their role being trivialised and approached with ambivalence (Abeyratne, 1998; Bamber et al., 2013). These misconceptions have further contributed to the public perception that their main purpose is to provide customer service (Banks et al., 2009). Airlines correspondingly tend to emphasise the service role in their recruitment literature (Wade, 2014; Kelleher & McGilloway, 2005). The potential for resulting role conflicts is discussed in section 10.

Although the service quality experienced pre-flight has a substantive impact on passenger loyalty (Etemad-Sajadi et al., 2016), Hapsari et al. (2017) demonstrated that inflight engagement between customers and crew has the most influential effect on passenger trust and loyalty. In the inflight environment, one of the most apparent delineators of expectations is nationality (Kim & Prideaux, 2003). For example, customers profit from cultural synergy if they can communicate with cabin crew in their native language. To enhance the interactions with people from a diverse set of cultural backgrounds, cabin crew are thus required to demonstrate a high level of cultural awareness skills. Chapter 2 provides an example of customer management, and how understanding the gestures and background of different cultures not only leads to a better customer service experience, but also contributes to smooth flight operations and the prevention of safety-critical incidents.

Summary: In the context of rapid changes in international air travel, existing safety and service procedures have undergone modification and received new impetus. Service expectations may increasingly impact the prompt performance of safety-related duties.

3. Training

In the context of increasing global security concern (Baker, 2020), the content and quality of safety training delivered to cabin crew is of critical importance (Rhoden et al., 2008). Training, experience and ability is crucial for passenger survival in incidents such as crash landings, ditching, aborted take-off, cabin decompression or fire. Safety in aviation is achieved via engaging in strategic processes such as developing training standards and material, as well as training style. There is global consensus about the need for appropriate training of cabin crew that is situated within an airline's safety culture, and aligned with safety-relevant environmental changes (IATA, 2019). While safety recommendations are intended to prevent recurrence, the IATA identified insufficient or inadequate cabin crew training and unclear definition of responsibilities as safety hazards in aviation.

Current practices in flight training have evolved mainly from accident and incident investigations (Shappell et al., 2017). Standard operating procedures help to ensure that crewmembers can function effectively in their primary role as safety agents. Flight safety manuals further emphasise that cabin crew require a mindset and priority-setting if confronted with certain safety threats (IATA, 2019; Flight Safety Foundation, 2004). However, in many cases there may be no single formula to deal with an emergency. Professional development has been identified as fundamental to task skills in contemporary cabin crew work (Chen & Chen, 2014). Cabin crew must be prepared to demonstrate that they acted reasonably under any given circumstances. Their ability to perform safety functions is therefore continuously checked in recurrent training sessions. In these sessions, crewmembers are involved in developing solutions, with the aim of leveraging the collective knowledge of the crew as a team (IATA, 2019). Rather than adhering to rigid, rote learning methodologies for situational awareness (The Journal for Civil Aviation Training, 2013), the Hudson River emergency landing provides an excellent example to highlight the importance of such scenario-based training.

Knowledge, attitudes, behaviour and practices are important for identifying how efficient training is, and ultimately allows for prioritisation of actions in planning training as part of educational programmes. Armstrong (2016, p.529) explains how the sophistication of cabin crew duties demands considerable investment of time and resources in training, and highlights the three key components of behaviour that training aims to modify (see also Chen & Chen, 2012):

- Knowledge – what individuals need to know
- Skills – what individuals need to be able to do; and
- Attitudes – what people feel about their work.

Succinct information about the benefits of training can further eliminate internal behavioural barriers by explaining what crewmembers can do to contribute to flight safety (ICAO, 2017). Investment in training not only increases the ability to perform safety functions, but nurtures customer loyalty through supporting safety and service excellence promises (Boyd, 2001).

Cabin crew are trained in first aid and must also have the skills to analyse risks associated with any identified hazard. For example, crewmembers must be capable to identify potential disease cases, and must be familiar with some understanding of the information procedures to ground crew and health officials (IATA, 2018a). Given the unique considerations of the aeromedical setting, emergency conditions may dictate that a passenger must be isolated due to suspicion of an infectious disease. This also applies to the knowledge of applying safe food handling practices and being aware of any contamination sources that may compromise the quality of food items, which in turn can lead to the transmission of foodborne illness (Sheward, 2008). Although cabin crew generally have high levels of theoretical first aid knowledge, research conducted by Mahony et al. (2008) found that crewmembers showed poor self-confidence in their cardiopulmonary resuscitation (CPR) and automated external defibrillator (AED) skills when confronted with an inflight medical case. Reflected in deficiencies in crewmember knowledge, some airlines have reduced cabin crew training part of their cost-saving measures (Parliament of Australia, 2019). The brevity of courses has not only implications for the volume of training delivered, but also for the extent to which learning transfer can take place (Watson et al., 2017; Wills 1998). Given the anticipated growth in air travel, inflight incidents of medical nature are likely to increase as more elderly people and people with pre-existing or communicable disease are traveling by air (Lee et al., 2017; Shepherd et al., 2006). Not being able to demonstrate that a crewmember has the required knowledge to perform such safety functions can result in an ‘inactivation’ of the crewmember by the pilot in command (Parliament of Australia, 2019).

Lastly, technical proficiency as well as non-technical skills to perform efficiently as a team are essential for preventing safety-critical incidents. The aviation industry has recognised non-technical skills in the form of Crew Resource Management (CRM) as an important part of the cabin crew and pilot proficiency training (ICAO, 2017b). Crew Resource Management grew out of the Tenerife air disaster in 1977 in which two aircraft collided with a loss of 583 lives - making it the most fatal accident in aviation history. The accident had a lasting influence on the industry, particularly in using standardised phraseology in communication and interpersonal interactions across aviation. It was concluded that the rapid diffusion of multiple non-technical errors (including loss of communication accuracy) led to the disaster (Weick, 1990). Classic examples of CRM are categorised as co-operation, communication, team building, conflict solving, co-operation, or error management (Ford et al., 2014). To ensure consistent communication, the IATA cabin safety guidelines (IATA, 2019) have emphasised the importance of adherence to procedures including team-building and the use of standard phraseology described in the next section.

Summary: The effective management of cabin safety is directly related to training standards. Cabin crew require appropriate initial and recurrent training to acquire and maintain skills and knowledge. In consideration of changing environmental and operational conditions, the appropriate level of training should be continuously delivered for this occupational group.

4. Crew Language and Bonding

Communication is crucial for maintaining smooth flight operations and thus an important aspect of aviation safety (Krivonos 2007). Cabin crew share a common interactional space where communication is central to understanding how work-related realities are created. Crewmembers make sense and create reality through a common language, which further gives structure and meaning to crews' fleeting encounters (Whitelegg, 2007). Cabin crew are constantly reconstituted in that teams are newly constructed on each flight or roster segment (Medard & Sawhney, 2007). Crewmembers may meet on one flight, and thereafter might not be scheduled together for years.

Similar to how Hantrais (1989) purports the idea that a unique language is the vehicle of expression that governs the practices and beliefs of a social group, 'crew talk' is the vehicle of expression for the practices governing the working life of cabin crew. For example, a lack of effective communication between crewmembers may restrain the flow of safety-critical information. Cabin crew use language in workplace-related contexts to construct their professional identity and community. Crewmember identity is thereby situationally constructed and emerges from discursive orientations to professional practices and performance. The use of insider language creates certain relational practices and patterns, which play an important role in how crewmembers relate to each other (Letherby & Reynolds, 2009). Regulations and policies internal to airlines define and constrain the language cabin crew use and how they communicate. However, Estival et al. (2016) emphasise that it would be misleading to call the internal language 'aviation English': the language is based on English but is near to incomprehensible to an English speaker without an aviation background. In the crew context, English is the working language that serves a specific purpose, used by both native and non-native speakers of English.

Following the formation of the cabin crew profession in the 1970s, cabin crew increasingly used their own codes and rituals to construct an 'occupational community' where emotional exchanges took place only among crewmembers (Letherby & Reynolds, 2009). Although there are analogies with other occupational communities, such as coal mining, where people have shared most of their lives together working in fixed places, the crew community is different in that it was formed in the mobile space of an aircraft, often among people who have never met before. Emphasising the collective bonding dimension among cabin crew, Taylor and Moore (2015) explain how crewmembers are collective actors, although fragmented by multiple identities and transient workplaces.

Cabin crew demonstrate their commitment to each other and to their profession through common language and bonding rituals. The discourse of ‘crew talk’ originates in commonly understood language from work relationships, where language is used to embody the occupational norms and the ‘taken-for-granted understandings’ about how things work in the airline world (Letherby & Reynolds, 2009). Operational routines generate social bonding which amount to more than ‘communities of coping’ (Korczynski, 2003). Many workplace interactions emerge to facilitate bonding and empowerment between crewmembers. There is a strong sense of camaraderie among cabin crew, where instant bonding is a tacit way of trusting each other in an emergency. The bond crewmembers create during their work trips can make the adoption of particular practices especially rapid (Chatman, 1989).

Summary: Bringing together unknown colleagues in random combinations produces an indefinable chemistry: Crewmembers develop an instant sense of team spirit, and immediately form a unit that installs trust for each other’s lives. These bonding propensities received additional impetus as the effects of increasing terrorist threats, as well as new occupational health risks became ever more apparent.

5. Health Systems, Duty of Care, and Fitness-to-fly

Important links in the organisational safety culture are the health and well-being systems in place. Airlines owe a duty of care to three groups: aircrew, passengers, and the destination country (Holland & Knight, 2007). Now crystallised into most Occupational Health and Safety (OHS) legislation, the concept of duty of care has emerged as an important legal responsibility for airline employers to its workers (Michaelis, 2003). Workplace safety applies to aircraft in flight or on the ground. For example, in the UK, regulatory responsibilities require that crew members are provided adequate health and safety protection and prevention services ‘appropriate to the nature of their employment’ (CASA, 2013). Sharma and Shrivastava (2004) further stressed the need for regulating the flying duties for cabin crew in accordance with their medical disabilities. Following a nearly four-decade long exclusion from protection by the Occupational Safety and Health Administration (OSHA), the sustained advocacy by the U.S. Association of Flight Attendants (AFA) finally led to the inclusion of cabin crew health and safety protections to improve safety and health standards for U.S. cabin crew in the workplace (Association of Flight Attendants, 2018).

The European Aviation Safety Agency (EASA) declared fitness-to-fly a priority safety issue and a pre-cursor to security related events (EASA, 2019). Given the high-risk environment cabin crew work in, airlines have a legal duty to ensure fitness for employment and to have procedures in place for health and safety management (Bagshaw, 2012; Hammer et al., 2014; IATA 2018c). Unlike other shift workers, crewmembers are required to adhere to unpredictable schedules which include shifts of multiple flight sectors, extended duty days with limited time off between flights, and poor sleeping conditions (Avers et al. 2009a; Caldwell, 2005; Griffiths & Powell, 2012; Nesthus et al., 2007). In the European Union (EU), cabin crew medical assessments may be carried out by an Aeromedical Examiner (AME) or approved Occupational Health Medical Practitioner (OHMP), who attests fitness to fly in a medical report (Civil Aviation Authority, 2015). The categorisation of deficiencies aims to reflect the potential role each one might play as an antecedent condition to a safety-related incident or accident (Pombal et al., 2005). For example, fatigue is an occupational health and safety hazard that can have a direct impact on work performance and flight safety (Cano, 1998; Sharma, 2007). Responsibility for fatigue avoidance is shared by both employer and employee (Gander et al., 2011; O'Driscoll & Cooper, 2002). Thus, shared responsibility is integral to address concerns about fatigue as they relate to the maintainability, reliability and success of safe flight operations. Fatigue is discussed in detail in section 7.1.

Important aspects of cabin crew health have been studied by McNeely et al. (2014; 2018a; 2018b). As called for in earlier research (Griffiths & Powell, 2012; Houston et al., 2012; Powell, 2013; Rhoden et al., 2008), these efforts provide a starting point for the sociological and operational analysis with a focus on identifying significant health conditions in cabin crew compared to the general population. Rather than raising concerns about the usefulness of employee health approaches *per se*, these authors emphasise the lack of practicality in policies and safety procedures considering the dynamic nature of flight operations. The safety function should not be understood as an isolated, abstract issue in airline operations but as an integral part of a security and health system being applied across the flight experience through the practices and knowledge of cabin crew. This incorporates aspects of recent operational changes (such as the operation of ultra-long-haul flights) that have complicated the understanding of contemporary occupational health risks.

Summary: Fitness-to-fly assessment can be an effective health and performance tool in high-risk work environments. Yet there is an inability to fit point-of-time medical assessments to actual operational fitness. Chapter 6 presents an approach to conceptualise fitness to fly, and outlines features of a pre-flight assessment tool which cabin crew can use to gauge their fitness-to-fly before each flight.

6. Scheduling

Cabin crew scheduling or 'rostering' is a vital part of flight operations, and a major political issue within an airline. The interconnected nature of airline operations means that disruptive events have the potential to propagate network disintegration (Sun & Wandelt 2018). Airlines address such vulnerabilities using schedule recovery techniques to avoid or reduce the impacts on flight operations, to minimise further costs to the airline, and to mitigate passenger inconvenience (Budd et al. 2020). Novak et al. (2020), Ladier et al. (2014), and Maenhout and Vanhoucke (2010) reveal the complexity of crew scheduling in that rules and regulations are based on complex legislation and contractual agreements, which must be met by rostering solutions. While airlines also seek to optimise the planning of crew schedules to increase profitability and decrease operating costs (Bazargan, 2016), scheduling departments solve complex scheduling issues by assigning crews to a pre-determined flight schedule, whilst observing regulatory work rules (Erdoğan et al., 2015). Scheduling is thus a highly constrained and complex optimisation problem.

Extensively investigated in operations research (Anbil et al.,1998; de Armas et al. 2017; Hoffman & Padberg, 1993; Medard & Sawhney, 2007), the problem of finding suitable work assignments for crewmembers in a given time frame is usually referred to as the *airline crew rostering problem* (Cappanera & Gallo, 2004; Ernst et al., 2004a;

2004b). Rostering consists of constructing monthly schedules for crewmembers by assigning them sets of flight sequences (so-called ‘pairings’), rest periods, training, and crew-specific characteristics such as annual leave. Crew scheduling methods are based on the ‘generate-and-optimise’ principle, and harbour important trade-offs for crewmembers (Kohl & Karisch, 2004). There are three dimensions of performance in optimising crew schedules: 1) to achieve cost effectiveness 2) to adhere to regulations, and 3) to achieve the best possible solution for the crewmember. Scheduling thus reflects both cost minimisation and employee contractual agreements, as well as observing all relevant rules and legislation, and considering work-life balance and personal preferences (Maenhout & Vanhoucke, 2010).

The central purpose of optimising crew schedule is being able to provide airlines with efficient solutions to a range of scenarios (Bazargan, 2016). Because of its potential perturbations, most airlines divide the overall scheduling problem into two related procedures: planning and recovery (Kasirzadeh et al., 2017). Crewmember availability changes dynamically during a planning period due to pre-scheduled activities, such as office duties or requested off-duty days. Within the complex and dynamic operational environment, any disturbance to normal operations has an impact on individual flight schedules. Of concern is the ability to adjust to problematic courses of events, for example, those caused by delayed flights or crew ‘legality’ issues, which are concerned with statutory duty limits such as exceeding a legal assignment window. (ICAO, 2017). Because of the high risk of irregular events, crew schedules are rarely operated as planned in practice (Guo et al., 2005). For example, a short delay of one flight can cause severe disruptions of the schedule later in the day. Planned schedules often must be revised because of disruptions caused by weather events or technical problems (Kohl et al., 2007). Other unforeseen disruptions or calling in sick also means a compensation in the planned schedule, which can create new disruptions elsewhere in the schedule (Kohl & Karisch, 2004). Crew roster recovery problems arise when flight duties need to be reassigned after such disruptions, under the described set of constraints and pre-allocated activities (Chen & Chou, 2016).

Most cabin crew work in a seniority-based system. Seniority (or job tenure) to some extent allows crewmembers to build a schedule that fits their needs. While each airline has a different definition of what seniority means and how it is implemented (Kohl & Karisch, 2004), cabin crew can bid for flight routes, which then are awarded on a seniority basis. They can also trade trips with other crewmembers within regulatory parameters, giving them more flexibility. Depending on airline-internal agreements, so-called ‘bid lines’ are constructed where individual crewmembers can bid for specific flights or days off. In contrast to preferential bidding which allows crewmembers to influence their flight schedules by submitting personal preferences associated with their desired work schedule (e.g. time off for a doctor’s appointment), standard bid line schedules represent a process in which cabin crew bid on contractually feasible flight segments based on seniority (Eltoukhy et al., 2017; Jacobs et al., 2018). Although schedule improvements in one dimension will be at the cost of some compromise in another dimension, the most senior crewmembers get to ‘cherry-pick’ the most favourable flights, or for example the most sought-after days off over holidays (Kohl & Karisch, 2004). Such bidding and seniority-based models are adding another layer of complexity to the ‘crew rostering problem’ with its intricate safety agreements and contractual rules.

Increasing competition and resulting cost pressures have encouraged airlines to operate tight schedules that are increasingly susceptible to disruptions. In addition to regular cabin crews, airlines typically maintain significant reserve (or ‘stand-by’) staffing levels to cover for crew shortfalls (Jacobs et al., 2018). These shortfalls can result from disruptions caused by crew unavailability, such as acute illness, delayed crew, or general high sickness rates. To ensure smooth operations and meet contractual obligations, reserve crews are required to absorb disruptions and cover trips that suddenly became unassigned during daily operations. Although considered a significant expense for an airline, crew reserves add a layer of recoverability that is essential for the smooth running of flight operations (Bailey, 2016). Generally, airlines require their reserve crews to be able to reach the airport within one or two hours of their notice. However, insufficient reserves to cover crew absences can also result in significant cost to the airline and inconvenience to the passengers, such as flight cancellation.

Much of a crewmember’s work-life balance depends on the ratio between the above parameters, expectations of the preferential flight bidding system, and the actual roster solution (Quesnel et al., 2020). Adequate rest is critical for cabin crew to perform their work, in particular because fatigue among cabin crew differs from many other workplace hazards in that its primary causes are attributed to scheduled duty patterns (Houston et al., 2012). Airlines must therefore abide by strict crew minimum rest requirements. For example, cabin crew scheduled to a duty period of up to 14 hours must receive a scheduled rest period of ten consecutive hours, defined as the time from airport gate arrival to gate departure (Association of Flight Attendants, 2018). However, the term ‘rest time’ can be misleading and requires further clarification. Rest time is typically measured from flight arrival until subsequent flight departure. Given the time consumed by de-embarkation, pre-flight preparation and passenger boarding, the actual sleep time can be as low as four or five hours. Rest periods often begin shortly after an aircraft reaches a gate position at destination and end one hour prior to the next departure. The ‘rest time’ also includes waiting times for crew transport, transition through airports including customs clearance, travel to and from crew hotels to airports, and finding time and place for meals. Some airlines schedule as little as nine hours of rest for cabin crew between duties (Association of Flight Attendants, 2018). Hence, the actual allowance for sleep during a 14-hour scheduled ‘rest period’ may well be reduced to below eight hours.

Updated rostering outcomes can be unsatisfactory in many ways, including disruptions of private plans, or exhausting maximum duty times. The extension of working hours is mainly a result of computerised scheduling, allowing for manipulation in shifting patterns to maximise crew productivity within the legal duty hour limitations (Boyd, 2001). Boyd notes how such manipulation often results in an increase in the total number of duty hours. In considering that cost factors are being optimised to great extent, Thiel (2008) highlights how quality-of-life criteria for crewmembers have received little regard and argues for an increased demand for higher crew welfare. Because of the low-cost carrier ‘efficiency mentality’, one of the major changes in contemporary air travel is that aircraft are used much more to increase productivity. This has influenced how schedule solutions and other protection mechanisms are built. Repeated time zone changes, too, are a routine part of international cabin crew work schedules. Duty rosters demand travel across numerous time zones in both eastward and westward direction, often without sufficient recovery time between flight sectors (EASA, 2019; Petrie et al., 1993). Reduced rest provisions are also employed in other ways. While originally designed to accommodate unpredictable factors such as delays or weather conditions, reduced-rest patterns under ‘exceptional conditions’ have become increasingly common (Air Safety Health and Security, 2016). Discretionary rest time reductions by airline operators may further undermine established rules of regulating authorities, as well as negotiated rest patterns between airline unions and managements. Internal airline regulations thus harbor the risk of exploiting these ‘exceptional’ conditions to become routine implementations, leading to further erosion of regulated rest times.

Summary: The demands for cabin crew vary in intensity and largely depend on monthly schedule design. Many crew scheduling issues are the inevitable consequences of the airline network development, increasing time and contractual constraints, as well as evolving criteria and aspirations for roster quality assessments. As individual schedules are dictated by operational needs, stipulating sets of rules as to how long a crewmember can work are paramount to flight safety. Higher number of practical requirements, a wide perspective for optimal solutions, and recognition for interdependencies are therefore essential to address the scheduling philosophy in its proper context.

7. Exposure to environmental and occupational hazards during operations

Cabin crew have historically been exposed to a range of hazards with a high risk of adverse health outcomes (Boyd & Bain, 1998; Livingston, 1992). Exposures that occur under routine operational conditions include poor cabin air quality from a number of sources; pockets of air turbulence; fatigue; cosmic ionising radiation; circadian rhythm disruption due to shift work and crossing time zones; periodic episodes of elevated ozone levels; high levels of occupational noise, pesticides from aircraft disinsection; and infectious disease agents (Griffiths & Powell, 2012; Mangili et al., 2015; McNeely et al., 2018a). Detailed descriptions of fatigue, ionising radiation, toxic fume events, and infectious diseases are provided in subsequent sections.

First, the potential magnitude of health impacts on routine flights is exemplified by the knowledge that some of these hazards are known or probable carcinogens (Liu et al., 2018; Buja et al., 2006; Pukkala et al., 1995). Causation for increased cancer incidence in cabin crew is likely multifactorial: Reports of health complaints such as fatigue, dizziness episodes, insomnia, stress, and anxiety suggest cabin crew have increased rates of certain physiological and neurological conditions such as skin cancer and motor neuron disease (McNeely et al., 2014). In a study of female cabin crew, most women perceived to be at greater risk for occupation-related cancers and reported frequent respiratory tract infections and colds, urinary tract infections, gastro-intestinal problems, blood circulation problems in the legs, back pain, thyroid disorders, hearing problems, and memory loss as typical work-related illnesses (Ruscitto & Ogden, 2017; Ballard et al., 2004a). Recent findings indicate that cabin crew have higher rates of specific cancers compared to the general population, some of which were related to job tenure (McNeely et al., 2018a; Winter et al., 2014; Kojo et al., 2013). The mechanisms and interactions of various factors in the development of certain cancers remain largely unclear.

Second, poor cabin air quality, the most extreme form of which are toxic fumes events, has been the subject of abundant media reports over the past few years (BBC, 2015; Independent, 2017; The Guardian, 2017). Dehydration from long-term exposure to dry air environments can further cause a disharmony of several pathological patterns and lead to increasing disruption of vital functions that sustain good health (Campbell, 2009; Lauc et al., 2020; Nagda & Hodgson, 2001).

Third, cabin crew themselves can be potential sources of contaminants such as viruses and bacteria that originate in the aircraft cabin (Isakbaeva et al., 2005; Mangili et al., 2015). Furthermore, structural components of the aircraft such as food can be sources of contamination (Hatakka, 2000).

Fourth, cabin crew can also be exposed to various environmental hazards during a tour of duty, not only during a flight. For example, exposure to sources of food or water contamination at certain layover destinations is wide-ranging. These can cause relatively minor symptoms such as diarrhea, but also lead to a range of serious infectious diseases (Espino et al., 2002).

Fifth, sleep deprivation is an occupational hazard of commercial flying. The combination of shift work with time zone shifts is particularly problematic as it causes desynchronization of body rhythms. For cabin crew, the ability to gain sleep when the body is out of synch with local time is an important requirement (Green, 2017). Sleep disorders significantly affect nearly one in three crewmembers, and age-adjusted prevalence of other health conditions in cabin crew suggests that occupational exposures may contribute to existing problems (McNeely et al., 2014).

Overall, epidemiological investigation is scant, and specific data on potential causes, incidence and prevalence of ill health among cabin crew are lacking (Harrison & Mackenzie Ross, 2016). Important investigations on occupational health outcomes are ongoing McNeely et al. (2018b);. Their focus on identifying significant health conditions in cabin crew compared to the general population provides a starting point for the sociological and operational analysis that earlier research called for (Griffiths & Powell, 2012; Houston et al. 2012; Rhoden et al. 2008).

7.1 Fatigue

Fatigue is the most discussed physiological impact from cabin crew work (Avers et al., 2009a; 2009b; Avers et al., 2011; Cho et al., 2000; Holcomb et al., 2009; Morris et al., 2020; Striker et al., 2000; Waterhouse et al., 2007). Fatigue is a complex phenomenon and multi-dimensional construct that has been defined and interpreted in a number of ways. For example, fatigue has been described as a state of tiredness that results in reduced mental and/or physical performance, and which can decrease a person's alertness, judgement and decision-making (Staal, 2004).

While the desynchronisation experienced after travelling through numerous time zones (termed "jet lag") affects an individual's quality of sleep and recovery time (Bin et al., 2019; Suvanto et al., 1990), for cabin crew, the performance decrements associated with fatigue are best considered in terms of symptoms such as forgetfulness; impaired judgment; slowed reaction time; reduced vigilance; poor communication; nodding off; or becoming fixated or lethargic (Rosekind et al., 1994). Fatigue thus has psychological, physiological, and emotional dimensions that can impact the performance of safety-related duties. Particularly during non-routine and emergency events it is important to note that fatigue is more than sheer sleepiness or tiredness. Table 3 discerns the differences in symptoms between travel fatigue and jet lag.

Table 3. Common symptoms of travel fatigue and jet lag, and differences in their causes

	Travel fatigue	Jet lag
Symptoms	General fatigue Disorientation and increased likelihood of headache Travel weariness	Poor sleep during the night-time, including delayed sleep onset (after eastward flights), early awakening (after westward flights) and fractioned sleep (after flights in either direction) Poor performance during the new daytime at both physical and mental tasks Negative subjective changes. These include increased fatigue, frequency of headaches and irritability, and decreased ability to concentrate Gastrointestinal disturbances (indigestion, the frequency of defecation, and the consistency of the stools) and decreased interest in, and enjoyment of, meals
Cause	Disruption of sleep and normal routine Difficulties associated with travel (checking in, baggage claim, customs clearance) and general dehydration	Slow adjustment of the body clock to the new time zone, so that daily rhythms and the internal drive for sleep and wakefulness are out of synchrony with the new environment
Differences between travel fatigue and jet lag	Travel fatigue is associated with any long journey Travel fatigue abates by the next day, the traveller having had a good night's sleep	Jet lag generally needs three or more time zones to be crossed rapidly. However, there is a noticeable difference in individuals' susceptibility to the effects of changing time; some even have difficulty in dealing with the 1h change accompanying the switch to and from daylight saving time For eastward flights, jet lag lasts for several days roughly equal to two-thirds of the number of time zones crossed. For westward flights, jet lag lasts for about half the number of time zones crossed. Again, there are obvious differences between individuals

Source: Waterhouse et al. (2007): Jet lag: trends and coping strategies

While 'sleepiness' merely signals the likelihood of falling asleep, it is distinguished from fatigue by a presumed impairment of the normal arousal mechanisms (Shen et al., 2006). The ability to concentrate and respond decreases dramatically as fatigue levels rise. Reaction time and performance diminishes with extreme fatigue. In a cabin crew performance assessment, Roma et al. (2012) illustrated how cabin crew - exhausted from working long hours with little rest in between flights - have either failed to properly carry out safety duties such as engaging or disarming emergency slides, or they reported for duty impaired. The authors further note how the likelihood of fatigue-related mishaps may have increased as airlines cut rest periods and routinely schedule cabin crew up to the regulation limits. One potential contributing factor of interest is the influence of commute times prior to reporting for duty. Crew working for carriers with large central hubs often have long ‘Home and Duty’ place commutes. However, no systematic field data could be retrieved regarding the relationship between commute times and objective performance capacity.

Fatigue is also part of a human factor interaction error. Research indicates that poor quality sleep and feelings of loneliness are experienced by many crewmembers (Cho et al., 2000; Désir et al., 1981). Combined with the lack of time spent with family and in social circles, frequent absence can encourage a sense of isolation and create emotional distance for relationships, which in some cases may generate depression amongst returning travellers (Pocock & McIntosh, 2011). Work-related isolation of cabin crew also stems from the inability to maintain continuous social relationships either at home or at work (Ballard et al., 2004b). Feelings of isolation have also been documented for the ones ‘left behind’ (Gustafson, 2014), leading in turn to feelings of guilt among those traveling for work at leaving close family members behind (Espino et al., 2002). The requirement for recovery during limited rest time between trips further reduces the ability to allocate time for family and friends (Xanthopoulou et al., 2008). Black and Jamieson (2007) report how this rest time is largely spent on recovering from fatigue, contributing to a sense of role confusion within the family. These insights also refer to the importance of gender division in that female crewmembers may experience considerably more stress through self-inflicted pressure to fulfil the role of mother and manage domestic commitments (Avers et al., 2009b). Workforces with a high degree of emotion work further have a tendency for social withdrawal (Repetti, 1989; Repetti & Wood, 1997). For cabin crew, socialising during off-time is therefore not necessarily a source of support but often contributes to depletion of resources. Consequently, time spent on social activities may even impede their health and well-being.

Fatigue-related time zone changes may further induce psychological disorders and have been identified as risk factor for depression (Griffiths & Powell, 2012). Similarly, Nesthus et al. (2007) point to the challenges associated with maintaining a healthy work-life balance. Interference with the body's natural rhythm as one causal factor for fatigue reflects a widespread disruption of many biological processes, including genetic processes that influence ageing (Archer et al., 2014), and raising the risk of heart attack or stroke (McNeely et al., 2018b; Nagai et al., 2010). Although it is difficult to determine whether preoccupation with family concerns or personal health issues are a consequence of job stress or existed before commencing a duty segment, the effects of fatigue can contribute to disrupted social cohesion and create imbalances across the responsibilities in the home sphere.

Fatigue is considered a real and serious concern and has been a major focus of airline accident and incident investigations (ASHS, 2016). The context for this concern is set by ultra-long-haul flight services, which are now introduced by various airlines. In contrast to Caldwell (2005) who clarifies that generally all human performance that induces changes to the internal body clock harbours the risk of fatigue, Ganesh and Joseph (2005) illustrate how fatigue may be a decisive factor precipitating an accident or incident in view of the complexity of in-flight situations. For example, continuous exposure to aircraft noise significantly contributes to both fatigue and to stress levels (Kelleher & McGilloway, 2005). From a risk assessment perspective, Edmondson (2004) in turn cautions against measurements for fatigue incidence rates as these largely depend on individual reporting behaviour, which in turn has many determinants in the cabin crew workspace. While there is consensus on both the symptoms experienced of fatigue, and the notion that job changes in the airline industry have added to the symptoms of fatigue (van den Berg et al., 2019; 2020; Roma et al., 2010), it remains unclear to what extent these changes have exacerbated the risk of exposure to fatigue. Underreporting of injuries among cabin crew caused by fatigue are common (van Drongelen et al., 2013). Injury statistics may thus not reflect actual incidence rates, allowing for inferences that cabin crew only report episodes of fatigue with extreme symptoms or outcomes, rather than communicating the probability of risk under various conditions. Despite causing a high degree of morbidity, measures of fatigue are largely subjective (Shen et al., 2006), and the relationship between subjective and objective measurements of fatigue remain poorly understood. Cabin crew errors due to fatigue may not be immediately apparent, but the potential for serious implications is likely to be underestimated.

Changes in operations have not only brought about additional risks to flight safety but have expanded the cabin crew safety role in response to extended flight times, increased flight occupancy, and changing passenger demographics (Ballard et al., 2004a; DeHart, 2003; MacDonald et al., 2003; Morley-Kirk & Griffiths, 2003). Several authors have noted a lack of recent studies that profile the scope and severity of cabin crew's health conditions (Anderson, 2015; Griffiths & Powell, 2012), with fatigue being a predominant factor. For example, symptoms of fatigue are intensified on longer flight sectors (Avers et al., 2011; Nagda & Hodgson, 2001), and operational disruption such as delays, have been found to increase fatigue reporting (Bourgeois-Bougrine et al., 2003). While the knowledge about cabin crew fatigue associated with ultra-long-range (ULR) flights is still limited and warrants ongoing monitoring, van den Berg et al. (2019) highlight the importance of sufficient rest, the need for company support, and management's engagement with cabin crew in general. In fact, the U.S. Association of Flight Attendants (AFA) demands that more rest should be mandated for cabin crew to manage fatigue (Association of Flight Attendants, 2018). Extended flight times may not only increase risks of exposure to occupational hazards such as fatigue but compromise effective monitoring and control of hazards as these are self-reported and often managed by the airline with 'disciplinary tones' (Financial Times, 2015).

Responsibility for fatigue avoidance is shared by both employer and employee (Gander et al., 2011). Fatigue risk is largely managed through prescriptive limits on maximum duty hours, and minimum rest periods (Signal et al., 2006). However, prescriptive rules based on time limitations are unable to account for all the interacting factors that affect fatigue such as circadian rhythms, time of day, and time zone transitions (Banks et al., 2009). This implies that, due to circadian rhythms, the time when the break occurs may be more important than the amount of scheduled rest.

Summary: Fatigue-causing factors have an adverse effect on cabin crew performance and may directly or indirectly impact flight safety. Integral to fatigue avoidance is an attempt to address health concerns as they relate to maintainability, reliability and success of safe air travel. Given the changing conditions in which cabin crew operate, the inability to function due to fatigue could pose serious threats to the health and safety of passengers and crew. This includes the situational contexts in which fatigue appears, the frequency of fatigue experienced by crewmembers, and the potential consequences (e.g., the potential impact of fatigue on passenger interaction, illustrated in more detail in chapter 2). Cabin crew fatigue warrants further evaluation not only for situational contexts, but in consideration of the increasing operation of ultra-long-haul services with duty times exceeding 14 hours. These ULH Operations require careful study to determine adequate fatigue management strategies.

7.2 Cosmic ionising radiation

The International Commission on Radiological Protection (ICRP) considers cabin crew ‘radiation workers’ at increased risk for exposure to cosmic radiation during their work (CDC, 2017b). Exposure to elevated levels of cosmic radiation is of galactic and solar origin (Bartlett, 2004). At flight altitudes, cabin crew are exposed to higher levels of ionising and ultraviolet (UV) radiation than the general population (Schubauer-Berigan, 2020); Sanlorenzo et al., 2015; Buja et al., 2006). Exposure from ionising radiation among cabin crew even exceeds that of nuclear plant workers (Barish & Dilchert, 2010). The U.S. National Institute of Occupational Safety and Health (NIOSH) has summarised factors that put cabin crew at higher risk of adverse health effects from exposure to cosmic ionising radiation (NIOSH, 2012).

Although Gundestrup and Storm (1999) asserted that no major cancer-related effect of the exposure to cosmic radiation in commercial aviation exists, research has shown increased incidence and mortality for certain cancers (San Lorenzo et al., 2015; Hammer et al., 2012; Hammer et al. 2014; Barish, 2009; Linnersjö et al. 2003; Buja et al., 2006; Pukkala et al. 1995). McNeely et al. (2018a) further highlight how the primary health threat of these radiation dose levels is an increased risk of some type of cancer later in life. While the Centers for Disease Control and Prevention (CDC) offer strategies for minimising radiation exposure such as reduction of duties for very long flights, or avoiding flights which fly over the poles, the agency notes how bidding for a flight schedule to reduce cosmic radiation exposures remains complicated, because ‘reducing one exposure may increase another’ (CDC, 2017b). As the intensity of exposure to cosmic radiation depends on length of exposure, altitude, latitude, and time of the year (for solar cycle or solar flares) (Aw, 2003), it is vital to determine whether current occupational standards provide sufficient protection (Pukkala et al., 2013).

Summary: Exposure levels to cosmic radiation will be of increasing concern. Advances in aircraft technology will enable aircraft to fly longer and at higher altitudes as a response to the predicted growth of air travel networks and increasing passenger numbers (IATA 2017; Sigurdson & Ron, 2004). Accordingly, the risk of exposure to ionising radiation will increase with the extension of polar air routes and ULH operations. More longitudinal data are needed to adequately respond to the real risks of radiation exposure associated with flying, and to determine whether there are other factors than radiation evident that could explain the excess risk of cancer.

7.3 Fume events from bleed air

Cabin crew may be exposed to cabin air contamination by toxic substances from engine bleed air. The term “aerotoxic syndrome” is used to describe the short- and long-term health effects caused by contaminated cabin air. The concept of aerotoxic syndrome as a clinical picture / disease pattern is not yet recognised by the aviation medicine community (Abeyratne, 2002; Bagshaw, 2014). The quality of air distributed throughout a flight is critically important to human health. Commonly referred to as a ‘fume event’, contamination of ‘bleed air’ has evolved as a potential health and safety hazards for passengers and crew (Shehadi et al., 2016).’Bleed air’ refers to the outside air that is drawn into the aircraft engines where the air is heated and pressurised to ventilate aircraft cabins. The air is then ‘bled off’ and circulated into the aircraft (Hunt et al., 1995). Contamination can occur through an engine oil or hydraulic fluid leak, or any other mechanical failures which allow oil fumes to escape into the airflow and contaminate the cabin air supply (Shehadi et al., 2016). Exposure to these fumes is potentially hazardous as some fluid components contain chemicals which are neurotoxic, i.e. damaging to the nervous system (Winder & Balouet, 2002). Fume events should therefore be regarded as an exposure to various chemical constituents, which may result in a range of adverse health effects (Chaturvedi, 2012).

Recent studies have detected measurable quantities of such chemicals in the cabin air of commercial aircraft (Crump et al., 2011; Spengler et al., 2012). While airlines and aircraft manufacturers claim that toxic fume events are rare, and that air quality still meets safety standards even if they do occur (Defossez, 2019), Michaelis et al. (2017) note how a clear cause and effect relationship has been identified linking the diagnoses and symptoms to the cabin environment.

To reflect the potential for chronic exposure, Winder and Balouet (2002) proposed the term ‘aerotoxic syndrome’ to describe the common symptoms reported by crew following exposure to toxic fumes in aircraft cabins. For example, studies have reported both short and long-term effects such as headaches, weakness and fatigue, nausea and vomiting, nerve pain, and cognitive impairment, e.g., (Coxon, 2002; Michaelis et al., 2017; Ross, 2008; Ross et al., 2011). Although the commercial airline industry accepts the occasional occurrence of toxic fume events, the incidence of these events is difficult to determine as cabin air is not routinely monitored for potential contaminants and airlines are reluctant to share reports which document these incidents (Michaelis et al., 2017; Winder & Balouet, 2002). The authors further conclude that the frequency of contamination events is difficult to measure as underreporting is common among aircrew, possibly due to fears about job security. While a variety of symptoms reported immediately following a fume event showed a temporal relationship with exposure, these studies relied on subjective measures of self-reported exposure (Harrison & Mackenzie Ross, 2016), making it difficult to draw valid conclusions regarding the cause of the health complaints. The causation, diagnosis, and treatment of long-term effects is still uncertain.

7.4 Ozone

The symptoms that were significantly associated with ozone concentrations in aircraft cabin environments were related to the eyes and the upper respiratory system, indicating that ozone and its oxidation products are contributing to these complaints (Strøm-Tejsen et al., 2008). Bekö et al. (2015) further note how ozone may be related to dry mouth and poorer perceived indoor air quality. Due to the lack of current knowledge regarding direct adverse health effects of ozone exposure, the Federal Aviation Administration (FAA) (2010) has encouraged re-evaluation of assessments for ozone to determine whether they are adequately protective of crew and passenger health. The agency notes that although aircraft are equipped with ozone catalytic converters, their mandatory use should be coupled with regular performance checks and maintenance. According to the FAA, future studies on ozone-related symptoms should be extended to flights where crew are routinely exposed to higher ozone levels, and research should investigate improved technologies for ozone control in aircraft cabins.

7.5 Oxidative stress

Oxidative stress is defined as the disturbance in the balance between the production of so-called free radicals and the body’s defence mechanisms. Misbalances in these systems can lead to oxidative stress and may play a role in genetic tissue damage and the development of chronic disease such as diabetes (Rani et al., 2016). The recent provision of in-flight Wi-Fi for passengers is increasingly raising concerns about its potential adverse health effects. Radiation generated by Wi-Fi hotspots or mobile phones was found to cause oxidative stress (Havas, 2017; Yakymenko et al., 2016). While the exposure to high altitude also causing oxidative stress, health concerns for cabin crew further include the effect of Wi-Fi radio frequency radiation on circadian rhythm (Mortazavi, 2017). The combined effects of exposure to these hazards remain unknown and require further investigation.

7.6 Turbulence

Turbulence can cause serious injury to passengers and crew. Research indicates how severe turbulence is becoming more frequent and intense due to climate change, as rising carbon dioxide (CO_2) levels in the atmosphere cause disruptions to the jet streams and create dangerous wind shears that increase the risk of turbulence. While aviation is known to be partly responsible for changing the climate (Stuber et al., 2003), Williams and Joshi (2013) show how climate change could also affect aviation. Atmospheric scientists particularly warn of so-called clear air turbulence (CAT), known as the most dangerous form of turbulence as it is invisible and virtually undetectable with current technology. Without warning, any unsecured objects and unbuckled crew can be violently tossed around in the cabin by CAT, causing serious injuries and even fatalities (De Villiers & van Heerden, 2001). For crew working in the aircraft aisles and galleys, these incidents pose a serious occupational risk. CAT is expected to double or triple in some regions, highlighting the need to improve operational forecasts and occupational measures to limit injuries among crew and passengers (Storer et al., 2017).

7.7 Mental health disorders

Risk factors for mental health problems may include extended and irregular working hours, sexual harassment, and lack of employer protections for occupational hazards (Gunnarsdottir et al., 2006). Sleep disorders in combination with circadian rhythm disruption have been associated with adverse mental outcomes, including suicidal ideation, suicide attempts, and suicide deaths (Escobar-Córdoba et al., 2017). While Pinkerton et al. (2012) reported elevated rates of suicide among cabin crew in general, Ballard et al. (2004b) found an increased risk for suicide among female flight attendants. Job stressors such as psychological demands, job-related role conflicts, and low supervisor support seem to predict psychological distress (MacDonald et al., 2003).

7.8 Infectious diseases: exposure to pesticides and foodborne contaminants

Given the large number of passengers traveling on a global scale, aircraft are considered one of the most complex indoor environments among mass public transportation, with a high risk of spreading infectious diseases (Bagshaw & Illig, 2019; Elmaghraby et al., 2018). Crewmembers must therefore be familiar with the measures to be taken to secure in-flight safety and be prepared to demonstrate that they acted reasonably under any given circumstances. For example, responsible infectious disease handling requires the knowledge to identify potential disease cases, to have adequate information on hygiene measures to prevent the transmission of diseases, and some understanding of the information procedures to ground crew and health officials (IATA, 2018a).

Cabin crew not only expressed concerns about the long-term health consequences of exposure conditions in the cabin environment, but also reported the threat of infectious disease risks as major concern (MacDonald et al. 2003). Garrett (1994) illustrates how the plague outbreak in India in 1994 is of interest in view of the role of crew training: The key to U.S. efforts to contain the disease were activities at airports that included handing plague information to airline personnel, with the expectation to recognise symptoms of the disease. Consequently, responsibility of detecting possible disease cases fell partly to airline employees, although none of them were medically trained. While modern aircraft cabins are typically fitted with high-efficiency particulate air (HEPA) filters that can remove up to 99.99% of particulate microorganisms (Hocking, 2000), these systems do not prevent the person-to-person spread of infectious disease agents, particularly in vulnerable travellers (Bagshaw & Illig, 2019).

One example of potential adverse health outcomes from chemical exposures is the exposure to pesticides on certain flights. ‘Disinsection’ is the term used to describe the practice of spraying pesticides in aircraft cabins to prevent the import of exotic vectors (e.g. mosquitoes) that can transmit diseases such as malaria, Zika or dengue fever (World Health Organization, 1995; 2018). Given the rapid expansion of international air travel, the WHO estimates that up to 60% of the world’s population is at risk of infection for vector-borne diseases (World Health Organization, 2018). Disinsection is required by a limited number of countries on either inbound flights while passengers are aboard (e.g. India, Madagascar, Uruguay), or when the aircraft is unoccupied (e.g. Australia, New Zealand). Chapter 4 uses aircraft disinsection as an example to describe the global disconnects in recommendations for airline-associated infectious diseases, and to discuss resulting compliance issues by crew that may be linked to the potential for adverse health effects from exposure to pesticides.

By highlighting the role of inflight food hygiene, another example of airline-associated infectious diseases is the occurrence and spread of foodborne illness. Food contamination hazards are associated with both food preparation processes on-ground, and the conditions under which cabin crew are serving meals on aircraft. Foodborne illness issues arise owing to the complexity and confined space conditions, as well as limited sanitary facilities on aircraft (Hatakka, 2000). For food safety, cabin crew are open to a variety of risk management issues of which they likely lack knowledge and training (Abdelhakim et al., 2018; Sheward, 2008). Although the IATA encourages cabin crew to follow the same code of practice as food handlers on the ground (IATA, 2018b), some outstanding challenges remain regarding the safe handling of food inflight (Sheward, 2008). For example, although adequate knowledge about food hygiene is considered a safety-related factor, food handling may be perceived purely as a service issue that is separate from the safety role (Abdelhakim, 2016; Abdelhakim et al., 2019). As a result, perceived differences in responsibilities between the dual roles may lead to negligent behaviour and food safety lapses. Chapter 5 discusses the role of cabin crew as inflight food handlers and highlights important links between inflight food service and flight safety issues.

Summary: Cabin crew are exposed to many known and potential disease-causing agents in their workspace. While environmental exposures can be responsible for acute and chronic health effects, establishing a causal relationship between exposures and adverse health effects remains difficult. Health complaints are often nonspecific and broad, making it difficult to define a precise condition or illness. The discussions of the impacts of environmental hazards rarely touch upon the cumulative effects of exposure. While adverse health outcomes may have been partly self-inflicted by voluntary exposure to hazards outside the workplace, this means that cabin crew have little margins of safety with respect to risk-taking because the effects of some occupational agents on health are cumulative and irreversible. These agents may be an important contributor to physiological and psychological ill health and work efficiency loss. The long-term and combined impact of exposure factors on the health of crewmembers, and in turn on flight safety, requires further investigation. Figure 8 presents an overview of the interconnectedness of safety culture, operational environment, and impact on individual health and behaviour.

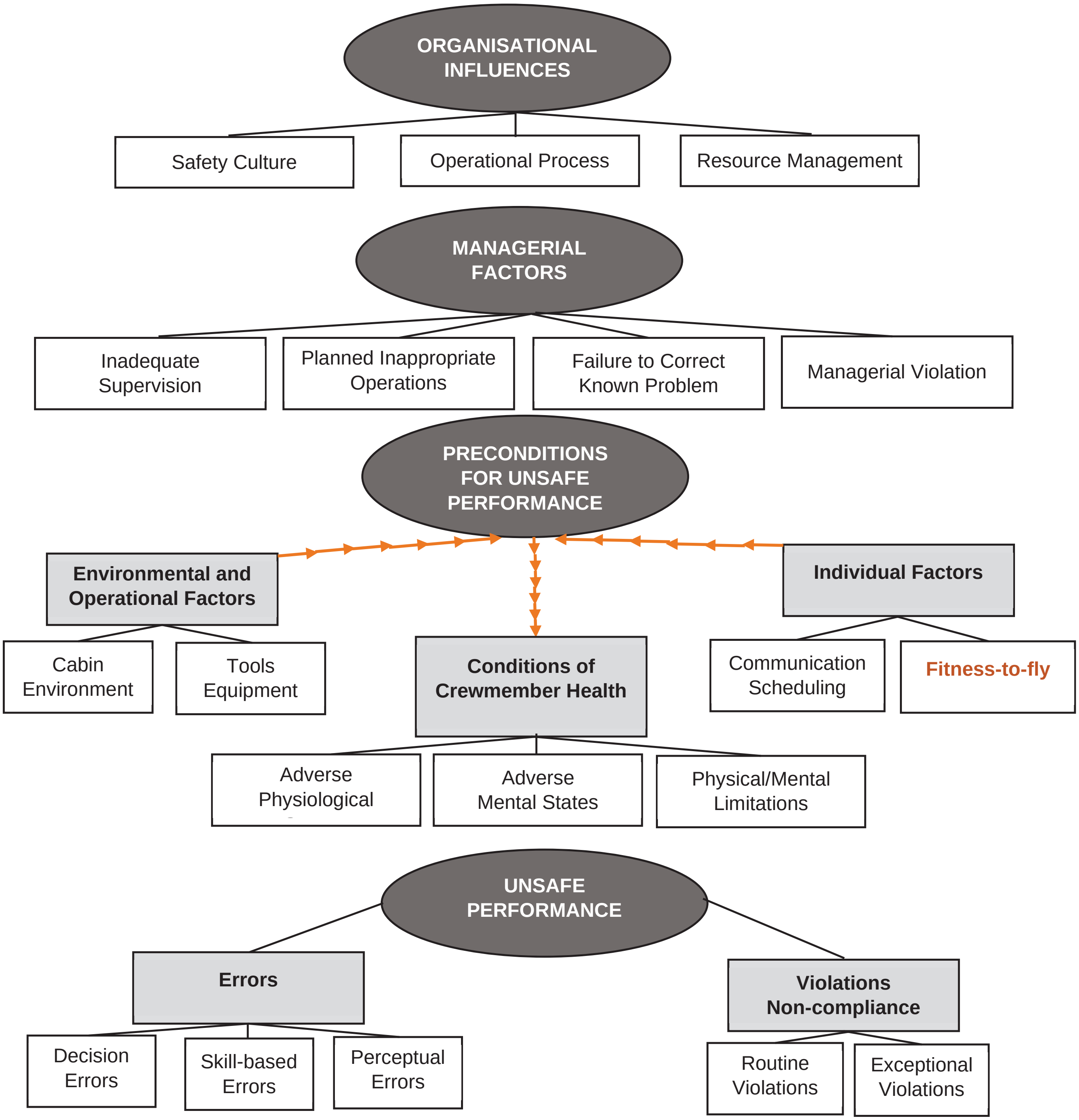

Figure 8. Common symptoms of travel fatigue and jet lag, and differences in their causes

8. Risk perception: Risk and uncertainty from a cabin crew perspective

Air travel has specific risk features that distinguish it from other modes of transport in that incidents may occur in a mobile space at any point in time over long distances. Hence, the inherent risk for the cabin crew occupation can be defined as the potential exposure to global hazards. The nature of air travel, operating in a global space, charges additional distinctive features to risk and uncertainty. The network covered by an airline largely dictates the nature of the workspace cabin crew must adapt to. Sources of unexpected disruptions such as travel delays or technical failures not only contribute to schedule disruption and the level of fatigue that crew experience (Ivancevich et al., 2003), but anxiety over personal health and safety in unfamiliar settings can also add to the build-up of uncertainties (Hottola, 2004).

To date there has been little agreement on the level of risk crew are exposed to from occupational and environmental hazards (Bagshaw & Illig, 2019; Harrison et al., 2009; NIOSH, 2012; Tashkin et al., 1983). This indicates a need to understand the various perceptions of risk and uncertainty that exist among cabin crew. Several authors stressed the likelihood of performance decrements caused by uncertainty under current duty arrangements (Sharma, 2007; Sonnentag & Natter, 2004; Stoleroff & Correia, 2009; Winget et al., 1984). It is unclear how the combined experience of different types of uncertainty impacts the health of cabin crew, and their ability to effectively perform the safety role.

Different definitions of risks exist: Risk may be defined as the potential occurrence of a hazardous event in any given time frame, or risk can be related to the likelihood of an exposed individual being affected by a specific hazard, including the probability of adverse health impacts (Janic, 2000). In instances of exposure to a hazard, individuals must consider potential threats and develop an understanding of the risk to respond. Past research identified factors that explain variation in risk perceptions, including risk acceptability (Douglas 1986; Fischhoff et al., 1981), perception of technological risks (Covello, 1983), cognitive and cultural biases (Flanquart et al., 2013), differences in layperson and expert perceptions (Slovic et al., 1981), the relationship between trust and risk (Shapiro, 1987), and social context (Quillian & Pager, 2010). In addition, general classifications of risk are offered by Evans (1997); Kuhlmann (1981); and Sage and White (1980). Among different types of societal risks, Sage and White (1980) further identified ‘perceived risk’ as the risk which may intuitively be felt and thus perceived by individuals.

Occupational and environmental risks and uncertainty are inherent to deepening an understanding of the way cabin crew perceive health and safety. Contemporary air travel is constructed on the apparent absence of risk, where hazard identification is an essential component of accident prediction (Gill & Shergill, 2004). Cabin crew may develop their own cognitive model of what constitutes a health risk that includes beliefs about symptoms and personal consequences of inherent uncertainties about health effects. Similarly, crewmembers may not perceive a threatening situation because of the absence of visible hazards. In such situations, judging the correctness of assumptions can be difficult or impossible. Some crewmembers may also have differing perceptions of inherent risk to exposure, leading to varying levels of uncertainty (Chen & Chen, 2014). Employees attribute uncertainty largely to poor management, and consider such problems avoidable through better organisation (Zapf et al., 2001). Stoleroff and Correia (2009) explain how the cabin crew’s approach to risk avoidance does not come from improving working conditions in general, but rather withdrawal from work to avoid risks and ‘wastage’, and to increase rest and recovery. The focus of the approach to risk and safety management is thus to capture cabin crew’s perception regarding their role in ensuring safety (Gill & Shergill, 2004).

There is no clear position on the idea of ‘safety at a reasonable cost’ (Gill & Shergill, 2004). To effectively perform their work duties, cabin crew must learn to cope with various uncertainties, on top of their routine service and safety tasks (Liang & Hsieh, 2005). As international air travel is characterised by an environment of increased threats, these conditions mark significant shifts in the work environment of cabin crew that could have important implications for their health and fitness (MacDonald et al., 2003). In an attempt to illustrate the negative impact of frequent mobility (termed ‘hypermobility’), Cohen and Gössling (2015) emphasise the glamorisation associated even with the negative sides of travel. For instance, jet lag may also invoke notions of ‘speed, distance and freedom to travel’, hence representing a socially admired mobile identity that involves the element of ‘travelness’ and ‘network capital’. This, too, can contribute to feelings of uncertainty towards risks.

Summary: The potential risks of flying are manifold. Unanswered questions about the level of risk of exposures to potential work hazards may impede cabin crew’s psychological health and integrity. While it may be difficult to determine cause-effect relationships, it is unclear how dangerous these hazards are perceived by cabin crew, and how crewmembers judge the associated risks of exposure.

9.Compliance with rules and regulations

Airline operations are associated with strict safety standards, where safety compliance as a concept is considered critical for enhancing flight safety (ICAO, 2017a). Emergency situations represent unique challenges in airline operations. The human element is crucial in the response to aircraft emergencies and in the prevention of abnormal situations. While safety-related functions assigned to cabin crew are well established across the aviation industry (IATA, 2012; ICAO, 2017b), little attention has been given to how crewmembers perceive their own safety-related behaviour, and how this behaviour is attributable to potential antecedents (Chen & Chen 2014). In addition, the roles of regulators and airlines in managing the occupational characteristics of the cabin crew employment are controversial, and duty regulations do not reflect the increased security responsibilities (Nesthus & Schroeder, 2007; Griffiths & Powell, 2012). Changing operational conditions are considered sources of uncertainty and confusion in situational health and safety contexts (ASHS, 2016).

Employee commitment can be impacted in both positive and negative ways by the workplace environment (Cohen, 2017). Perceptions of, and attitudes towards, safety procedures and compliance with regulations are typically grounded in risk-taking behaviours (Lee et al., 2006). Driven by individual attitude patterns and company policies, different practises emerge about how to assess risks, and how to comply with procedures and regulations (Hörmann, 2001). Chen and Chen (2014) further explain how flight safety requires more than cabin crew’s reactive behaviour to deal with potential occurrence of incidents and accidents on flight. Cabin crew’s risk perception is therefore important for understanding their proactive safety and compliance behaviour (Borman & Motowidlo, 2014; Griffin & Neil, 2000).

Evidence suggests that safety perception and communication is closely related to employees' safety behaviour and compliance (Cigularov et al., 2010; Griffin & Neil, 2000; Parker et al., 2001). For example, cabin crew ignore the consequences for their own health, and this neglect may affect their safety-related compliance behaviour (Grout, 2015). Airlines also tend to use differing or inconsistent measurements when reporting wellbeing initiatives, thereby complicating evaluation and comparison of their effectiveness (Cowper-Smith & de Grosbois, 2011). Grover (1993) demonstrated how performance pressure caused by time constraints and lack of capabilities or resources causes non-compliant and lying behaviour. For example, cabin crew reported concealing information about the safety of the flight by forming opinions on how much passengers should know, and concern that passengers may dramatise safety-relevant information that does not constitute an imminent emergency (Scott, 2003).

Perceived 'penalties' imposed by the organisation can further contribute to the likelihood of non-compliance and dishonesty (Scott, 2003). Research has continually emphasised the significant effect that organisational leadership has on employee safety behaviours (Yukl 2002; Clarke & Ward 2006). In a study of cabin crew dishonesty in airline organisations, untruthful or noncompliance-motivated behaviour was found to have received reinforcement from company training and real-flight scenarios in that some cabin crew felt forced to lie by organisational expectations (Scott, 2003). Consistent with Grover's theory that one cause for dishonesty or non-compliance is conflicting role demands (Grover 1993; Grover & Hui, 1994), some crewmembers resorted to deceitful or noncompliant behaviour, when unable to resolve conflicting roles. Spurred by organisational performance expectations, cabin crew seemed to have an internalised morality-based hierarchy of behaviours which allowed them to approve of dishonesty or non-compliance to protect themselves from harm or reprimand (Scott, 2003). Convincing themselves that noncompliance with certain regulations is well-intentioned altruism thus served to mask the caustic effects of dishonesty or noncompliance for self-preservation.

Scott (2003) further found that the effect of organisational expectations for on-time performance can drive employee choices: To ensure timely departure, crewmembers would lie to say that all passengers are seated, because they could then claim to have departed “on-time”. Behavioural experts point out that people often fail to recognise the moral components of an ethical decision because of ethical fading (Tenbrunsel & Messick, 2004). Ethical fading allows people to convince themselves that being compliant or noncompliant is not applicable to decisions that in any other circumstances would be ethical dilemmas. This mainly happens because influencing factors subtly neutralise the “ethics” from an ethical dilemma. Ethical fading therefore allows crewmembers to transform morally wrong behaviour into socially acceptable conduct by dimming the guilt of the ethical spotlight.

Response procedures require coordination and adherence to protocols that can become fragile under the combination of time pressure and high service workloads. The effects of stress and time pressure may create situations where crewmembers inadvertently skip checklist items, or where the ability for attention and decision making is hampered (Burian et al., 2003). For example, Damos et al. (2013) investigated cabin crew safety performance and noted situations where security checks were neglected. Requirements for quick performance to meet service standards and customer expectations can also lead to negligence or unsafe behaviour in food handling. For instance, inadequate cleaning of workspaces and failure to practice good hand hygiene are primary contributors to infectious disease transmission (Bloomfield et al., 2007). The workplace is known to be an important source of contamination, yet little information is available on pathogen spread and mitigation strategies in cabin environments (Wilson, 2020). In addition, controversies around the mandatory imposition of safe food handling practices exist among regulatory international agencies, and food safety laws in different countries often do not establish clear guidelines (Vaglenov, 2014). Combined, these factors can lead to role conflicts and confusion among crew and increase the risk for safety lapses (Damos et al., 2013).

Bergman and Gillberg (2015) indicate how motivation and job commitment among cabin crew has diminished because of negligent and exploitative working conditions. On the organisational leadership angle, the case of British Airways' restructuring in the 1980s in an increasingly deregulated market serves as example to highlight the various roles of an airline organisation and the difficulties of building or rebuilding credibility and trust among its employees (Manzoni & Barsoux, 2002). It also raises questions on how much management styles are shaped by an organisation’s initial culture and leadership experiences. The British Airways case illustrates the importance of recognition and fairness in radical change situations and raises questions on the causes and consequences of an airline safety culture. Once a culture of employee care that was widely admired even beyond the airline sector, 'that culture seemed to radically change as employees felt no longer cared for' (Doganis, 1994). Cabin crew commitment and performance can thus decrease due to poorly planned organisational changes and may give rise to poor performance or even noncompliance.

Summary: Compliance safety behaviour relates to ensuring personal and workplace safety through abiding by policies and regulations aimed at minimising the risk of potential injury or hazards. Environmental and operational changes are increasingly creating new compliance obligations. The topic of aircraft disinsection in chapter 4, and safe food handling in chapter 5, will further illuminate how risk-avoidant behaviour by crew can spur noncompliance and create a public health dilemma.

10.Safety versus Service: Role Conflict and Role Ambiguity

Compared to their roles in the early days of commercial aviation, cabin crew are now confronted with a complex list of duties and obligations. These obligations have occurred from changes such as extended flight times or demands for higher service standards (Child et al., 2019), but also because of the rise in terrorist activity and rapid spread of infectious diseases (Mangili et al., 2015; Tatem et al., 2012). Cabin crew have more responsibilities than most front-line service employees because they must ensure cabin security, perform safety-relevant tasks, and at the same time provide customer service (Chen & Chen, 2012). Taylor and Moore (2015) describe how the apparently contradictory requirements of cost cutting and increasing demand for service excellence have imposed a double burden on cabin crew. Requirements to fulfil the safety and service role is placing cabin crew under increased time pressure, creating a potential conflict between achieving airline-specific performance standards and the complete execution of safety and security duties.

Examinations of current management policies revealed that prompt performance of safety and security duties is adversely affected by the number of service duties (Damos et al., 2013). These observations showed how safety procedures were often omitted or delayed in favour of service performance, or that crewmembers did not take their breaks to complete service items. The authors further note how some airlines have established performance standards to ensure desired quality of in-flight service. Such standards are often specified time deadlines by which cabin crew must complete specific service activities. Failure to meet the required performance has been noted to imply disciplinary actions (Damos et al., 2013). Underpinned by Murphy (2001) who argues that the default behaviour for the cabin crew role is to ‘accommodate’, these findings may also have the unintended consequence of eclipsing visions of what the cabin role entails, and of obscuring the ways in which such management actions may foster a culture of fear and punishment.

Authorities have underestimated the consequences of role conflicts cabin crew may experience (House of Commons Transport Committee, 2007). The main job stressors of cabin crew derive from social and organisational factors, such as isolation and role conflict (Chen & Kao, 2010), as well as emotional labour (Al-Serkal, 2006). In turn, the combination of organisational job stressors such as high job demands, time constraints and role conflicts, and low job resources such as lack of support or low autonomy, shows strongest associations with emotional exhaustion (Zapf et al., 2001), and was found to exacerbate the risk of burnout (Bakker et al., 2006). These trends show that human factors and cabin safety have become increasingly important to flight safety. It can be concluded that the resurgence of role conflicts over service versus safety is the result not of sudden changes, but of broad, long-term accumulation of factors related to the expansion of either role. The publication in chapter 2 was built on this knowledge and presents a more detailed description of role conflict and role ambiguity.

Summary: Effective risk assessment and management systems are essential to reducing the likelihood of neglecting or omitting safety duties stemming from role conflict or role ambiguity. Reporting systems that invite cabin crew to raise issues of concern are fundamental to a robust safety management plan (Flight Safety Australia, 2015). The level of safety culture largely depends on the right communication channels and the willingness of staff to adopt the safety thought as genuine priority.

Chapter 4 and 5 will further depict the impact of role conflicts relating to aircraft disinsection and inflight food safety. Figure 9 illustrates the interdependencies of factors discussed in this chapter.

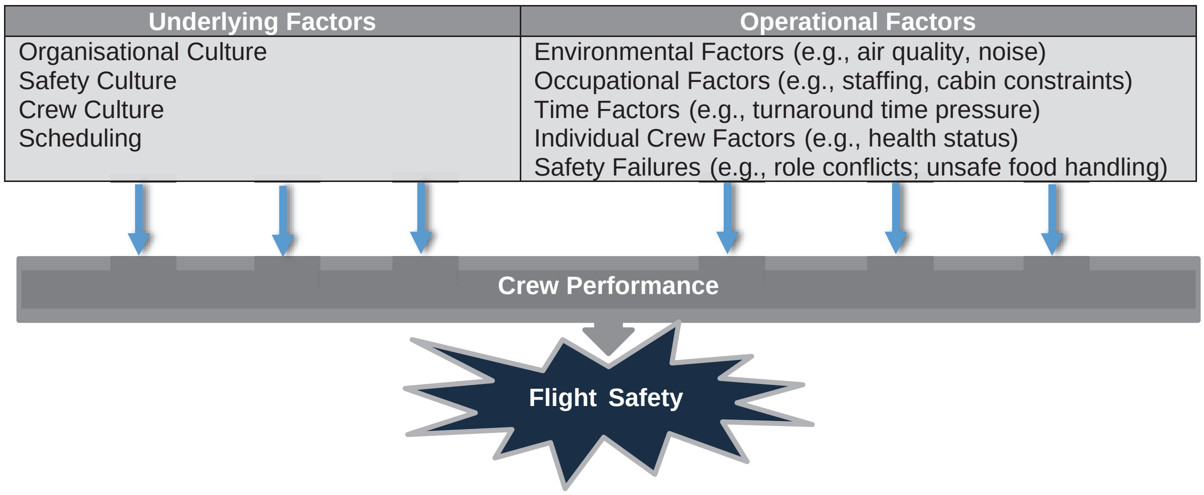

Figure 9. Underlying and operational factors that impact on performance

Chapter summary

This chapter examined the literature about the cabin crew role in an industry characterised by competitiveness and organisational changes. Operational and environmental changes have further complicated the understanding of occupational health risks, creating a range of work-related uncertainties. There is a lack of standardised methodology to define acceptable exposure levels, and the absence of harmonised standards and guidelines for fitness-to-fly combine to leave open questions about potential health risks and resulting performance deficits.

The relationship between performance of the safety role and individual health demands a focus not only on the implications of these two factors for flight safety, but on leadership management behaviour. Factors such as increasingly intense customer service, time pressure, poor wages, and air rage characterise contemporary air travel – and depict a significantly different cabin crew role from that experienced by previous generations (Baum, 2010). To ensure consistent compliance with safety procedures requires a healthy workforce, and an open and supportive organisational culture. Given the potentially important consequences of poor health, it is crucial that research continues to develop theories and measures which capture the complexities of health management as part of work roles. Data from within airline organisations are needed to demonstrate their links to actual job performance.

Operating within a framework of regulations and demands that meets passenger service expectations as well as ensuring their safety and health, comes with a broad set of challenges. These activities are likely to intensify in the future and increasingly affect the role of cabin crew as key employees to flight safety. Some assumptions about the existing paradigm of safety in air travel are not consistent with the knowledge set out in the literature. Physical and mental health factors stemming from the uncertainties of occupational exposure to hazards appear to have significant influence on cabin crew response performances. To ensure flight safety, significant areas of research include the ambiguities surrounding the cabin crew work in regulation and policy, role conflicts between safety and service, and the key role of cabin crew as safety agents in food hygiene and infectious disease control. Careful observation of the fit-to-fly reporting behaviour of crewmembers, as well as exploring the constituents of fitness-to-fly that benefit flight safety will be needed to meet the challenges for safety in aviation.

The next chapter comprises the publication ‘Managing Asian Tourists on Long-Haul Flights.’ In illuminating aspects of the service role, this study demonstrates how safety-related crew responsibilities contribute to the delivery of service, and how crewmembers act as cultural mediators in critical incidents to prevent situational escalation of events. By linking variables of the service role to potential implications of health and safety outcomes, the paper illustrates the need for ongoing integration of safety principles into service practices to ensure effective communication among all on board. The work also describes approaches to the empirical evidence in actual flight operations, including the notion of how extended service duties may adversely affect safety responses.

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CHAPTER 2

The Role of Cabin Crew: Service Aspects

Thesis structure

Grout, A. (2017). Managing Asian tourists on long-haul flights. In P.L. Pearce & M.-Y. Wu (Eds.). *The World Meets Asian Tourists (Bridging Tourism Theory and Practice, Volume 7),* (pp.93-110). Bingley, UK: Emerald Group Publishing Limited.

<u>Publication:</u> Managing Asian tourists on long-haul flights

Abstract

The voices of cabin crew on international air routes have scarcely been heard in tourism management studies. Using an auto-ethnographic account and interviews with cabin crew colleagues, this chapter presents some of the complexities in managing Asian tourists on long haul flights. Typical and real incidents demonstrating problematic behaviors by Chinese, Indian, Japanese, and Korean passengers are documented and discussed. The results show that the aircraft environment can be a site of intensity, rich in contradictions and tension. Key challenges include cabin crew grappling with unfamiliar passenger values, facing their own and staff judgments, and status issues. Adjusting and developing training curriculum for cabin crew to enhance cultural awareness is a core resolution to optimize service delivery.

Keywords: International air travel, Asian passenger behavior, cultural similarities and differences, incident analysis, in-flight management.

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CHAPTER 3

Online Blog Analysis: Cabin Crew Health, Safety, and Fitness-to-fly

Grout, A. & Pearce, P.L. (2020). Health, Safety, and Fitness-to-fly from a cabin crew perspective. *Manuscript under review.*

Note: A fuller and extended 30,000-word version of this submitted paper is available as a manuscript from the thesis author.

Publication: Health, safety, and fitness-to-fly from a cabin crew perspective

Abstract

The role of cabin crew members centres on ensuring the safety of and delivering services to those who traverse the skies. The aims of this study were to document and explain the concerns of cabin crew who can be conceived as an active narrative community frequently reporting on the challenges of the role. Almost 900 blog entries from an international, multi-lingual cohort of 37 blogs were identified from private sites outside of the official company communication channels. A detailed three stage coding scheme identified five major reasons for posting blogs. Further, the key factors shaping fitness-to-fly concerns were identified as route and flight schedules, within the aircraft disease transmission, and enduring fatigue. Attribution of responsibility was shared between self-directed and company practices, though cynicism towards and a decline in trust in the employers were frequently noted. Practices to improve the health and safety of all parties were catalogued.

Keywords: cabin crew, narrative community, blog analysis, disease transmission, passenger safety, cabin crew health, fitness-to–fly issues

Introduction

Airline crew members must meet fitness-to-fly standards to ensure that they can carry out their work (International Air Transport Association, 2019). This study focuses on the work environment of those whose employment involves managing the cabin environment rather than actually flying the aircraft. Being a cabin crew member is a complex role involving alertness, risk perception, judgement, and interpersonal skills. The main spheres of operation are safety and customer service (Grout, 2017, 2020). Importantly, any impairment to the effective functioning of cabin crew may compromise the safety and health of passengers, other staff and the crew members themselves. This study examines the online conversations and discussions by cabin crew to ascertain the pivotal issues involved in their work environment that influence their fitness-to-fly.

In the world of 2020 and the CORONA-19 pandemic, several of the procedures discussed in this work are highly pertinent to the health and safety of passengers and airline crew. The work was carried out before the onset of this globally important health crisis but potentially helps to inform the raft of changes airlines must enact to meet the evolving standards for looking after passengers and crew. The work thus reflects past airline practices and offers insight for future work standards and operations.

The researchers employ the concepts of narrative communities, attribution theory and some aspects of risk to frame the work (cf. Douglas, 2005; Noy, 2006; Weiner, 2010). The study is, however, conceived as constructivist and inductive (Jennings, 2010). It gives prime position to the voices of the crew members. The research team consists of a highly experienced former crew member and a well-travelled tourism academic who together have the insights to understand the sometimes syncopated and abbreviated language used in the travel blogs and discussion boards.

More specifically, by analysing rich peer to peer blogs this study addresses cabin crews' motivation to report on their personal health and fitness-to-fly concerns. Additionally, the researchers seek to document the content of the crew members' fit-to-fly issues and attendant risks and perceived responsibility. The work is conceived as a foundation study to assist in developing a stream of analyses about a sector of travel and tourism workers who, at least compared to hotel employees for example, have not been studied very often by mainstream tourism researchers (Baum, 2015).

Literature review

The theoretical framework that informed our understanding of cabin crew perceptions and attitudes consists of the concept of narrative communities, the theory of attribution, and aspects of risk perception.

Narrative communities

In attempting to develop an analytical method that captures the congeniality of cultures through narratives and storytelling, Müller-Funk was one of the first cultural theorists to make a connection between the narrative concept of communities and the study of within culture meaning (Müller-Funk, 2008). By conceptualising cultures as 'narrative and memorial communities' ("Erzählgemeinschaften," see Müller-Funk, pg. 53), i.e. as communes that share a repertoire of cultural narratives, Müller-Funk explains how these communities also share a distinct range of narrative patterns that serve as tools for locating and resolving narrative-based commonalities. Narrative communities in his view are personal stories that people subscribe to and that guide their behaviour. They are the stories we tell ourselves, not just those we explicitly tell other people, about the world(s) in which we live. Any given narrative is therefore, as Bruner similarly argued, "a form not only of representing but of constituting reality" (Bruner, 1991, pp. 5). In this analysis, the researchers pursue narrative insights about the working world of cabin crew as such an exposition may ultimately help manage the very concerns cabin crew set out to voice.

In exploring airline health and safety issues from a cabin crew perspective, the theory of narrative communities helps specify the relationship among crewmembers, and reveals common memes and clichés. Further, the narrative community perspective typically helps interpret rituals, and identify the special bonds that bind group members

(Pearce & Wu, 2018). At core, members of a narrative community reinforce one another's values and perspectives through talk, debate, common views and reference to dominant personnel. Noy (2006) argued that pivotal reflective and summary points in everyday talk among the community members inform the meaning of the experience. An awareness of the right topics to discuss and the language to employ when representing oneself have also been identified as pivotal in understanding the move from peripheral to core identity in leisure and work groups (Goffman, 1968; Harris, 2005). Good examples of tourist groups where the narrative community concept is very applicable include backpackers, self-drive communities, package tourists and cruise participants (Bauman, 2003; Noy, 2006; Pearce & Wu, 2018).

Through collecting the stories of Israeli backpackers, Noy (2006) described the interplay of quotations and constructed dialogues, and examined the crucial role they play in creating a voiced community. According to Noy, narrative communities illustrate how storytelling fundamentally becomes a social pool of shared knowledge, values, and hierarchy, and how a sense of belonging emerges through reciprocal voices on multiple social levels - the individual, the group, and the collective. In other words, the storyteller and the audience share the ground they have covered together. Of particular relevance to our study is the interpersonal persuasion that travellers use to convince others of facts, benefits or perceptions. Like backpackers and other clearly identified tourism sector cohorts, cabin crew are likely to value and benefit from the sharing of their insider stories. One aim of this work is to document the cabin crew motivations for their online storytelling.

Attribution theory

The theory of attribution identifies how people attribute internal or external causes as determining factors in events and behaviours. At core the approach understands blame (Health and Safety Executive, 2005). For example, *what* causes events, *who* is to blame, or *how* are risks allocated (Weiner, 1985, 2010). Weiner identified ability, effort, and task difficulty as the most important factors affecting attributions for achievement. Weiner classified attributions along three causal dimensions: the locus of control, stability, and controllability. The principle of attribution is thus a three-stage process: first, behaviour is observed, second, behaviour is determined to be deliberate, and third, behaviour is attributed to internal or external causes. The locus of control dimension has two poles: internal versus external locus of control. The stability dimension is particularly interesting for the dynamic nature of cabin crew work as it captures whether explanations of causes change over time or not.

Guided by Weiner (1976, 1985, 2010), Försterling (2013) described how the tendency to structure unrelated events in terms of personal perceptions and intentions can lead to misjudgement or underestimation of situational factors. As causal attributions are often the topic of blog conversation, this insight is potentially helpful in explaining how cabin crew allocate perceived risks and hazards in the context of duty of care and fitness-to-fly. Crewmembers demand valid explanations from management regarding these risks, and the answers they get shape their subsequent behaviour. Grice (1975) argues that for individuals to cooperate, such explanations need to follow four ‘maxims’: quality, quantity, relevance, and manner. The type of delivery of these maxims forms an important platform to explain how crewmembers construct their own ‘truth’, how they reason as individuals, and how they derive consequences that generate actions such as reporting sickness or complying with directives. In documenting the cry will be considered as a platform to see how the interplay of external and internal explanations of the problems with cabin crew conditions are represented.

The theory of risk perception

The extensive writing about risk adds another element to the theoretical framework of this study (Douglas, 2013). The theory of risk perception links with the attribution theory approach and can be used in conjunction with that search for explanation to understand how cabin crew perceive and interpret problems. In their cultural theory approach, Wildavsky and Dake (1990) note how the theory of risk can predict and explain which groups will perceive potential hazards as especially dangerous. That is, to what degree are different people equally worried about the same risks, or to what extent do some perceive certain risks as great that others think of as small? And how do concerns differ across different kinds of risks? Only by comparisons across types of risks and hazards can we learn whether perceptions of risk depend upon the meaning individuals give to objects of potential concern. In turn, the psychometric paradigm focuses predominantly on two main cognitive factors that dominate a person’s perception of risk: the dread (identifiable) risk factor and the unknown risk factor (Slovic, Fischhoff, & Lichtenstein, 1980). While this approach cannot explain differences in levels of risk perception among groups (e.g. questions such as 'Why is an environmental risk feared in one social context and not in another?'), the theory holds that perceptions toward occupational risks are closely related to preferences for appropriate risk management strategies. Along this line of thought, the researchers examine how cabin crew perceptions are related to beliefs associated with health and safety concerns of their workspace. This area of interest extends to preferred strategies to manage these risks and concerns. Understanding differences in occupational risk perception and thus risk judgment might facilitate the development of effective risk management strategies, including communication about health risks. Figure 1 portrays the framework for the study.

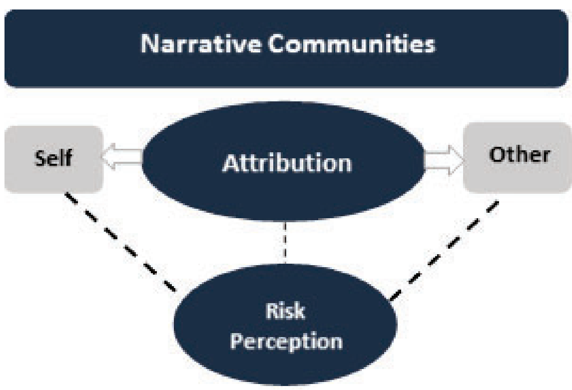

Figure 1. Illustration of the priorities in the theoretical scheme

Netnography as research tool

The observation and analysis of online communications is called netnography, a term coined by Kozinets (1997), combining the words "interNET" and "ethNOGRAPHY". Online blogs provide a rich resource for investigating the sociological, psychological and personal insight needed to better understand the cabin crew workspace (cf. Mkono & Markwell, 2014). By analysing group fora and private blogs, we report how cabin crew use online platforms to communicate their experiences of journeys and destinations, discuss job concerns, and how the worker/traveller dichotomy finds expression in these exchanges and narratives. In addressing the need for investigating health and safety issues, this exploration of networked communication of crewmembers' experiences considers personal motivations and concerns as key factors in the creation of blogs. The analysis focuses on three core interests: 1) how blog posts thrive on the combination of statements and feedback; 2) how contrasts in comments develop in the context of air travel with elements of the theory of narrative communities, the theory of attribution, and the theory of risk perception; and 3) how comments negotiate the tension between organisational pressures and the expression of health and safety concerns. As a succinct justification of the ever-expanding use of blogs in service industry and tourism research, Table 1 offers a partial but illustrative timeline. It is the intent of the researchers to add to this blossoming approach to online blogs by working with the information provided by cabin crew.

Table 1. Netnographic methodology examples in ascending chronological order: 2005-2017

Author(s) / Year	Title of Paper
Kozinets (1997)	"I want to believe": A netnography of the X-Philes' subculture of consumption
Kozinets (1998)	On netnography: Initial reflections on consumer research investigations of cyberculture
Kozinets (2001)	Utopian enterprise: Articulating the meanings of Star Trek's culture of consumption.
Kozinets (2002)	The field behind the screen: Using netnography for marketing research in online communities
Langer and Beckman (2005)	Sensitive research topics: Netnography revisited
Ignacio (2006)	E-scaping boundaries: bridging cyberspace and diaspora studies through netnography
Sandlin (2007)	Netnography as a consumer education research tool
Negra et al. (2008)	E-procrastination: a netnographic approach
Dewhirst (2009)	New directions in tobacco promotion and brand communication
Belz and Baumbach (2010)	Netnography as a method of lead user identification
Bowler Jr (2010)	Netnography: A Method Specifically Designed to Study Cultures and Communities Online
Björk and Kauppinen-Räisänen (2012)	A netnographic examination of travelers' online discussions of risks
Kulavuz-Onal and Vásquez (2013)	Reconceptualizing fieldwork in a netnography of an online community of English language teachers
Rageh and Melewar (2013)	Using netnography research method to reveal the underlying dimensions of the customer/tourist experience
Mkono & Markwell (2014)	The application of netnography in tourism studies

Wu and Pearce (2014)	Chinese recreational vehicle users in Australia: A netnographic study of tourist motivation
Roy, Gretzel, Yanamandram, and Waitt (2015)	Reflecting on ethics in netnographic research
Bridges (2016)	Facebook as a netnographic research tool
Costello, McDermott, and Wallace (2017)	Netnography: Range of Practices, Misperceptions, and Missed Opportunities
Berdychevsky & Nimrod (2017)	Sex as leisure in later life: A netnographic approach
Kozinets (2018)	Netnography for management and business research
Stainton (2018)	The 'Blogosphere' as a platform for interpretative phenomenological analysis: the case of TEFL tourism

Aims

By using a netnographic research, and a thorough approach to coding that information, the researchers address the following aims:

1. To evaluate cabin crew's motivation to write blogs and report on the personal health and fitness-to-fly concerns
2. To investigate and report the content of the blog writer's concerns about being fit-to-fly
3. To examine risk and perceived responsibility in the context of being fit-to-fly

METHODOLOGY

Rationale for choosing an online blog study

Cabin crew represent a globally distributed but well recognised occupational group. As such, they are members of an identifiable 'physical', as well as an online community. Blog data are by nature primary data which are not affected by the researcher (Jones & Alony, 2008). We considered this methodology most suitable due to its unobtrusive nature, its ease of access, and ongoing availability. Insights into a "naturally occurring community" (Kozinets, 1997, 2002, 2007) allowed us to analyse language used by cabin crew, and to take advantage of the unsolicited narratives that crewmembers exchange online.

Rationale for manual coding:

We deliberately chose a manual coding procedure to help us attend fully to the data. Although this process proved very labour intensive, it was important to understand and reproduce the meaning of 'encrypted' airline language. The following blog post illustrates the complexity of language items used. These could be coded in very different ways, depending on the familiarity with both language and operational context:

"As you can see I'll have four lines coming up to Switzerland – I put it as a low bid and got 2 GVA and 2 ZRH. I only got 2 turnarounds this month, although I'm at the bottom of the bidding line…as a bonus, all legs start from terminal X, where I would always stop to get a coffee after deadheading from LAX to FLL on the red eye".

This kind of material was understood using our own repertoire of 'insider filters' and knowledge of the operating environment. Here, our perspective acknowledges the pragmatist paradigm, which chooses "the right tool for the right job" as all methodologies and conceptual frameworks are context-specific (Patton, 2002). Attempting to explain the insider language in terms of its individual constituents is rather like trying to understand any machine by analysing its single elements. It is certainly possible to learn something about the content, but in the process of decoding, the dynamics of reports vanish, and further quantitative analysis would be unlikely to reveal the richness of 'in-between line' recordings or hidden interactions. Such in vivo approaches to coding, also referred to as "natural coding" are further useful for their reliance on the bloggers themselves for giving meaning to the data (Saldaña, 2015). The terms 'theme' and 'category' as well as 'blogger' and 'author' are used interchangeably throughout this work.

Finally, netnographic observations allow for greater continuity in research as transcription of interactions automatically takes place in the process. With these background considerations in mind and attending to the aims of the study, the following procedural details can be specified. Kozinets' (2010) approach was closely followed in the methodological stages and procedures, including data collection, analysis and interpretation. In terms of member checks (i.e. getting feedback from participants), participation was excluded. This choice was very deliberate as both personal and organisational sensitivities involving specific identification of businesses and researchers' views needed to be carefully managed. James Cook University advice and ethics approval for the broader study was provided. The approval was conditional on individual airlines and personnel not being identifiable. The researchers' decided to avoid direct contact with bloggers or airline companies to avoid any personal or professional litigation.

Data Collection and Analysis Process

In this analysis, we looked at blog posts relating to health and safety issues with no preconceived categories to provide ideas of what themes are important. To test the information content, it was first necessary to operationally define what might be useful information. Six evaluative criteria reflecting health and safety issues were chosen to gauge whether blog comments were deemed relevant to the study aims. These criteria represent factors identified as information cues that existed in associated health and aviation literature (Smith & Leggatt, 2010). In evaluating each comment against these criteria, we asked, 'Does this comment communicate any of the following cues about cabin crew health and safety'?

1. Cabin crew health, wellbeing, fitness-to-fly
2. Fatigue, jet lag
3. Cabin air quality (fume events, aerotoxic syndrome, disinsection, germs)
4. Safety, security (incidents and accidents)
5. Cabin crew job profile (past and current conditions, workload)
6. Airline management

A comment needed only to communicate one of the six cues to be considered 'informative'. Data collection and analysis was a 3-level process of data reduction:

1. Search on Internet search engines as per key words, languages, and time span
2. Application of inclusion criteria, determining saturation of data with inter-rater agreement, initial coding of relevant issues, merging codes to form categories
3. Looking for patterns and explanation in the codes and categories.

These stages are described in detail in the following sections.

Our initial objective as observer was to get to know the authors ('players') and learn as much as possible about rituals and topics through immersion in the online community. In this familiarisation process, which Kozinets (2010) termed 'Entrée', we collected two types of data:

- Archival – data without my involvement
- Fieldnotes – observational and reflective notes

To connect this work with a larger frame of reference of online scholars, our initial fieldnotes consisted of a set of guidelines representing our decisions on structure and conduct for observation of the online community. To avoid the dilution of our recollections over time and to generate additional insight, we wrote memos throughout the collection phase (cf. De Crop, 2004).

Information sources

The filtering process took place in the following search engines:

- Google
- Yahoo!
- Wikisearch
- Twitter
- Ning.com

In addition, we entered search terms on Facebook, YouTube, Flickr, Digg, and MySpace. To adequately cover communal terrain, we refined our search to target cabin crew communities that could exist at the brand level (e.g., Boeing, Airbus), the airline business model (scheduled carrier, charter carrier, private carrier), and the hierarchical job level (flight attendant, in-flight manager, purser), however these produced no results.

We applied the following keywords in English, German, and Spanish:

English	German	Spanish
Blog, forum	Blog, Forum	Foro, blog
Cabin crew, crewmember, flight attendant, stewardess, air hostess	Kabinencrew, Flugbegleiter	Azafata de vuelo, tripulante de cabina de pasajeros

Fitness-to-fly	Flugtauglichkeit	Aptitud para volar
Physical health, mental health, jet lag, fatigue, health problems	Physische Gesundheit, mentale Gesundheit, Erschöpfung, Gesundheitsprobleme	Salud física, salud mental, fatiga, problemas de salud
Flight safety, safety culture	Flugsicherheit, Sicherheitskultur	Seguridad de vuelo, cultura de seguridad
Occupational risk, environmental risk, hygiene, contamination, infectious disease	Berufsrisiko, Umweltrisiko, Hygiene, Kontamination, infektiöse Krankheit	Riesgos laborales, riesgos ambiental, higiene, contaminación, enfermedad contagiosa

Once the initial search produced a result, we entered the keywords in each blog search template to further refine the search.

Inclusion criteria

In line with Dey (1993), the inclusion criteria are not narrowly defined and refer mainly to the boundaries of the overall topic (i.e., fitness-to-fly, health and safety) rather than the substance of a specific subject being discussed. To be included, blog fora and private blogs had to be publicly accessible, i.e., without requirement of a password. Guidelines for inclusion of blogs:

- *Language* - English, German, Spanish
- *Relevant* to the central concept of fitness-to-fly
- *Active* blog status (blog forums: including interactive flow of communications)
- *Heterogeneous* – presence of different contributors
- *Data-rich* - offering rich descriptions

We included blog fora and private blog comments between October 2008 and October 2016 that identified relevant issues. We considered the time span of collection long enough to allow filtering and topic detection to take place, with particular attention to blog communications capturing special events such as strikes or union negotiations, or media reports circulating around ‘hot topics’ such as:

- Aircraft disinsection (e.g., a landmark legal case in 2013 to probe the link between Parkinson’s disease and pesticide spraying)

- Food hygiene, cabin cleanliness and onboard contamination sources (e.g., outbreak of Norovirus onboard aircraft in 2009)
- Plane crashes (e.g., Germanwings crash in 2015)

Data collection / Search strategy

Stage 1:

Our initial search extracted 35 online blog fora and 21 private blogs, of which two blogs were in German, one blog in Spanish, and 53 blogs in English.

First, we evaluated the relevance of the blog content to the topic. At this stage, we employed a research assistant to double-check the process of de-coding comments that displayed airline-internal language, and to translate two German blog fora, and one Spanish blog forum into English. The research assistant was a native English speaker with professional proficiency in German and Spanish, and as former international cabin crewmember, was familiar with the insider language and the operational context of aviation. We independently translated and checked the data for relevance, and for correcting any possible misunderstanding of the context. After applying the search criteria, we discarded twelve group fora and seven private blogs.

In summary, we collected data from 37 online blogs, which in total represent 890 blog entries, chronicled between October 2008 and October 2016 (see table 2). The narratives run along the timeline of progression in the cabin crew work. Eighteen blog fora and 11 private blogs were created between 2011 and 2016, indicating an overall growth in blog volume over time. For example, in just six months, the 'UpUp&AGay' blog has grown from one post to 62 posts with 328 comments in 14 threads. Most blogs were in English so there is some confidence that a global picture of the phenomenon has been captured. There was no need to participate in online communication because content analysis answered our research questions sufficiently.

Table 2. Blog entries according to language and type of blog

Language	Type of blog		Number of relevant blog entries
	Blog forum	Private blog	

English	20	14	
German	2	0	
Spanish	1	0	
TOTAL: 37	**23**	**14**	**890**

<u>Stage 2</u>

In line with Kozinets (2007), we collected data by directly copying posts from online communications. We captured postings exactly as they appeared on screen without editing or correcting sentences, and entered relevant blog comments into individual excel spreadsheets, which we developed for this analysis (see figure 2 for an example). We converted and sorted data as we recorded them. Following Kozinets (2010), these helped us to decipher the reasons behind actions rather than simply offer the description. In this way, data collection does not occur in isolation and thus has pivotal implications for data analysis.

2	Topic	Date	Author	Staff level	Country	Gender	Comment
3	Sanitation/Water	2-Nov-14	faflys	Crewmember	U.S.		I wonder about the sanitation in our galleys. Airlines say they closely follow federal guidelines for drinking water, and say no passengers have ever complained about getting sick
4	Sanitation/Water	7-Nov-14	airborne@LH	Senior Crewmember	Germany/Netherlands		thank god I don't drink coffee and tee during flights!
5	Radiation/Cancer	4-Oct-14	ifly	Senior Crewmember	Austria	Female	Are there any studies as to if and how flying affects fertility/pregnancy in airline employees? Or any studies on how radiation affects the fetus of a pregnant flight attenda
6	Radiation/Cancer	6-Oct-14	Airhostess1000	Senior Crewmember	U.S.	Female	I'd also be interested in finding out about flying and breast cancer...we seem to los more than our fair share of coworkers to this horrible disease...
7	Nosebleeds	2-Jul-14	FL_F/A	Trainee	U.S.		I started having nosebleeds after I've been flying 2-3 days in a row. They usually show up in the mornings. I've been to an ENT specialist, but after taking a CT scan he told me that he couldn't find any reason for them. What do you think causes them and should I be alarmed? The last nosebleed had a small clot in it. Thank you.
8	Nosebleeds	6-Jul-14	Guest				i find when i work on a 777 aircraft i get lots of nosebleeding .... the air is too dry other crew members complain of the same syntoms :-(
9	Nosebleeds	8-Sep-14	sushiseal	Senior Crewmember	Canada		I do get stuffed up on extremely long-haul flights, though. It takes a couple of days after my flights to completely recover from my symptoms. I've actually heard that on long-haul flights, your blood thickens because of altitude. This would go a long way towards explaining "economy-class syndrome" and fatal/non-fatal blood clots. Something to keep in mind for those who do these flights often... Get plenty of rest between such flights, and take care of your health.
							I ve had nosebleeds on the airplane too! I went to see my doctor and he stuck a swab with medicine that burned the inside of my nose. The procedure was painless

Figure 2. Example of a data collection spreadsheet

We first identified 37 recurring issues and sorted these data into preliminary categories. The objective of making the category sets diverse and challenging was to better test the process of our approach and to build a category representative of an operational ‘real world’ classification scenario. To ensure correctness in reproduction of the insider language, as well as the translation of German and Spanish blog entries, initial agreement among one of the researchers and the research assistant was preceded by several discussions to reach inter-rater agreement. Next, we were able to draw common themes from the data to reassure contextual interpretation. We also considered the challenges of ‘real-life scenarios’ which emerged from the initial literature review. This process helped to ensure classification without biasing our evaluation towards a theme. After repeated examination, we re-sorted data into seven categories. We describe this process in detail in subsequent sections.

In reflective field notes, we also recorded our observations relating to visual and graphical data, and documented personal impressions during the online time. Kozinets (2010) highlights how these data often convey interesting information and emotional content, generating a deeper sense of immersion.

Stage 3: Saturation of data

Theoretical saturation was developed in the approach of grounded theory (Glaser & Strauss, 1967). Generally, saturation means that data collection should continue until nothing new is generated (Green & Thorogood, 2018); the point at which there are fewer surprises and no more emergent patterns in the data (Gaskell & Bauer, 2000); and when there are no new perspectives on the research question (Mason, 2010). Data saturation is reached when further coding is no longer feasible (Guest, Bunce, & Johnson, 2006). In addition, Strauss and Corbin (1990, 1998) suggest that saturation is a “matter of degree”, where new discoveries do not necessarily add anything to the overall story or theory.

According to the saturation principle, data collection continued if the blog posts still generated new insights on the topical areas. By incorporating the view of Morse (1995) to “value variation over quantity”, and the notion of Burmeister and Aitken’s (2012) that data saturation is not about numbers *per se* but about the depth of the data, we ignored the frequency of occurrence of any specific incident, and instead focused on reporting different types of occurrences that added depth and breadth to the information retrieved. How to address and mitigate our personal perspective during data collection and analysis was a key component for the study. In line with Chenail (2011), it was important to continually recognise our personal role in the study to limit any concerns during data collection. For the data to be saturated, it was therefore imperative that the interpretation of the phenomena represented that of the online participants and not our own (Holloway, Brown, & Shipway, 2010).

Data Analysis

To expedite the analysis of data, coding initially followed a manifest (i.e., 'explicit') content approach (Dooley, 2016). To enhance categorisation of issues according to emerging themes, we supplemented the coding process by latent (i.e., 'implicit') content analysis at the interpretation stage. Hsieh and Shannon (2005) describe several variations of qualitative content analysis: conventional, directed, and summative, whereas Elo and Kyngäs (2008) focus on the inductive and deductive approach. On top of synthesising these different approaches, Graneheim and Lundman (2004) further clarify terminology and provide an overall transparent procedure to follow in the analysis. While qualitative content analysis is predominantly descriptive (Patton, 2002), the procedure described by Graneheim and Lundman (2004) suggests that clear distinctions between descriptive categories may be fused with the interpretive part of the themes. Although interpretation of comments was often unavoidable, and in part added another useful dimension, the descriptive approach allowed for staying close to the crewmembers' own words. The information presented was evaluated at face value without appraising each comment for credibility, deceptiveness, or the soundness of the information.

Questions we asked during the coding process included:

- Which codes can we relate together under a more general code or theme?
- Can we organise codes sequentially (e.g., is code B preceded by code A)?
- Can we identify any causal relationships among codes?
- Do issues change over time within codes?

In addition, factors of the themes used to analyse blog comments included:

- 'Passengers do not recognise that we should prioritise safety over service'
- 'Passengers do not understand that we must comply with rules and regulations'
- 'Passenger demands, and safety procedures are often contradictory'
- 'In practice, it is not clear whether we can complete safety checks accurately and in time'

- ‘It is difficult to meet safety requirements’

Generating consistency among codes was crucial as it helped us to see the relationships among codes and brought to light underlying ideas and meanings. In parallel to the blog analysis, we conducted a brief search of media reports on the evolving themes. Where possible, we followed these reports to avoid researcher bias. Using the model of Mayring (2015) of inductive category formation as guidance, we incorporated three levels of engagement and worked from the ‘bottom up’ as follows:

Level 1: After re-reading the data set, we highlighted those blog comments that suggested key concepts through which to better understand relevant data. To extract and organise comments and discrete reactions, we then labelled passages in the posts that identified relevant commentaries that related to the research questions and applied descriptive codes directly to the data. In terms of determining the unit of classification, we used a concise approach and designated each relevant commentary as the unit of assessment (see Figure 3 for an example of initial coding). However, some commentaries provided a dual unit of assessment. For example, where commentaries were indicative of knowledge and training deficits relating to topics in media reports (e.g., infectious diseases in air travel or cabin air contamination), these were encoded in both the pre-category ‘training’ and ‘infectious disease handling’.

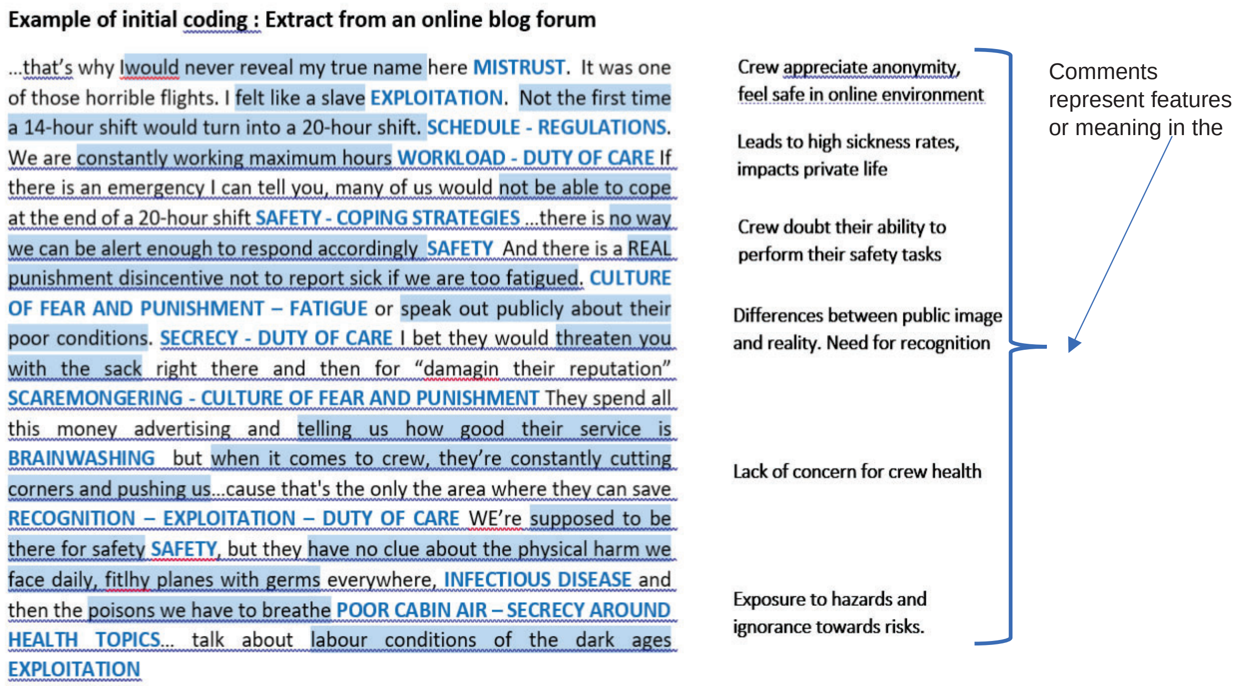

Figure 3. Example of initial coding

<u>Level 2:</u> The building of themes

The broad areas that emerged from the literature review provided a rough initial framework for generating major themes. We continuously reflected on the data with the themes, for it is this interaction of themes and data which enables the generation of a category set (Dey, 1993, p.105). At level 1, certain themes arose consistently from the blog posts and were evident from our field notes. Consequently, the core element of our initial analysis involved coding the blog posts under the specific areas related to fitness-to-fly. This, however, proved difficult given the differing issues that arose from re-reading the blog data. We then realised the importance of not allowing our initial questions to constrain our openness to new themes. The data emerging from this initial focus affected our decisions about which further sites and events to observe. New priorities developed through the course of the research. In each of our approaches, emergent issues provided guidance to the development of themes. Perplexing or problematic comments in terms of confidentiality or security provided a rich source of ideas for examining similar entries in related blogs, and proved helpful in generating a theme system. To capture media coverage, each comment was coded for whether it made explicit reference to media such as newspapers, television websites, newsmagazines, or aviation journals. The comment was also coded if it presented dissenting media content from airline management positions, and if it delivered a critique of the media figure associated with the quoted media source. Lastly, one confounding property of theme construction is that the assigned data cannot always be precisely bounded; they are within “fuzzy boundaries at best” (Tesch, 1990, pp. 135–8). One example is the theme ‘scheduling’ which consists of issues such as duty times, fatigue, and rest periods. These issues could also be organised within the larger theme of ‘health’.

Following the initial coding process, we aggregated similar codes to form major categories. The aim was to develop a core theme that encompasses the dimensions of all codes, including the production of range and specific details of data. In accordance with Woods, Gapp, and King (2016), this approach enabled the theoretical explanation of core issues in a logical sense, and captured variation within the blog data. Figure 4 provides an example of deriving the category ‘Control’ from the following initial codes:

- Culture of fear and punishment
- Betrayal
- Scaremongering
- Bullying
- Keeping anonymous
- Secrecy around health topics
- Exploitation
- Brainwashing

All these codes were about management control in crew operations.

Crewmembers described a loss of trust as a result of these experiences

Figure 4. Deriving the category ‘Control’ from initial codes

Level 3: We summarised what we had learned from the codes and the themes, and applied latent content analysis to interpret the implicit meaning of the material. In summary, we organised 890 comments, extracted from 37 international blog authors, into seven manifest themes. Any codes that did not illuminate the themes remained an important part of our ongoing analysis.

Demographic data

An analysis of comments by author level, gender, airline or country was largely not possible due to anonymity. Authors appeared to guard their confidentiality by valuing anonymity, and often adopted false identities, such as 'FlyBoy' or 'IFlyandServe'. Across the blogs, only a minority stated their staff level, country of origin or employing airline. Where the country of origin was stated, blog comments often reflected differing situations such as the tighter regulatory environment in the European Union, poor labour conditions in the United States, or places where cabin crew have no unions or seniority system. The fact that most blogs are in English attests to English being the working language in aviation. This allowed us to claim with confidence that we had a solid global capture of the phenomenon.

RESULTS and DISCUSSION

Addressing research aim 1: *To evaluate cabin crew's motivation to write blogs and report on the personal health and fitness-to-fly concerns.*

The blogs covered a large spectrum of interests, reflecting the diversity among crewmembers as well as shared characteristics of central, unifying interest. The analysis classified five needs which motivate crewmembers to blog:

1. Need for recognition
2. Need for social contact
3. Need for trust
4. Need for information
5. Need for documentation

These needs shaped the depth, content, and reliability of the blogs. While internal blogs provide more technical information about their work, the main motivation for cabin crew to blog anonymously about health and safety concerns is the fear of potential managerial repercussions if confidential information is disclosed. There appeared to be a fear of talking negatively about the company, or displaying concerns that conflict with organisational policies. As some threads generated much engagement, writing blogs appears to boost morale, solidify bonding propensities, and generally serving as a source of pride being part of the 'crew family'.

The presence of the blogs across time provides an indication of the authenticity of disclosed opinions and incidents. For example, the widely expressed need for recognition, documentation, information, and self-expression suggests the genuine reporting of individual accounts. These needs are consistent with the advantages of communicating within a narrative community that offers identity protection and self-management (Harris, 2004; Noy, 2005). Figure 5 outlines the identified needs followed by a brief explanation.

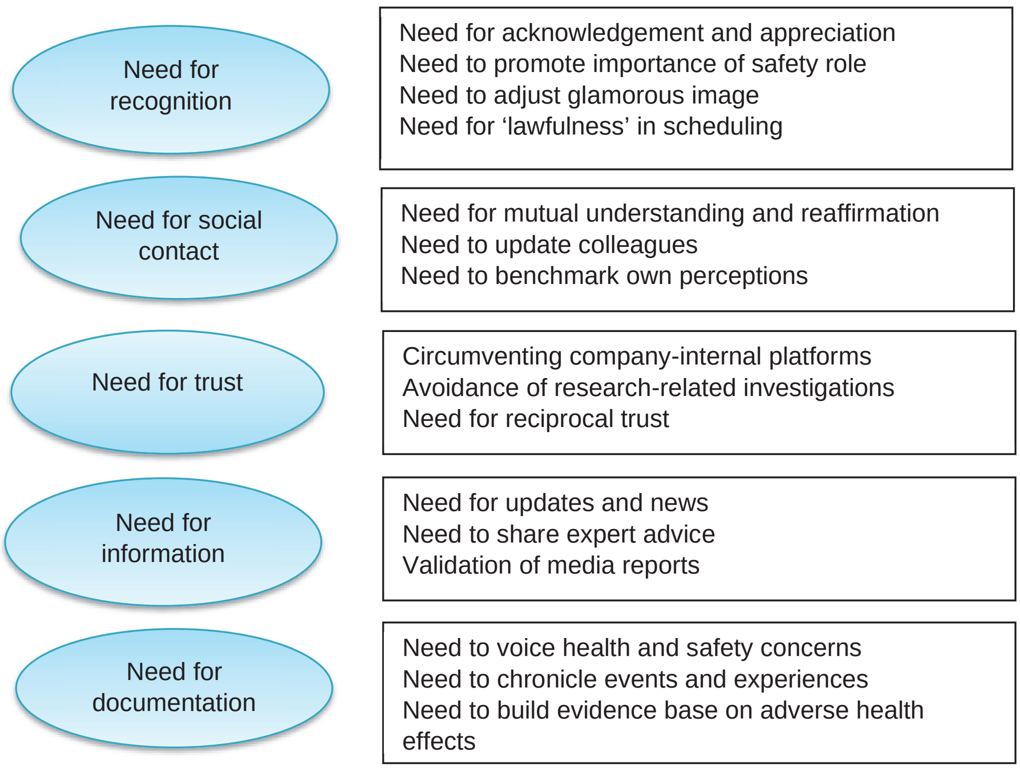

Figure 5. Identification of motives for cabin crew to blog

Need for recognition

The stressors crewmembers describe are all related to the disruption of personal recognition patterns. Recognition and self-expression are a recurring theme in the blogs. Describing their life as crewmembers and expressing their opinions and concerns, links with the notion of Lasica (2002) of expressing a blogger's idea of the truth and "letting the world know about you".

Recognition and duty of care:

> *"…I was so burnt out and fatigued from* [airline]*… In commercial aviation, you most often will only be a number"*'

> *"Pilots are the focus of the studies... we are not, or if we are these studies are dismissed as not taken seriously enough to actually bring about change…"*

Need for social contact

Reaffirmation through social contact represents another recurring theme in crewmembers' motivations to blog. Maintaining contact with fellow colleagues is a motivator to continue the blogging activity. The activity here offers a parallel to what Meyer and Allen (1991) termed normative commitment. Much of the self-perpetuation apparent in the comments results from shared feelings of obligation to read and respond. There is an element of voyeurism attached to the consumption of revealing information about other people's real experiences, and the interactive nature of blogging provides such public inspection of heart felt issues (Jacobs, 2003).

Need for trust

The blog platform functions as a relief valve permitting crewmembers to 'pour their hearts out' in a safe environment – in the anticipation that others will understand them. In this sense, blogs provide an important channel of mutual support.

Need for information

Cabin crew share common interests that are discussed in the same blog threads, providing people with information and greater expertise about areas of interest. Blogs also enable an 'underground' culture of information sharing. Although the truthfulness or objectiveness of such information might be questionable, bloggers can add depth to the way they discuss, and report related issues (Rosenbloom, 2004, p.32).

> *"…I heard management warned flight attendants could face disciplinary action under the airline's social media policy if they spoke out about events of toxic cabin air"*

Need for documentation

Documenting one's experiences is recognised as a major motivator to blog (Nardi, Schiano, Gumbrecht, & Swartz, 2004). Cabin crew work is unstable in the sense that changing schedules and new workmates area reality of the workspace. Being a blogger suits the variable nature of the cabin crew work, and the narratives document crewmembers' lives as they unfold within the framework of schedules. Data entries such as photos or links to health-related topics further enable crewmembers to pass on experiences and concerns about fitness-to-fly.

> *"Our health is always at risk.… It's just not a clean environment."*

Addressing research aim 2: *To investigate and report the content of the blog writer's concerns about being fits-to-fly*

The blogs reflect how, historically, the airline industry has been proactive and reactive to safety threats and thus has matured into a very safe industry in terms of technical safety. However, this progress appears to have slowed down over time. Blog authors perceive increasing workloads, inadequate information about potential occupational risks and hazards, and low experience of new recruits as latent threats, with little organisational response apparent. Various destabilising events, from the aftermath of the 9/11 events in 2001, the 2003/2004 SARS pandemic, or the Germanwings accident in 2015, and beyond, are reflected in the blogs.

The blogs revealed that cabin crew have little confidence in online surveys that were distributed through social platform channels and without the support of airline-related stakeholders such as unions. Cabin crew's reluctance to participate in research can be understood through trust issues when they are required to reveal health and safety-related information online (Roy, et al., 2015). There was also a lack of confidence in company research and a belief that insiders know more about the problem than some contracted or consultancy researchers.

> *"I saw there is research done about our health that addresses the effects of regular travel, and as cabin crew I actually feel a sense of relief when I see these difficulties in print, being recognized and*

> *explored from the outside. 'See, we're not making it up!' I want to say to the company people who meet such topics with suspicion. Studies like this are our best hope at pushback against 'the optimizer' that builds our schedules"*

Most blogs took up subjects of 'known interest' and 'known facts', assuming an understanding by peers and engaging in 'like-minded' advocacy. The common perceptions indicate that health and safety issues are indeed representative of the 'objective conditions' specific to the air transport environment. It is notable though while many blogs contained a degree of sophisticated information about occupational risks and health, at times they also contained examples of inaccurate and confusing information from unknown sources. For example, there was ambivalence about the benefits of aircraft disinsection, and most authors felt they were poorly informed about the potential adverse health outcomes.

> *"Incessant uncertainty is at the root of what makes our jobs difficult…unpredictable schedules, and all sorts of contamination issues on layovers…and guess what…on board too!!...Like reports about toxic fume events and pesticide sprays to kill flies"*

The following examples illustrate how increasing workloads, and the exposure to hazards such as insecticide spraying, contamination sources, and infectious agents appeared in the authors' own words:

> Regulations and guidelines:
> *"…Air travel today has become extremely stressful…. Look at the hodgepodge of rules and regulations everywhere, inconsistent and seemingly meaningless… Add to this, higher workloads, poisons in the air, sick passengers, high expectations from the traveling public, and you have a recipe for high drama in the skies. I am sure these stresses contribute to safety events… Health is a concern that should be investigated…"*

> *"Working conditions have worsened to the point that along with emotional invincibility, physical invincibility is being demanded as well. Extremely long workdays, and the feeling that their companies are wearing down the employees to an extent I have not seen before. After all, no human being ever "gets used to" jet lag, exhaustion, sleepless nights, or the feeling of not being valued …Traditional emphasis on pride in one's company and loyalty to it is being replaced by concern only for profit. This has had a shattering impact on the emotional lives of many people…Until we are seen as safety professionals, until our working conditions - health & safety are considered, we will always be relegated to fodder of the airlines - a necessary evil needed to give the appearance of safety. But whose safety - Theirs (pax)* [passengers]*… or ours? If the airlines could mandate passengers to look after themselves, we would be out"*

> *"Swamp Talk has become part of work, financial moaning by management, cutting seniority benefits, poor management and bullying… has become part of the flying experience!!!"*

We can see similar discursive choices in the following examples relating to infectious disease risks:

> *"In my opinion the toilets pose the biggest safety issue. The sink is so small, you can't wash your hands without splashing water everywhere…Thanks whoever designed this to turn my job in a danger zone!"*

> *"Flight Attendants are supposed to "maintain the cleanliness" of the lavs* [lavatories] *during the flight, but you'd be hard pressed to find one who does…afraid of catching some awful disease. Most just ensure they're restocked with toilet paper and paper towels"*

> *"Maybe first class and business class get a good cleaning, but not between every flight. And remember, they're using a rag to start row one, and when they end up in row 35, that rag has wiped a lot of tables.*

It's just not a clean environment. What happens in one part of the cabin is potentially spread everywhere…"

"In Flight Medical Emergencies range from a simple Faint, Gastrointestinal, Respiratory and Cardiac. F/A's [flight attendants] *deal with more Med E's* [medical emergencies]*] than most of the Public realize!"*

"Passengers are told not to fly with heavy colds and some other illnesses but some of the airlines don't seem to care about their employees."

[Swine Flu] *"When I read the title to this thread, I immediately thought that Swine Flu was when someone in management gets sick."*

"…swine flu does spread via transport on things as an example hand to cup to serving that cup to passenger that puts the cup to their mouth. Then add that we REALLY don't wash our hands that often.'"

"Cabin crew are very liable to sickness in the 1st 6 months on line because of all the germs onboard the aircraft."

"Thanks [name]*! I was thinking the same thing...Look at my hands and arms. I wear the battle scars. Lots of little cuts. Hand washing is fine but as soon as you touch the faucet or the door you are germy all over again. I also have been bringing wipes since the Lysol was banned.'*"

"As long as my airline is going to discipline me for calling in sick and putting me into steps of progressive discipline, then gloves should be the norm for picking up passenger's garbage."

"…So when will we see a change? What is going to have to happen for the airlines to realize that EVERY crew member on EVERY flight must be fit enough to perform all of their safety duties, even the ones we don't like to think about and hope we'll never have to perform?

> *Because if we're totally honest with ourselves, right now that's not the case."'*

Addressing research aim 3: To examine risk and perceived responsibility in the context of being fit-to-fly

In a series of blog posts crewmembers raised specific concerns about fatigue caused by abusive scheduling or duty assignments. Airlines wilfully schedule long duty days or long series of days ('lines') without adequate time off. These kinds of attributions here are fully consistent with Weiner's perspective about consistency of stakeholders' behaviours resulting in external attributions, specifically here to the management and airline policy (Weiner, 2010). Nevertheless, bloggers also noted internal attributional issues, accepting some responsibility for their own behaviour in the work environment. Bloggers openly spoke about their health, how they manage conditions, and dispelled common myths about 'crew getting used to jet lag and fatigue'; sympathising with fellow crew members that expressed similar concerns:

> *"…you are right FlyBoy. It's typical company BS that cares more about that one person onboard that might be offended than the health and overall safety of their employees"*

Questions arise as to how valid the certificate of medical fitness-to-fly is when crewmembers express concern about exposure to potential hazards, e.g. not being supplied with relevant safety equipment such as vinyl gloves (provision of one-use equipment to prevent reuse) for rubbish collection and food handling. In line with Mellert et al. (2008), air quality is another important parameter with negative impact on crew member's perception of risk (particularly on long-haul flights), as well as disrupting crewmember performance.

We were unable to determine whether authors were able to distinguish between accurate and inaccurate information dispensed in the blogs. Crew expectations on duty of care appeared to be strongly linked to specific airlines. Concerns that referred to health problems and the large number of security issues that have occurred since the 9/11 event were frequently attributed to operational factors. In future research access to real incident reports, could perhaps validate that these issues developed from actual cabin events and incidents during the specified time frame.

The results do support the view that flight safety is influenced by the way in which cabin crew interpret their professional role. Organisational health and safety motivation in the cabin workplace, respectively, seems to have a direct or moderating effect on crewmember health and wellbeing in the context of operational situations. Some authors occasionally provided a hypothetical scenario on risk-related issues, giving respondents a choice in a very structured hypothetical environment. Droge et al. (2010) showed how through a blog's interactive component, common concerns and elements can be formed as authors benchmark their own experience against that of others. Indeed, support from other crewmembers and recognition by management appear to be the most important buffers of work-related risks and stressors.

> *"Are they out of their minds?? 'Welcoming passengers into the galley area'. They are a logistical and health and safety nightmare to crew doing food prep…. with their hands everywhere!!!"*

> *"….I did have to pass a medical exam when I was first hired. It's called being fit-to-fly. Considering the environment we work in, I believe it is important to be healthy and physically fit but we get in contact with germs and disease on our flights and layovers all the time. I bet many of us carry the odd bug and not know it…we just get on with business as usual"*

Employers and employees have a shared responsibility for duty of care, yet organisations must ensure that employees understand their duty of care. Cabin crew endeavour to work in a climate of authenticity and view management actions as a breach of duty of care by not acting on what they perceive to be foreseeable hazards. Airlines should ensure that the cabin workspace and environment at layover is safe and that crew are not put at risk from work carried out. Bloggers felt they have a right to be consulted when decisions are made regarding their health and safety, and demanded adequate information and training so that they can perform their role safely. For example, cabin crew perceived that intrinsic differences in health care delivery in the destination countries would provide reduced opportunity for access to medical services. Smith and Leggat (2010) note how delay in treatment may result in illnesses progressing to more advanced clinical sequelae. Uncertainty also existed about notifying management of any health issues that could put others at risk to health or safety in their workspace:

> *“I have flown with plenty of crew members whom I have looked at in the briefing and thought, “If there’s an emergency, I need to make sure he/she gets off the plane too because they won’t be able to do it themselves.”*

> *“I'd love to someday be free from suspicion when I call in sick”*

> *“(Airline’s) scare tactics border on abuse when so-called "on-board supervisors" or "team leaders" talk with you to lend their "support."…gosh, when you catch someone else's strep throat from that last NRT run, what else CAN you do but call in sick? A not-so-unusual case.”*

The approach to and essence of these results and points are summarised in Figure 6.

Figure 6. Cabin crew perceptions on risk and perceived responsibility

Overall, the narrative methodology approach proved powerful because the blog authors were engaged crewmembers. Both through the language used within the narrative community, the solidarity and trust in each other exhibited by openly discussing topics, and the willingness to challenge responsible management behaviour, safety concerns of substance were identified. These concerns pose major issues for human resource attention in the airline industry.

CONCLUSION

By tracking a pathway through the detailed blogs of cabin crew, we identified why these blogs are written, what they write about in terms of fitness-to-fly, and the perceived risks and responsibilities attendant upon that issue. We have allocated considerable space in this manuscript to the voices of cabin crew, principally because the material collected offers insights from active workers that reveal much about the complexities of occupational life within an industry sector that operates with a very strong concern for its image. The broad conceptual schemes that informed the work - the value of studying narrative communities, the attribution of responsibility and risk perception - function as useful touch points throughout the descriptive appraisal. To the authors' knowledge there is only a very limited amount of academic work directly considering such spontaneous and open perspectives of cabin crew. The opportunities to build on this analysis with close inspection of the sub-themes identified in this appraisal offer multiple pathways for improving the working conditions and practices of cabin crew members. All stakeholders in this sector do, however, want and need the cabin crew to be truly fit-to-fly. This statement is made even more poignant by the potential transmission of truly globally destructive viruses and infections that can be affected by the kinds of workplace practices and conditions discussed throughout this paper.

Chapter summary

The diversity of contributing factors to cabin crew perceptions illustrates that one set of regulations cannot cover all individual health or operational conditions, and that there is no absolute solution to these challenges. Still, the answer to such critical questions must be addressed to cater for future developments of commercial aviation. As cabin crew have better access to health information through the Internet and expect to be more engaged in health decision making, traditional models of occupational health communication strategies must be revisited to adapt to this changing demographic. Here, the reduction of a culture of fear and punishment is pivotal to obtaining safe flight operations.

There is more to fitness-to-fly than just good physical health – it goes hand in hand with hazards and risks, and how these are perceived. For risk perception, there is a fundamental divide in the two contradictory concepts of risk – those of objectivity and subjectivity. While findings suggest that neither view is tenable, the challenge is to identify objective and subjective components inherent in crew statements about risk and to understand how they are combined. The strongest argument in favour for subjective risk perception is the failure of management to effectively appoint good health communication tools that leverage media reports, and explain how risks and hazards interact with the operational sphere. The ideology on which perceptions are based have become unconscious habits of ‘common’ thought, creating views that obstruct scientific inquiry, whilst fuelling scepticism and mistrust.

Figure 10 depicts how cabin crew are confronted with obligations that have occurred from organisational changes, but also as a result of the rapid spread of infectious diseases, largely facilitated by air travel.

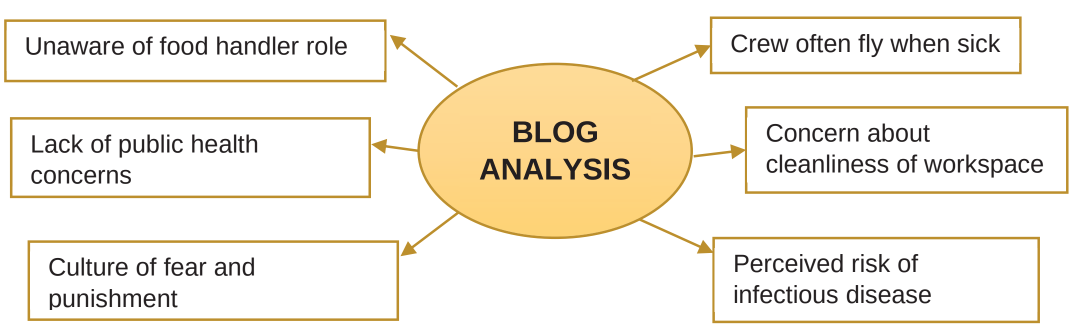

Figure 10. Interplay of blog findings as basis for chapters 4 and 5

Infectious diseases have become a considerable source of anxiety among cabin crew, as exposure to disease pathogens can not only occur during a flight, but during a complete tour of duty. Chapter four and five illustrate the potential for exposure to infectious diseases in the operational sphere. Crew duty patterns, enabling global travel to numerous locations over short periods, can further have serious knock-on effects on contracting and transmitting infectious diseases to the wider public, with potential consequences for both fitness-to-fly and public health. Both types of examples encompassing chapters 4 and 5 support a central theme of this thesis: the essential role cabin crew play, the measures for improving and protecting the health and safety of the public, and the imposing array of factors that undermine the crew capacity to respond.

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CHAPTER 4

The Cabin Crew Role and Infectious Disease Control: Aircraft Disinsection

Publication 1

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Publication 2

Grout, A. & Russell, R.C. (2020). Aircraft Disinsection: what is the use as a public health measure?. *Journal of Travel Medicine,* taaa124.

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Key words

Infectious disease epidemiology, transmission, aircraft

Abstract

International air travel has an increasing impact on the epidemiology of infectious diseases. A particular public health, economic, and political concern is the role air travel plays in bringing infected passengers or vectors to previously non-endemic areas. Yet little research has been conducted to evaluate either the infection risks associated with air travel or the empirical evidence for the effectiveness of control measures on aircraft and at borders. This paper briefly reviews the interface between international and national legislation, policy, and guidelines in the context of existing infection risks and possible scenarios. We found that public health guidance and legislation, which airlines are required to follow, are often contradictory and confusing. Infection control measures for air travel need to be underpinned by coherent and enforceable national and international legislation, founded on solid epidemiological evidence. We thus recommend a systematic review of existing evidence, further research investment into more effective onboard vector control, health screening, and risk communications strategies, and development of enforceable and harmonised international legislation.

Introduction

Low air fares and a multitude of social and economic factors have resulted in increased air travel. The number of journeys flown by passengers each year has grown from approximately 640,000 in 1980 to more than 3.4 billion journeys in 2015[1]. The epidemiology of infectious diseases associated with air travel and the challenges of control are important, yet relatively little discussed or researched, public health concerns[2]. Aircraft can now travel to virtually any part of the world within 24 hours, and may enable infection spread either by: (i) in-flight infection transmission or (ii) transporting infected passengers or vectors from endemic to non-endemic regions, e.g., malaria-infected mosquitoes, putting populations in destination countries at risk. The combination of rising passenger numbers, new travel destinations, and on-board transmission events, can impact imported disease patterns, including SARS, MERS, and Ebola[3]. For example, the current Zika outbreak is believed to have been introduced to the Americas by air travel[4]. Managing these risks requires knowledge of transmission dynamics and the potential effectiveness of control measures, suggesting that frontline employees (e.g., airline staff) would need appropriate training in handling suspected disease cases.

As a result of experiences with SARS, the International Air Transport Association (IATA) issued the '*Emergency Response Plan and Action Checklist*', which consists of guidelines and best practices for aircrews during public health emergencies[5]. To reduce the risk of onboard disease transmission, the Centers for Disease Control and Prevention (CDC) provides cabin crews with information on general infection control measures and guidelines to identify ill and potentially infectious passengers[6]. However, airline conditions that require medical clearance vary, and may be subject to individual airline policy [7].

The effectiveness of infectious disease response strategies largely depends on the prompt identification of cases[8]. Current measures, such as entry and exit screening, isolation, quarantine, and travel health information may not be feasible or sufficient to control disease transmission. For example, the value of entry screening has been questioned by Bell[9] and Hale[10], while an evaluation of border entry screening concluded that a combination of disease-associated communications with passengers and clinicians may be a more effective strategy for global infectious disease control[11]. Collectively, the unique dynamics and interactions at play in an aircraft environment require a distinct response to infectious disease control.

We consider the disconnects between global health law, national jurisdictions, organisational guidelines, and aircrew compliance by discussing existing risks and presenting two infection scenarios based on current airline practice[12].

Infection risks

In-flight transmission

While risk of disease transmission exists whenever people congregate in confined spaces, aircraft are unique in having individuals from often diverse geographical regions, with differing population immunity and exposure risks, interacting with aircrews and each other[6]. Infection may occur via (i) direct transmission through contact with skin, blood or other bodily fluids (e.g., Ebola virus), or (ii) indirect transmission without human-to-human contact.

Indirect transmission on an airplane can occur through infectious droplets (e.g., influenza virus), through contaminated surfaces or objects (e.g., methicillin-resistant *Staphylococcus aureus*), or via vectors including mosquitoes, flies, and fleas (e.g., malaria, leishmaniasis).

Long-distance air travel in particular exposes passengers to a number of factors that may affect disease transmission. A pathogen's transmission characteristics, ambient climatic conditions, time spent on board, and aircraft type may hamper quantification of general transmission risk[13]. Absolute figures for the risk of in-flight disease transmission are therefore not readily available and the evidence base is limited[14]. Mangili *et al* reported in-flight transmission of influenza, SARS, tuberculosis, measles, smallpox, and other pathogens[2]. On a 3-hour flight from Hong Kong to Beijing in 2003, 16 of 120 passengers were infected with the SARS virus by a single ill passenger[15], while modelling has demonstrated the possibility of in-flight transmission of MERS-CoV[16].

Protective measures are in place in modern aircraft, but may not be as robust as assumed. For example, commercial aircraft use High-Efficiency Particulate Air (HEPA) filters to limit exposure to small airborne particles. However, there are no regulations *requiring* HEPA filters or testing filter effectiveness[17].

Carriage of infected passengers or vectors

In 2014, Ebola was brought to the US[18], the UK[19] and Nigeria[20] by undiagnosed Ebola sufferers aboard aircraft. Brownstein *et al* demonstrated the impact of air travel on the global spread of seasonal influenza, noting that decreased air traffic following the attacks of 11 September 2001 was associated with a delayed influenza season[21]. Maloney and Cetron documented the air-travel associated transmission of meningococcal disease[22]. Global air travel may spur epidemics by bringing viruses and parasites to new locales[23]. Infected mosquitoes on intercontinental flights are believed to have contributed to the global spread of malaria[23, 24]. West Nile virus is widely suspected to have been spread to the US by an infected mosquito carried by plane [24]. The introduction of Zika to the Americas is noted to have coincided with an upsurge of air travel to Brazil from endemic countries in 2013[4].

Managing the risk of transporting infected passengers requires knowledge of transmission dynamics and potential effectiveness of airport entry and exit screening, the ability to appropriately isolate or quarantine individual passengers on an aircraft, and adequately trained aircrew able to identify signs of infection and take appropriate measures. For example, WHO maintains there is little risk of vector-borne diseases being transmitted aboard aircraft [25], but recommends "disinsection" of aircraft (a public health measure involving insecticide treatment of aircraft interiors and holds[25]), stating that "*there have been frequent instances of insects of public health importance being introduced from one country to another, with occasional dire consequences*"[23]. However, the effectiveness of disinsection is unclear[26]. Minimising the risk of inadvertently carrying insect vectors requires consistent use of effective control measures, including disinsection insecticides that are safe for frequent aircrew exposure.

Legislation and guidance

Public health measures for international air travel include a range of national and international legislative tools, policies, and guidelines. Globally, 196 countries signed the legally binding International Health Regulations (IHR), aiming to control global disease spread[27]. However, the only IHR provision relating to air travel is the requirement that all chief pilots provide a brief Aircraft General Declaration on passenger health to ground staff before disembarkation.

The International Civil Aviation Organization (ICAO) and the International Air Transport Association (IATA) coordinate with WHO and provide recommendations, but specific controls are left to the discretion of individual countries. National guidance and legislation is uncoordinated across countries and, with no strong evidence underpinning control measures, often inconsistent. Following the SARS epidemic, IATA recommended that all air carriers create an "Emergency Response Plan" for public health emergencies, but these are guidelines only and legislative powers lie with national authorities[5]. Airlines face conflicting obligations, since they must comply with infectious disease controls in both origin and destination countries[28].

Airlines owe a duty of care to three different groups, i.e., passengers, aircrew, destination country populations, and these duties sometimes conflict. For example, the US Environmental Protection Agency prohibits usage of some insecticides due to potential risks to aircrew, while national laws in Australia and New Zealand require their usage. US airlines flying to these countries must purchase insecticides at stopovers, and airline unions have raised serious concerns about their “inconsistent and inappropriate application,” toxicity and potential adverse health effects[29]. Other airlines reported difficulties in aircraft storage of aerosol insecticides that were either banned or prohibited from import in some destination countries[30]. Additionally, doubt exists as to the efficacy of disinsection, with research identifying increasing mosquito insecticide resistance[26]. Although the ICAO encouraged more research into non-chemical disinsection procedures in 2013[31], procedures have not changed and airplane disinsection policy and implementation remain inconsistent worldwide.

Airlines and national authorities may refuse passengers they consider to be a health risk. The US Air Carrier Access Act states that carriage can be refused where a passenger presents with a disease that “is *both* readily transmitted during a flight and which has serious health consequences (e.g., SARS but not AIDS or a cold)”[32]. This rule applies to all flights of US carriers and flights to or from the US but clearly requires any disease to be diagnosed pre-flight. Considerable debate continues about the effectiveness and practicality of passenger entry and/or exit screening. Further research must be prioritised before national and international legislation can take a consistent, evidence-informed approach to screening as flight duration and pathogen transmission dynamics are just two important factors that challenge ‘one size fits all’ recommendations[33].

Liability

Enforcement of national laws is highly variable, with non-compliance carrying financial penalties and criminal sanctions in some countries, whilst in others there is little evidence of enforcement. Some 191 countries are signatories to the Montreal Convention, which imposes obligations to protect passengers[34]. However, while this Convention enables compensation claims to be made, proving an airline’s liability for someone contracting an infectious disease in-flight may be very challenging evidentially. Even if transmission time can be proven, airlines can defend the extent to which they should be expected to identify the risk. They may argue that liability should lie with the infectious passenger who took the flight without notifying the airline or health authorities[35]. While industrial injury claims have been brought on behalf of aircrew for alleged adverse reactions to constant insecticide exposure in aircraft, these have been defended on the basis that airlines were following WHO guidelines[36, 37].

The Montreal Convention does not apply to individuals in a destination country who may become infected by a passenger or imported vector. While there may still be regulatory liability, and personal litigation against an airline may be undertaken, again, proving causal transmission may be extremely difficult, particularly if the disease did not become symptomatic until sometime after the flight in question.

Scenarios

Two hypothetical scenarios illustrate the potential occurrence and wider implications of disease transmission on aircraft.

Scenario 1: Direct transmission

Ebola is an infectious and often fatal disease marked by fever, nausea, vomiting, and less frequently haemorrhaging, spread through infected body fluids. On a flight from Frankfurt to Washington, a 40-year-old passenger started complaining of a severe headache, abdominal pain, nausea, and sweating. He recalled no specific symptoms before boarding, but claimed he had been feeling generally unwell since his arrival from Abuja, Nigeria, an interim stopover on his itinerary that had originated in Kampala two days earlier. About three hours into the flight his symptoms worsened and the cabin supervisor requested medical assistance. As there was no doctor on board, a nurse examined the passenger and, suspecting he might be infectious, advised the crew to “*isolate him as a precautionary measure*.” The passenger was taken to a seat near the galley and looked after by two crew-members for the remainder of the flight. Meanwhile, he had violent bouts of vomiting and became increasingly disoriented. The cabin supervisor notified the chief pilot of a sick passenger, but did not communicate the severity of his condition. The pilot assumed the situation was controlled and did not contact US health authorities. Upon landing, the passenger’s condition had deteriorated and an ambulance was requested. After 24 hours the passenger was determined to be positive for Ebola.

This scenario illustrates a lack of communication between crew-members and between aircrew and ground staff/destination. This delayed notification of a potentially severe health risk from infected body fluids, such as vomit, and an ambulance with infection control facilities should have been requested while the plane was airborne. This represents non-compliance with IATA guidance and a potential criminal breach of US health and quarantine laws. US laws are enforceable against both individuals and organisations, with penalties including fines and imprisonment[38].

Scenario 2: Vector-borne transmission

Vector-borne diseases (e.g., malaria, yellow fever, Zika) are transmitted by mosquitoes or other vectors to humans, causing a significant proportion of the global infectious disease burden[39]. Mosquito ecology suggests that aircraft are associated with a higher risk of introducing a live infected mosquito than are sea or road transport[40]. Following national requirements, disinsection was carried out by aircrew during descent into Mumbai airport. The flight had originated in London. A passenger who regularly travelled this route objected to being sprayed with insecticide, pointing to potentially dangerous adverse health effects. He added that having travelled on different carriers, he had not witnessed any in-flight spraying for years. On the return flight, several passengers complained about the presence of mosquitoes in the cabin before take-off. The aircraft had been parked on the apron of Mumbai airport, with cabin and cargo doors open during baggage loading and passenger embarkation. Passengers demanded protection from mosquitoes and wondered why spraying was conducted upon entering India, but not upon departure.

This scenario illustrates inconsistencies and lack of monitoring of disinsection policy. Indian national law requires disinsection on inbound flights, but is itself a reservoir of vector-borne diseases. Guidance from WHO and IATA uses permissive rather than mandatory language on disinsection and it is left to national policy whether countries choose to implement a “blanket approach” to *all* arriving aircraft or only require disinsection on *selected* aircraft. Policies are not always clear and it is necessary to balance fears of health risks from both insecticides and mosquitoes.

Conclusions

To be effective, infection control measures for air travel need to be underpinned by coherent and enforceable national and international legislation, founded on solid epidemiological evidence. As aircrew are not infectious disease specialists and would not normally have medical training, recognising potential disease cases and adequately communicating an inflight illness remains challenging and ad-hoc. The dynamics of existing, emerging, and re-emerging infectious pathogens mean that infectious diseases will always challenge control efforts as pathogens exploit novel evolutionary niches. Incoherent guidelines and inconsistently applied laws hinder control efforts unnecessarily and the research underpinning airline control measures needs to be strengthened considerably.

Public health involves balancing the rights of the majority against those of the individual and issues related to air travel require particular review and improvement by the global health community. First, a systematic review of the evidence supporting control measures for infectious diseases transmission via air travel should be conducted. Second, airlines and the global health community need to invest in research to identify better, non-toxic (to humans) insecticides or non-chemical means to control insect vectors. Third, airport health screening requires additional research and investment to better identify infectious passengers. Such passengers may otherwise travel undiagnosed and on disembarkation disappear into the local population, at risk to themselves and others. Some responsibility should lie with the individual. Disease transmission can be minimised if passengers take appropriate precautions before or during a flight, or refrain from flying altogether when ill. Current education and communication strategies (and refund policies for missed flights) therefore warrant improvement. Fourth, these measures cannot be implemented in the absence of enforceable and harmonised international legislation and governance. Achieving this would be a significant challenge but a starting point might be for international or regional bodies, such as WHO or the European Union to produce model legislation or standards for the guidance of member states. This would require close consultation with IATO and/or ICAO. Enforceability might be encouraged by treating this as a security issue, comparable to ensuring the mechanical safety of aircraft.

In the context of regular global air travel and evidence of dangerous non-endemic diseases appearing in new, vulnerable populations, airline-associated infection risks are growing. Potential costs, or inconvenience to passengers and aircrews, may be a lesser evil than transmission of potentially fatal infections to vulnerable populations. However, without concerted efforts from the global health community, the threat can be expected to worsen.

Author contributions

AG developed scenarios and drafted the manuscript with EMS, who wrote on legal aspects. NH contributed to writing and interpretation. RC provided interpretation and critical review. All authors approved the version for submission.

Declaration of interests

We declare that we have no conflicts of interest.

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Publication 2: Aircraft Disinsection: What is the usefulness as a public health measure?

Abstract

Rationale for review: Insecticide treatments in aircraft (termed "aircraft disinsection") aim to support the containment of potentially disease-carrying vector insects. The introduction of non-endemic mosquito species is of concern as some mosquitoes can act as vectors of many serious human diseases. Expansion of vectors to previously non-endemic regions, extended flight networks, and mosquito resistance to insecticides pose challenges to contemporary vector-control approaches. Despite established efficacy of aircraft disinsection in trials, there is increasing concern over its effectiveness and feasibility in flight operations, and its usefulness as a public health measure.

Key findings: We explored the literature on disinsection through a narrative approach to obtain a pragmatic assessment of existing and future implementation challenges. We describe the shortcomings that hinder evaluation of the success of aircraft disinsection. These shortcomings include operational constraints that may impact effective treatment outcomes, lack of longitudinal data on pesticide exposure scenarios, lack of compliance mechanisms, pesticide resistance in mosquitoes, and limited evidence of the extent and type of mosquito species potentially transported via aircraft.

Conclusions and recommendations: Concerns about the introduction of non-endemic mosquito vectors reinforce the need for effective preventive measures. Import of disease vectors is likely to occur in the future under changing environmental and operational conditions. Optimal impact from disinsection requires appropriate deployment, commitment and use. The current system of evaluation is inadequate for producing the evidence needed for informed policy decisions. While utilising the results of research into environmentally sustainable vector-control methods for use in aircraft, future approaches to aircraft disinsection require improved evidence of anticipated benefits and harms, reliable monitoring data on insecticide resistance, and must be supported by strong vector control at airports.

Introduction

Vector-borne diseases affect people worldwide, resulting in substantial morbidity and mortality.[1] The global growth of air travel and human migration has contributed to increasing movement of disease-carrying insect vectors across international borders.[2,3] Over the past five decades, there has been an unprecedented emergence of arboviral diseases such as dengue, chikungunya, yellow fever, and Zika virus disease.[4] The International Health Regulations (IHR) state that aircraft disinsection is a necessary measure to help prevent the global spread of vector-borne diseases.[5] “Disinsection” means "the procedure whereby health measures are taken to control or kill the insect vectors of human diseases present in baggage, cargo, containers, conveyances, goods and postal parcels".[6] As per World Health Organization (WHO) guidelines, the spraying of aircraft with pyrethroid insecticides is required by a number of countries for inbound flights while passengers are either onboard, or as a pre-embarkation knock-down and/or residual treatment when the aircraft is unoccupied.[7]

Malaria, transmitted by species of *Anopheles*, and dengue fever, transmitted primarily by the species *Aedes aegypti*, are examples of mosquito-vector-borne diseases that account for about 17% of the global burden of infectious diseases.[8] Both genera have been repeatedly detected on aircraft,[9-11] and have survived long-haul flights in cargo and cabin spaces.[12-14] One consequence of transporting vectors by aircraft is "airport malaria", (i.e. where a mosquito leaves the aircraft and survives long enough to transmit pathogens to other humans within the airport vicinity), with each case representing direct evidence of aircraft-related importation of infected *Anopheles* mosquitoes.[15] The same mode of direct disease transmission can apply to other aircraft-imported vectors of, for example, dengue fever and yellow fever.[16] Figure 1 illustrates how detections of *Aedes aegypti* at Australia's international airports have increased markedly in recent years.[17]

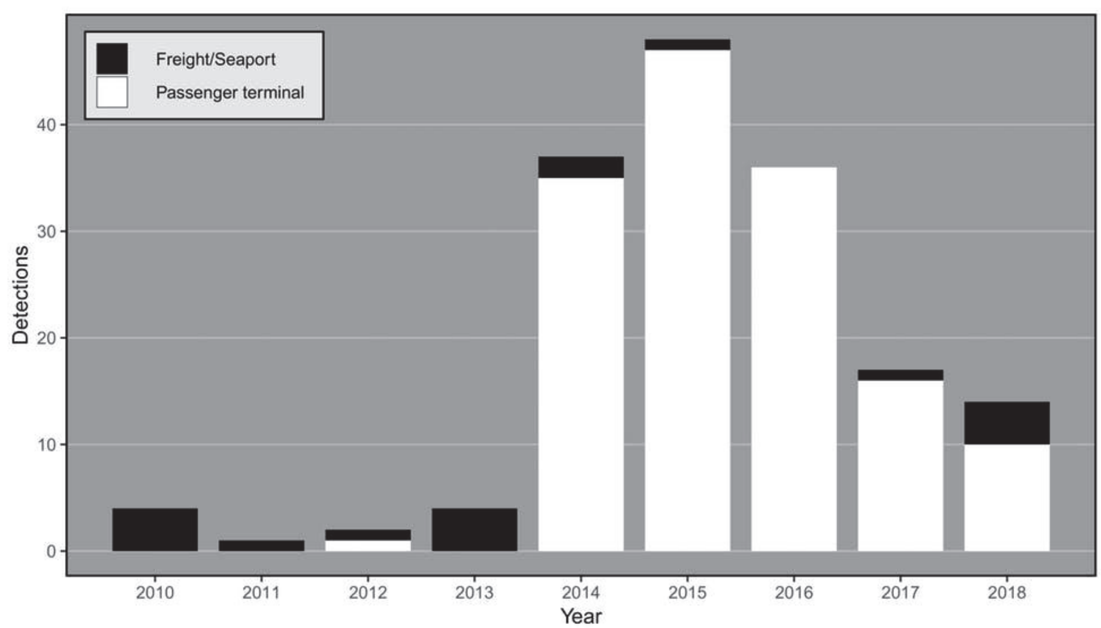

Figure 1. *Aedes aegypti detections per year at Australian international terminals. Detections at passenger airline terminals are shown in white, while those at seaports or freight terminals are in black. Each detection represents either a single adult retrieved from a trap or one or more larvae or pupae retrieved from an ovitrap.*
Source: Schmidt et al. (2019).

More serious consequences for public health can result from establishment of imported disease vectors in previously non-endemic regions. Vector-borne diseases pose a transmission risk in areas where the relevant vector is present.[18] The power of transporting vectors to new regions is illustrated by the introduction of the mosquito species, *Anopheles gambiae,* to Brazil in 1930, sparking devastating *Plasmodium falciparum* malaria epidemics that caused over 16,000 deaths.[19] While this introduction was likely associated with sea conveyance, Table 1 provides examples of mosquito vector detections at international airports.

Table 1. Mosquito vector detections at international airports

Article	Findings
Ward (1984)	Over the course of three decades, 14 non-endemic mosquitoes (including five species of *Anopheles*) were introduced into Guam through increased air traffic
Goh et al. (1985)	Of 330 incoming aircraft at Singapore airport, 57 aircraft harbored mosquitoes and other insects, many of which were vector species
Whelan et al. (2012)	First recognised case of locally transmitted dengue in Australia's Northern Territory since the 1950s, with the likely source being a mosquito which escaped a military aircraft arriving from Bali.
Ibañez-Justicia et al. (2016)	Detection of six *Aedes aegypti* at Amsterdam's Schiphol airport
Schmidt et al. (2019)	Continued detection of *Aedes aegypti* in aircraft despite disinsection

With nearly eight billion people expected to travel yearly by 2036,[20] new destinations in areas highly endemic or receptive for vector-borne diseases are likely.[21] The increasing frequency of air travel[22] illustrates the importance of making the expansion in air travel inclusive of sustainable infectious disease control strategies,[23] in particular between countries in resource limited settings with suboptimal capacities to detect and respond to infectious disease threats.[24] Expanding air transport networks will likely increase the potential transport and dispersal of *Aedes aegypti*, which has been associated with a rise in dengue incidence and spread.[25,26] While worldwide travel bans have dramatically reduced all types of travel during the current COVID-19 pandemic, air travel is likely to resume as case numbers decrease.[27] Reliable assessments of risks to guide an evidence-based approach to infectious disease control are thus essential for airlines to regain public trust and restore passenger confidence in air travel.

For many vector-borne diseases, vector control is an effective means of reducing transmission.[28] One necessary action is to identify if interventions are *not* working as expected.[29] According to Shaw and Catteruccia [30] there are alarming rates of insecticide resistance in insect populations, prompting the need for new control strategies. Questions about the usefulness of disinsection *per se* include whether vector control at airports is more efficient than aircraft disinsection,[31] and whether the introduction of pathogens through infected travelers is far more likely than through infected mosquitoes transported on flights.[18] It is further unclear whether crew are adequately trained to conduct, and comply with, the inflight spraying process.[32] Regardless of its effectiveness in reducing introduction of vector mosquitoes, disinsection is expected to remain an integral tool in the global vector management system.

In this paper we trace the history of aircraft disinsection to illustrate the difficulties encountered in earlier treatment procedures that have persisted throughout its further development. We highlight the challenges for developing practical solutions for vector-control practices, and underline the need for updated evidence to support continuing aircraft disinsection.

Methods

Search strategy and selection criteria

We identified relevant articles through searches in PubMed; Google Scholar; the Springer Online Archives Collection; and World Health Organization (WHO), International Air Transport Association (IATA), and International Civil Aviation Organization (ICAO) archives. We included articles published in English and German from January, 1940, to February, 2020, by use of the terms “aircraft disinsection”, “pesticides”, “disease control”, and “mosquito vectors” (see figure 2). Articles were included for analysis if they met at least one of the pre-defined criteria:

- Investigation of the possibility of mosquito introduction via aircraft;
- Assessment of the effectiveness of aircraft disinsection;
- Policy interventions for vector-control practices on aircraft;
- Descriptions of vector-control strategies on aircraft.

Literature based on anecdotal reports, and where only abstracts were available, were excluded. To allow for appropriate interpretation, the search was extended to the Conference Paper Index, international airline websites, and websites of national authoritative bodies. We analysed relevant articles using a narrative synthesis.

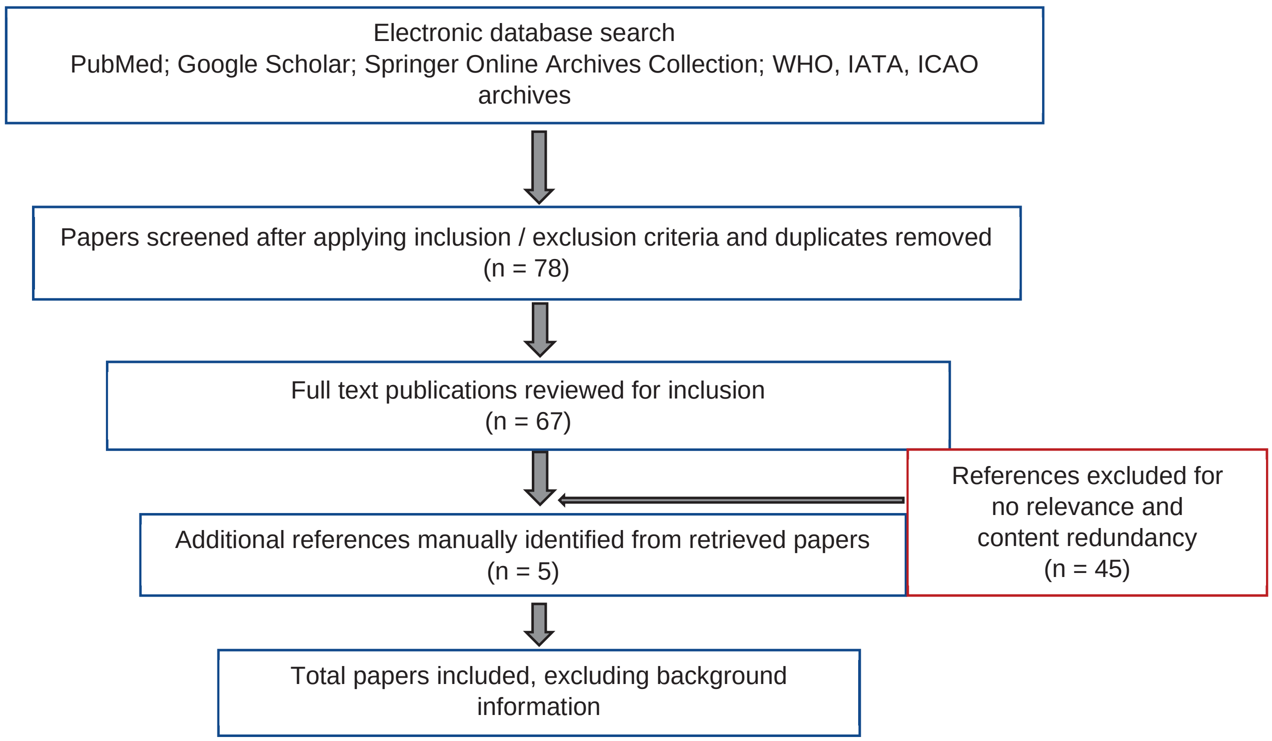

Figure 2. Literature selection process for relevant records related to aircraft disinsection

HISTORY OF AIRCRAFT DISINSECTION

Evidence on importing vectors in aircraft, as well as the need for control, was first documented in the 1920s.[33-35] Disinsection, however, was not widely adopted until the introduction of long-distance commercial air services in the 1930s.[36] In 1933, the first published protocol for aircraft disinsection was included in the International Sanitary Convention for Aerial Navigation to protect communities and flying personnel against diseases likely to be imported by aircraft.[37] Further, Williams [38] recommended insect control measures at airports in the tropics, along with disinsection of aircraft arriving from endemic regions. While endorsing chemical treatment of aircraft in principle, the WHO deemed in-flight spraying an “unacceptable” procedure that must not be carried out in the presence of passengers. WHO recommendations also gave vector surveillance priority over aircraft disinsection and stressed that environmental vector control in and around airports must be national priorities.[39]

Historically, the effectiveness of in-flight spraying under the conditions encountered in airborne aircraft has been questioned.[40] Difficulties in determining efficacy in live bioassay trials included the restricted movement of test insects. Although Tew et al. [41] concluded that complete mortality was likely in free-flying insects, Pearce and Schoof [42] and Evans et al. [12] identified weaknesses of this method, such as rapid removal of insecticides through ventilation, and the abundance of shelters allowing insects to escape treatments. Sullivan et al.[43] highlighted how low mortality rates demonstrate that mosquitoes can survive long-distance flights, signaling that air travel accelerated the spread of vector-borne disease, and also demonstrated the failure of control measures.[44] By exhibiting a knockdown rate of 100% even in sheltered spaces, subsequent trials demonstrated that in-flight disinsection, if done properly, is indeed effective, and that failure of disinsection effectiveness was generally attributable to non-compliance with recommended procedures.[45,46] According to WHO,[44] limiting factors for successful disinsection included:

i. difficulty of compliance monitoring;
ii. potential interruption to airline operations;
iii. impracticality of treating different aircraft compartments separately;
iv. passenger health concerns about insecticide exposure.

The essential role airlines play in vector control is reflected in the first edition of the International Health Regulations (IHR),[47] which recognized that different countries may have different legislation on aircraft disinsection. Despite lack of solid evidence regarding the magnitude of epidemiological risk for vector introduction,[48] airlines were deemed responsible for vector control on their aircraft, and airport health authorities were required to establish environmental sanitation measures around airports to prevent disease vectors from entering and/or leaving aircraft, and be transported internationally.

Pyrethroid-based insecticides used on aircraft today were first recommended by the WHO in 1973. One principal concern was understanding the health implications of their use in aircraft cabins.[49] Countries were therefore encouraged to provide appropriate information to passengers and crews upon request. Emerging resistance among important mosquito vector species also led the WHO to acknowledge the need for alternative chemical formulations.[50]

Criticism of the IHR's effectiveness was present long before 1995.[51,52] Concerns included lack of compliance by member states, and the narrow scope of regulations, which only applied to a small number of diseases. However, against the background of increasing evidence on vector importation, Gratz et al. [36] urged the continuation of aircraft disinsection. At the same time, concern about potential adverse health effects from insecticide exposure became more prominent. For example, despite the wide use of pyrethroids in indoor environments, toxicological studies pointed to the potential risk of neurological damage from exposure.[53-55] While the WHO reaffirmed chemical disinsection, there remained much debate about the effectiveness and feasibility of the agents and methods. To advance non-chemical approaches to disinsection, the International Civil Aviation Organization (ICAO) and the United States (US) Department of Agriculture initiated the evaluation of air curtains as mechanical means of vector control.[56,57]

CONTINUING CONCERNS

Lack of reliable data

Common uncertainties regarding aircraft disinsection are due to a combination of scientific, social, and environmental factors. Barriers to successful efficacy-testing include:

i. questionable usefulness due to increasing resistance to pyrethroids in some mosquitoes;[58]
ii. changing climatic conditions that may significantly affect vector behaviour and survival,[59] producing varying results in new bioassay trials;
iii. advancements in aircraft size and design (e.g. multi-deck aircraft), requiring that exposure assessments address characteristics such as different aircraft airflow systems,[60] and uncertainties in onboard ventilation performance against standards.[61]

Questions also remain as to how well current monitoring activities associated with disinsection can address its purpose in global vector control in both scale and quality. The argument for aircraft disinsection and surveillance may be eroded if pathogen introduction by mosquitoes is indeed considered low-risk due to few detections of mosquitoes on aircraft.[18] At the same time, difficulties in finding mosquitoes in aircraft [62] may present barriers that preclude detecting such events. While New Zealand and Australian authorities still collect and publish surveillance data showing that international transport of mosquitoes on aircraft is a continuing issue,[37] we were unable to access country-specific data on vector surveillance efforts at airports and airport vicinities in an international context.

Health effects

Aircraft disinsection applied on certain flights results in occupational exposure to insecticide, with uncertain health impacts. While methods of use and type of insecticides are considered safe if label directions, policy, and pesticide application guidelines are adhered to, insecticides may have non-specific health effects, such as allergic reactions, in some individuals.[63] Reports of adverse health effects [64,65] and elevated burdens for cabin crew,[66] as well as asthma-related symptoms in passengers,[67,68] have been related to exposure to disinsection. Overall, there is a lack of epidemiologic studies specifically addressing exposure to pyrethroids in indoor environments.[69]

Operational constraints and compliance mechanisms

Operational feasibility is an important factor in developing practical recommendations and standards.[16] For airlines, issues to be resolved include potential damage to aircraft materials by chemicals, and meeting duty of care requirements for the health and safety of passengers and crew. Largely attributable to concerns about potential adverse health effects, non-compliance with treatment routines, or inconsistent application, are key disadvantages of in-flight treatments.[70-74] Passenger and aircrew reports suggest major differences in how disinsection is performed.[75] Perceived implausible needs for treatment, e.g. requirements for disinsection of aircraft departing from vector/disease-free regions where a threat to public health by air traffic does not exist or is questionable,[16] or varying degrees of enforcement in different countries,[76] may have further caused confusion among those responsible for its performance. Thus, the degree to which disinsection is perceived to be effective and useful has likely contributed to its reduced acceptance, in turn fostering a climate of non-compliance in the absence of agreed standards for how aircraft disinsection is performed.[75]

CHALLENGES FOR THE FUTURE

Policy and international regulations

National legislation and airline practices largely rely on the scientific credibility of WHO recommendations and guidelines, which have served as baseline for policy development. Given that evidence-based decision-making is necessary for optimal aircraft disinsection outcomes, current WHO recommendations largely rely on scientific evidence that is predominantly based on efficacy trials for which evidence is outdated or lacks relevance to contemporary settings.

Disinsection activities purported to follow WHO recommendations further vary among jurisdictions. Individual countries dictate whether airlines disinsect aircraft upon arrival or departure, and whether this can be done for reasons other than those stated in the IHR.[5] While regulatory approval for insecticide products lies within the jurisdiction of each country,[77] for some countries, such as the US, aircraft disinsection presents unique challenges, as pyrethroid insecticides are currently not registered for use in occupied aircraft cabins in the US.[78] In order to satisfy both country requirements for disinsection and compliance with Environmental Protection Agency (EPA) restrictions, US carriers must purchase and apply disinsection products at stopover destinations.[79] This approach, however, seems incompatible with EPA regulations and occupational health in that aircrew can unknowingly be exposed to pyrethroids even on flights that do not require disinsection.[75] Occupational exposure may contradict US national law if US crewmembers work in residually treated international aircraft that also operate within continental US.

Reduced acceptance of aircraft disinsection may have further generated from challenges of country-specific legislative requirements for risk assessment of exposure to insecticides, as specified in article 58 of the IHR.[5] Combined, the absence of updated evidence and internationally agreed regulatory pathways for insecticides used in disinsection presents challenges for translating regulatory requirements into operational actions, and carries the risk of poor judgment, non-compliance, and disjointed decision-making.

Effectiveness, usefulness and operational feasibility

The responsibilities for disinsection are shifted from national health ministries to airlines, which are legally liable to abide by country requirements.[5] However, airlines are largely left to their own devices in overcoming the complexities of international regulations, and for developing practicable solutions to operational challenges.[76] Challenges include ethical criteria such as exposing passengers and crews to pesticides, assessing potential damaging effects on aircraft material, and varying climate control settings in aircraft cabins, potentially leading to rapid removal of insecticides through ventilation.[60] Also, airlines may not know in advance which aircraft operate to destinations requiring treatment and would therefore have to treat all aircraft at the required intervals. Such approaches provide an added layer of operational complexity for airlines operating large numbers of aircraft on an array of routes.[80]

The lack of knowledge of the extent to which cargo or baggage compartments, baggage unit load devices (ULDs, aka “aircans”), passenger jetways, and buses that transport passengers, crews and luggage to/from aircraft carry mosquito vectors further hampers effective control mechanisms.[72] Strategic surveillance is critical for vector control,[81] and should be used to define the roles and responsibilities of local authorities to minimize the potential for vector introduction and establishment. Predictive risk models, such as the VBD-AIR tool,[82] can help identify high-risk airports by quantifying seasonally changing risks of vector and vector-borne disease importation and spread by air travel. Through modelling global distributions of vector-borne diseases and international air routes, the VBD-AIR tool was developed to help form an evidence base to plan mitigation strategies, and to better define the roles of airlines and airports in the transmission and spread of vector-borne diseases. Evidence of mosquito presence on aircraft (as well as their source and timely reporting), can then be used to:

i. estimate the risk of introduction by aircraft;

ii. prioritise implementation of proper and effective control measures;
iii. indicate the degree of control achieved.

Disinsection has shown value in preventing the international transport of vector mosquitoes,[83,84] that could result in regions/countries becoming newly susceptible to outbreaks of vector-borne disease if the pathogens are imported with aircraft passengers. However, data gaps and difficulties in identifying the benefits received through disinsection in vector-borne disease control may explain much of the controversy over its usefulness as a public health measure. Although sustained success may only be demonstrated by the absence of a threat (in this case, mosquito vectors), lack of evidence of the success of procedures is not in itself evidence that successful treatment outcomes do not exist. Importantly, policies for aircraft disinsection need to be monitored and, over time, corrected or terminated if they prove ineffective or unenforceable.

Health issues

Occupational health reports on work-related pesticide illness suggest that aircraft disinsection may be responsible for some reports of acute and chronic health effects in cabin crew.[85] In a recent systematic review, Pang et al.[86] found no convincing evidence that aircraft disinsection produces operationally significant levels of pyrethroid-related health effects. However, in the absence of longitudinal assessments on cumulative exposure to pyrethroid-based insecticides, information on the potential chronic effects of pyrethroids at low concentrations remains limited and controversial. Studies on pyrethroid exposure and Parkinson's disease further have weaknesses such as lack of detailed exposure assessment, and are too sparse to support firm conclusions.[87,88] To determine whether health effects posed by vector-borne diseases outweigh concern about exposure to insecticides requires clarification of the relative importance of chronic exposure to pyrethroids in aircraft cabins.

Lastly, there is insufficient knowledge on the extent to which airlines regularly inform passengers about the safety of insecticides (including through pre-boarding notification of disinsection), as well as the level of training aircrew receive in administering disinsection, since most cases of adverse health effects have been the result of inflight spraying.[89]

Mosquito Resistance to Pesticides

If vector-borne disease control is dependent on the ability to control the mosquito populations that transmit diseases,[90] then disinsection is likely to be limited in its control capacity when insecticide resistance is present, particularly for important disease vectors such as *Aedes aegypti*.[17] Increasing resistance of mosquitos to pyrethroid insecticides [91] has likely decreased the efficacy of disinsection. In particular, the scarce evidence on how resistance may impede disinsection suggests that no appropriate studies have been implemented to determine the operational impact of resistance.[92] Strode et al. [93] highlight significant inconsistencies in testing and reporting, in that data are "either missing or are unreliable", and not reproduceable. Identification of monitoring tools for insecticide resistance capable of informing disinsection efforts in a timely manner could address the urgent need for entomological data to refine our understanding of relationships among entomological risk factors and effectiveness.

Systemic challenges, such as the diminishing capacity and lack of skill of medical entomologists to perform vector surveillance and monitoring,[94] may further complicate informed decision-making. While surveillance efforts in Australia and New Zealand showed that resistance is not present in Australian *Aedes aegypti*,[95] resistance is common in many *Aedes aegypti* populations elsewhere,[92,96,97] and many countries where transmission of vector-borne diseases occurs have yet to carry out regular susceptibility testing.[98] Overall, poor vector surveillance and changes in vector behaviour may thus combine to threaten the effectiveness of current treatments.

WHAT CAN BE ACHIEVED TOGETHER

Airlines have a dual duty of care to protect the health of passengers and crew by ensuring that aircraft disinsection is safe and treatments are effective for their intended purpose. Thus, there is a need to assess whether policies based on the relative benefits and risks of disinsection can protect human health. Figure 3 illustrates the factors that need to be considered to achieve successful disinsection outcomes.

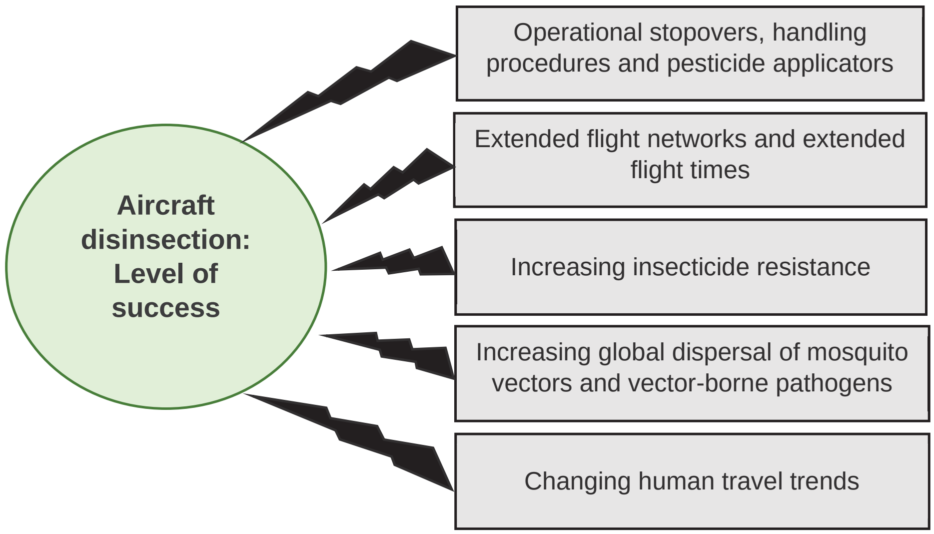

Figure 3. Factors impacting on the success of aircraft disinsection

For quality assurance of disinsection in operational settings, data systems need to be developed to draw together parasitological, entomological, and disease transmission data sets. Airlines and aviation stakeholders need to jointly work on streamlining processes, such as insecticide application and resistance management, policy-making, and application pathways to counter the current and future public health threats that airlines may inadvertently transport across the globe.

To be successful and sustainable, disinsection requires the capacity for research infrastructure at high-risk airports. The current lack of surveillance and control efforts in and around airports can greatly contribute to the “export” and establishment of mosquito vectors, dependent on the departure or arrival destinations.[74] There is a need for clarity over the extent to which environmental control measures have prevented mosquitoes from entering aircraft at high-risk airports. This includes strengthening capacity for vector control in low-income settings by supporting mosquito-borne disease-endemic nations with surveillance of vector resistance and environmental control strategies proven to be effective; training local researchers; and allocating resources to monitor site-specific patterns of pathogen transmission and disease.

Routine vector surveillance should then be supplemented with aircraft spot checks, and investigations focused on mosquito habitat and adult surveillance. Promising approaches include the WHO initiative to classify high-risk airports where aircraft disinsection is mandated.[80] Here, classification should reflect both the overall risk of mosquito-vector-borne disease spread at certain airports, and the risk of transporting vectors via aircraft. This requires criteria for classification (e.g., modelling approaches to vector movement), and the classification criteria must be periodically assessed.

Lastly, alternative approaches, such as air curtains,[56,57] should be further evaluated to overcome difficulties in trialling new procedures and practices in real-flight situations compared with static on-ground mock-ups. The IHR reflects the suitability of alternative measures by formally changing the definition of aircraft disinsection to include the *control* as well as the *killing* of insects,[5] thereby allowing the possible inclusion of non-chemical methods, such as air curtains. Limited insecticide use would reflect one aim of the IHR to protect against exposure, and further support the WHO's Integrated Pest Management strategies and resistance management principles.[65] Use of Predictive Geographical Information Systems (GIS) that support evidence-based vector control, risk-stratification, and climatic models can further optimize implementation of disinsection.[82] The benefits of targeted vector control will be a reduction of insecticide exposure to passengers and crew, and possible prevention of resistance in vector-carrying insects and therefore, long-term economic savings.

RESEARCH OPPORTUNITIES

Environmental changes create new research obligations and require dissemination of information on vector control in international air travel. The best way to provide this evidence is through regulatory review and approval processes informed by local entomological and epidemiological data, rapid decision-making processes, and the ability to revise decisions as new information becomes available. For aircraft disinsection to possess the fundamental capacity for effective control of potential vector insect incursions, these capacities must include well-trained pesticide applicator personnel, and maintenance of compliance and monitoring systems. To better explain what is working and what must be done differently, improved operational research can facilitate greater cooperation among airlines across countries, and build the knowledge base needed to train operators (including cabin crew). Table Nr. 2 provides examples of future research opportunities.

Table 2. Research opportunities for aircraft disinsection

<table>
<tr><th>Type and aim of studies</th><th>Study considerations</th></tr>
<tr><td>Studies of resistance that modify mosquito susceptibility</td><td rowspan="7">Policymakers and implementers should take the initiative to encourage and finance research, and to continuously evaluate and transparently report the results
Develop study designs that facilitate better-informed decisions by working across the disciplines of epidemiology, toxicology, public health, social and behavioral science, environmental health, and biomedical sciences.
Ensure that study results are actionable and reflect the complex aviation policy environment.
Secure development funding to ensure that treatment procedures reflect current evidence.</td></tr>
<tr><td>Studies to determine whether the intended efficacy of disinsection is mediated by operational factors and/or environmental changes</td></tr>
<tr><td>Studies that explore the mechanisms through which aircraft disinsection assists in vector-borne disease control</td></tr>
<tr><td>Qualitative studies that target crew risk perception and compliance behavior</td></tr>
<tr><td>Studies of the effects of repeated pesticide exposure via different infection routes</td></tr>
<tr><td>Operational research to identify actionable changes in practice and policy</td></tr>
<tr><td>Studies that reconsider the conceptual basis of aircraft disinsection</td></tr>
</table>

Ease of delivery and public acceptability are equally important for the success of disinsection. New evidence could also be open to public and occupational debate. For example, transparency can help policymakers and airlines to gauge aircrew and passenger reaction to ideas before they are fully formed, thus better anticipating the need for different courses of action.

Following identification of high-risk airports by the WHO, health authorities and airlines should expedite necessary changes and/or additions to existing regulations as a priority.

CONCLUSION

Aircraft disinsection has the potential for positive public health impact but depends on key procedural issues to ensure success. The benefits of disinsection in preventing vector-borne disease transmission are difficult to assess but, equally, there is insufficient evidence to exclude aircraft disinsection, as a routine procedure, from an integrated vector-control strategy. Combined, the threat of vector-borne disease spread and the potential risks of aircraft disinsection represent a public health dilemma: for passengers and crew, there is a need for greater information about both types of risks. Given the alarming increase in numerous vector-borne diseases occurring worldwide, missed opportunities for updating knowledge of aircraft disinsection risks legitimizing and perpetuating a narrow understanding of this global public health measure. For vector-borne diseases, the same commitment to collective responses shown during the COVID-19 crisis may help strengthen the stimulus for sustained action in addressing the systemic weaknesses that hinder generation of urgently needed data. If disinsection efforts have worked, it is time to acknowledge its success, but most importantly, to demonstrate future confidence in its use.

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Chapter summary

These papers illustrated how the inability to predict occupational exposures and public health outcomes explains much of the inherent difficulties of current prevention programmes for infectious disease control, such as aircraft disinsection. Chapter 5 expands on the role of cabin crew in infectious disease control and how inflight food and beverage services require attention to safety issues. The publications illustrate how the practice of medical screening before and during employment is particularly relevant to food safety in that hygienic practices in food handling form part of the cabin crew safety role.

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CHAPTER 5

The Cabin Crew Role and Infectious Disease Control: Aviation Food Safety

Thesis structure

Publication 1

Grout, A. (2019). Safe Food on Aircraft: Key Management Principles. In P.L. Pearce & H. Oktadina (Eds.). *Delivering Tourism Intelligence (From Analysis to Action, Volume 11),* (pp. 189-200). Bingley, UK: Emerald Group Publishing Limited.

Publication 2

Grout, A. & Speakman, E.M. (2019).

Are we there yet? In-flight Food Safety and Cabin Crew Hygiene Practices

Journal of Environmental Health 82(4), 30-32.

Publication 3

Grout, A., & Speakman, E.M. (2020). Inflight Transmission of Foodborne Disease: can Airlines improve? *Travel Medicine and Infectious Disease 33*, 101558.

Publication 1: Safe food on aircraft: key management principles

Abstract: Foodborne illnesses are common worries for travelers. Inflight food safety issues reflect the interrelated factors arising from an expanding airline industry, with its increased passenger loads, extended flight times, and multiple service activities. Adapting to these new challenges, and especially the global spread of foodborne diseases, requires an understanding of the cabin crew role as food handlers and the risks associated with this task. This chapter outlines the key factors that determine the safe delivery of inflight food services, highlights the benefits of best practice to airline operators, passengers, and tourism boards, and addresses the policy implications for airline regulators and national health authorities. **Keywords:** Aviation food safety; cabin crew; foodborne disease; food handler; food hygiene

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<u>Publication 2:</u> Are we there yet? In-flight food safety and cabin crew hygiene practices

Abstract

Amid the rapid expansion of global air traffic, aviation food safety is a critical issue (Huizer et al., 2015). More than one billion in-flight meals are served annually (Jones 2007), and the aviation catering market is expected to be worth US$18 billion by 2021 (Business Wire 2017). Food served on planes is prepared in industrial kitchens close to airports and then transported to planes where it is stored, reheated and served. The process is complex, with many opportunities for food contamination. Yet while food preparation on the ground is subject to considerable regulation at both national and international level, similar rules do not apply to food served in-flight. Airline caterers may need to comply with local food safety regulations, as well as those of country of the aircraft registration and the destination country, while also following international food safety guidelines (Solar 2016). Despite the greater challenges of ensuring in-flight food safety compared to that offered in establishments ‘on-ground’, we argue that the same food safety principles should apply. This perspective considers one key factor of in-flight food hygiene: the availability of hand washing facilities for aircrew.

Food safety regulations are public health measures designed to prevent the spread of disease. Foodborne illness is a widespread and costly – yet preventable – public health problem (CDC, 2016) which can arise in-flight because of the complexity of the food service environment and the confined conditions (Hatakka, 2000). Sheward (2006) sees cabin crew as the 'missing link' in the food handler chain. Yet the nature of the onboard workspace and absence of legislative enforcement hamper adequate crew hygiene and food safety behaviours.

Maintenance of a consistently high food safety standard is ever more important, particularly on 'ultra-long-haul' flights, where increased handling of food over an extended period of time brings ever more opportunity for food safety lapses. Poor food safety management and food-borne illness in-flight can become a flight safety issue: by incapacitating pilots or cabin crew, rendering them 'unfit to fly' (McMullen et al. 2007; Mitchell & Evans, 2004). Additional pressures come from the fact that passengers and crew disperse rapidly after flights and any illnesses they suffer may not be tracked (Aiello & Larson, 2002).

Hand washing has long been considered an elementary public health measure (Foddai et al., 2016). During a flight, cabin crew frequently handle food whilst simultaneously completing multiple tasks at any given time. While contaminated hands play a key role in foodborne illness incidents (Curtis & Cairncross, 2004), access to clean toilets and hand hygiene serve as primary barriers to reduce the risk of transmission of pathogens that cause foodborne disease (Aiello & Larson, 2002). Most national legislation requires compliance with food safety protocols and dictates that handwashing facilities should always be provided to food handlers in proximity to their workspace.

Staff toilets and hand washing facilities are mandated in 'on-ground' food establishments (Food Safety Agency, 2018; FDA, 2018). Yet although aircraft kitchens will usually have sinks, they are mostly inadequate due to limited space and the common use of spring-loaded faucets, requiring one hand to hold the faucet open (Hedberg, 1992). These factors impact on cabin crew hand washing practices (Pragle et al., 2007).

Although airlines have responded to the limited number of handwashing facilities by providing hand sanitizers as part of galley equipment, evidence from a systematic review questions the efficacy of hand sanitizers as a substitute for handwashing in food handling settings (Foddai et al., 2016). Kampf et al. (2010) reported limited efficacy of hand sanitizer gels and advised that hand sanitizers should only be used *after* handwashing, and never as a substitute. Further barriers to adequate crew hand hygiene in-flight include time pressure, insufficient food handler training, and usage constraints of vinyl gloves. The use of vinyl gloves for example, typically required for food handlers ‘on-ground’, is a voluntary measure and depends on airline protocols (Flight Safety Foundation 2004).

The International Health Regulations (2005) (IHR) require the maintenance of sanitary conditions on conveyances and the WHO Guide to Hygiene and Sanitation in Aviation notes that inadequate water supply for handwashing “may lead to an inability to prepare or serve food in a sanitary manner, thereby impacting on the provision of safe food to passengers” (2.1.3.2). The IHR is “legally binding” but actually unenforceable and the World Food Safety Guidelines for Airline Catering and the IATA Cabin Operations Safety Best Practices Guide also rely on voluntary compliance. In practice, there is no enforceable legal requirement for modern aircraft design to provide galley sinks for adequate handwashing. Even more remarkable, there is no legal requirement for aircraft to have installed toilets.

The context of aviation food has changed. New dynamics in air travel such as extended flight times and increasing passenger loads provide more opportunities for food-borne diseases to occur. A new regulatory approach to in-flight food safety needs to align as closely as possible to ground level standards and be supported by effective compliance monitoring and enforcement. Structural improvements may be necessary to enable adherence to personal hygiene protocols. As a focal point of hand hygiene pressures, designated staff sinks can be an effective way to improve safe food handling on board. If hand sanitizer gels are provided as alternative, their acceptance by staff and their effectiveness in the cabin workspace should be determined. Such research could contribute evidence to inform policy as the aviation industry continues to increase the number and length of flights worldwide. Cabin crew need a more informed understanding of what ‘food safety’ actually means.

Meeting the challenges of providing safe food amidst increasing air travel requires an understanding of the complexities associated with the cabin workspace, the uncertainties relating to training and education of crew, and the policy responses across relevant aviation and public health sectors. Food safety is a critical component of general aviation safety. Devising more effective ways to adhere to food safety standards in-flight can result in significant public health benefits. Shifting policy is a slow proposition but the need for safe food handling onboard will only increase.

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Publication 3: In-flight transmission of foodborne disease: how can airlines improve?

Key Words: Epidemiology; aircraft; contamination; food hygiene; aviation food safety; densification

Abstract

Food contamination during air travel presents unique risks to those affected. Foodborne pathogens can cause serious illness among all on board, and potentially jeopardize flight safety. These risks are likely to increase with current trends of "densification" and a predicted massive expansion of air travel. While aircraft are being equipped with ever newer designs with a focus on efficiency and comfort, regulations remained largely unmodified in terms of basic hygiene requirements. Strict guidelines for food hygiene exist for on-ground food settings and catering kitchens. There is uncertainty about hygiene standards on board commercial aircraft, and little regulatory oversight of what happens to food in-flight. In two hypothetical scenarios we indicate the potential risks associated with poor food handling practice onboard aircraft, with the ultimate aim of bringing aviation food safety in line with on-ground regulations. Changes in cabin design alongside adequate training in safe food handling have the potential to increase public health protection. We urge a review of existing in-flight hygiene protocols to better direct the development of regulation, prevention, and intervention measures for aviation food safety.

Introduction

Food handling practices on board commercial aircraft are often under-regulated and there are real barriers that hinder adherence to hygiene measures. Airlines serve hundreds of millions of meals to passengers each year [1]. With the increase in global air transport, ever more people are potentially exposed to the risk of poor food hygiene in aviation settings. Due to fierce competition between airlines, there has been a growing trend of "densification", i.e., designing aircraft to maximise seat numbers, cutting space in aircraft toilets and galleys. There are more flights, carrying more passengers, to more remote destinations and with longer flight times than ever before.

Recorded cases of food-borne disease account for only a small fraction of actual disease events [2]. The WHO estimates that each year as many as 600 million people worldwide fall ill from contaminated food, 420 000 of whom die [3]. The application of hygiene protocols is an effective measure to prevent the spread of disease [4]. Most countries have established complex, enforceable food hygiene regulations for on-ground food settings, such as ensuring that food handlers have easy access to toilets and handwashing basins. However, these regulations do not generally apply to food handling in flight and adapting standards to aircraft cabins presents a challenge: there are operational constraints, such as limited space for sanitary facilities, and also time constraints, such as having to comply with protocols and internal rules. Despite the difference with routines and rituals in on-ground food settings, food safety is governed by the same fundamental principles of hygiene, food science and public health. These disciplines have well-established theoretical foundations and robust methodologies. However, they are under-represented in the aviation environment and industry practices and are often not underpinned by enforceable legislation or lack a solid epidemiological evidence base [5].

Although aircraft are recognised as important vehicles for outbreaks and the rapid spread of foodborne diseases [6], only few reports of foodborne illness exist that are associated with aircraft [7]. This may be due to the strict food controls in airline catering stations, but many in-flight illness events go unrecognised, and may only be investigated if they have a major public health or economic impact [3]. In most instances, identification of epidemiological links between cases is extremely challenging. Illness often occurs after passengers and crew have dispersed to different public health jurisdictions [8]. Potential in-flight contamination and resulting outbreaks are difficult to differentiate from disease cases attributable to pre-flight exposure. Outbreak investigation is further limited by ill people not seeking health care, delayed reporting, limited testing of specimens, or lack of cooperation between airlines and health authorities regarding passenger data. Even in the event of disease tracing, investigation efforts often only go back to the catering station [9]. See Box 1 for reports of outbreaks of foodborne illness associated with commercial air transport.

Box 1

Reports of outbreaks of foodborne illness associated with commercial air transport, including suspected outbreaks of Norovirus gastroenteritis from other inflight contamination sources during 1947 – 2011.

Year	Agent	Vehicle / contamination source	Origin	No. cases	Reference
1947	*Salmonella typhi*	Sandwiches	Anchorage, USA	4	[10]

1961	*Staphylococcus aureus*	Chicken	Vancouver, Canada	13	[11]
1965	*Staphylococcus aureus*	Roast turkey	Adelaide	4	[12]
1966	*Salmonella, staphylococcus*	Roast chicken	Adelaide	3	[12]
1966	*Staphylococcus aureus*	Trifle desert	New Delhi	15	[12]
1967	*Escherichia coli (E. coli)*	Oysters	London	23	[13]
1967	*Salmonella enteritidis*	Mayonnaise	Vienna	380	[12]
1969	Multiple	Unknown	Hong Kong	21	[14]
1969	Multiple	Unknown	Hong Kong	24	[15]
1970	*Clostridium perfringens*	Turkey	Atlanta, USA	25	[16]
1971	Unknown	Shrimp and crab salad	Bangkok	23	[17]
1971	*Shigella sonnei*	Unknown	Gran Canaria	219	[18]
1971	*Shigella sonnei*	Seafood cocktail	Bermuda	78	[19]
1972	*Vibrio parahaemolyticus*	Seafood appetizer	Bangkok	15	[20]
1972	*Vibrio cholerae*	Appetizer	Bahrain	47	[21]
1973	*Vibrio cholerae*	Cold asparagus & egg salad	Bahrain	66	[22]
1973	*Salmonella Thompson*	Breakfast	Denver, USA	17 (at least)	[14]
1975	*Staphylococcus aureus*	Ham	Anchorage, USA	197	[23]
1975	*Salmonella oranienburg*	Unknown	Rome	23	[12]
1976	*Salmonella typhimurium*	Cold salads	Las Palmas, Spain	550	[24, 25]
1976	*Salmonella brandenburg*	Multiple items	Paris	232	[26, 27]
1976	*Staphylococcus aureus*	Cream cakes	Rio de Janeiro	28	[28]
1976	*Vibrio parahaemolyticus*	Unknown	Bombay	28	[29]
1978	*Vibrio cholerae non-01*	Sandwiches	Dubai	61	[29]
1982	*Staphylococcus aureus*	Custard	Lisbon	6	[14, 25]
1983	*Salmonella enteriditis*	Swiss steak	New York, USA	12	[14, 25]
1983	*Shigella* sp.	Unknown	Acapulco	42	[14, 25]
1984	*Salmonella enteritidis*	Aspic glaze	London	866	[30]
1985	*Salmonella enteritidis*	Mousse with cream	Faro	30	[31]
1986	*Salmonella infantis*	Multiple items	Vantaa	226	[32]
1988	*Shigella* sp.	Cold food items	Minnesota, USA	240	[33]

1989	*Salmonella enteritidis*	Multiple items	Spain/Finland	71	[34]
1991	*Salmonella* sp.	Unknown	Greek Island	415	[35]
1991	*Staphylococcus aureus*	Chocolate cake	Illinois, USA	26	[36]
1991	*Norovirus*	Orange juice	Melbourne	3053	[37]
1992	*Vibrio cholerae*	Seafood salad	Lima	80	[38]
1992	*Vibrio cholerae*	Seafood salad	Buenos Aires	75	[38]
1993	*Enterotoxigenic E. coli*	Unknown	Charlotte, USA	56	[39]
1997	*Salmonella enteritidis*	Chocolate éclair	Canary island	455	[40]
2002	*Norovirus**	Contaminated surface (vomitus)	London	5	[41]
2008	*Norovirus**	Contaminated surface (vomitus, faeces)	Boston, USA	22	[42]
2009	*Norovirus**	Contaminated surface (vomitus)	Unknown	27	[43, 44]
2009	*Norovirus**	Contaminated surface (vomitus)	Los Angeles, USA	63	[45]
2009	*Shigella sonnei*	Raw carrot	Hawaii	47 (at least)	[46]
2011	*Salmonella heidelberg*	Milk or eggs	Tanzania	25	[47]

* These cases were not traced to a specific food source but were likely related to other sources of contamination from inflight vomiting events. Contaminated surfaces or food preparation areas are a key transmission source for norovirus, particularly in confined spaces [48].

International air travel harbours a range of food safety hazards that emerge from the nature of aircraft cabin environments. Features of the aircraft cabin that predispose to pathogen transmission are large numbers of individuals in a confined space, and shared sanitary facilities [49]. Although the risk of in-flight food poisoning also depends on the types of foods delivered, the characteristics of people consuming the food, and the source of airline catering, contamination usually arises from unhygienic practices in food handling, inadequate food storage, and poorly enforced standards [14]. Evidence suggests that pathogens can survive for hours to months on various surfaces and spread to other individuals via direct or indirect contact. This persistence has been identified in aircraft cabins on tray tables, worktops, sink faucets and washroom door handles [50]. Larger aircraft built for longer distance and increased passenger capacity will present even greater challenges to food hygiene.

An incidence of food poisoning among crew can directly affect flight safety. For example, pilot incapacitation can have a direct impact on flight performance, and a common cause of pilot incapacitation is gastrointestinal illness [51]. Even subtle incapacitation of a pilot at a critical phase of the flight may jeopardize flight safety, such as symptoms occurring in the onset-stage of food poisoning. Regulatory and monitoring systems appear to be non-existent for in-flight food safety [52]. Few clear standards exist for hygiene requirements in aircraft cabins, and airlines generally establish their own set of cleaning standards [53]. While poor hand hygiene is often at the root of major food poisoning outbreaks, there are no requirements for a minimum number of washrooms, such as a toilet/passenger ratio, similar to an emergency door/flight attendant/passenger ratio [53], and no requirements for designated crew toilets or handwashing sinks in galleys. There is also little oversight of in-flight food handling processes, such as audits or compliance controls [52]. While aircraft are being equipped with ever newer designs with a focus on efficiency and comfort, regulations remained largely unmodified in terms of basic hygiene requirements.

In this Commentary, we discuss three dimensions of food hygiene in-flight: onboard contamination sources, personal hygiene, and barriers to safe food handling. Two hypothetical infection scenarios illustrate the potential for in-flight contamination, aimed to highlight the divide between on-ground and in-flight food safety regulation.

Contamination Sources

Evidence suggests that about one in every five cases of food-borne illness is caused by contaminated food handlers' hands [54]. When applied to the confines of aircraft cabins, not only may contaminated hands play a key role in the occurrence of foodborne illness, but the nature of the galley design also impacts on safe food-handling practices [55]. Outbreaks of gastrointestinal illness on aircraft have been traced to in-flight incidents of vomiting in the cabin and lavatories [45]. Washroom use played a role in infection transmission when 41 travellers contracted gastrointestinal illness from one traveller's vomit [4]. The lack of recognition of vomiting events by cabin crew can lead to failure in informing destination health authorities, thereby impeding disease tracing and follow-up efforts. As passengers and crew share toilet facilities, there is a greater risk for increasing the spread of infection.

The potential for disease transmission by cabin crew is illustrated through their work in the cabin, where transmission can recur from the same source over multiple flight sectors [43]. Outbreaks resulting from indirect transmission through exposure to contaminated surfaces occurring days after the contamination incident have been reported in other contexts [56]. The type and sequence of work activity also determines the risk of contamination. For example, failing to wash hands after touching soiled workplace surfaces is likely to be riskier than failing to wash hands after touching one's uniform. Failure to wash hands after using the toilet is likely to be riskier if the next activity is preparing a bread basket than refurbishing toiletries.

Although food handlers are typically discouraged from handling food or beverages if they have symptoms of illness that could be contagious, cabin crew were found to often fly when feeling unwell or sick [57]. Infected crewmembers may thus also act as a reservoir for disease transmission in-flight [41, 58].

Personal Hygiene and Barriers to Safe Food Handling

According to the WHO, handwashing with soap and water is the most important hygiene measure to prevent the spread of infection. There may be debate about handwashing in terms of detergents used and length of the washing process, but the benefits of handwashing in preventing foodborne illness are well documented [59]. The WHO, the International Flight Services Agency (IFSA), and the International Air Transport Association (IATA) all provide guidance on best practices on in-flight food safety and hygiene practices [1, 60, 61]. IFSA's guidance is based on the HAACP (Hazard Analysis and Critical Control Point) system, which is widely used in the food industry and which involves identification or specific hazards and measures for their control. Although the IATA notes that cabin crew should follow the same code of practice as on-ground food handlers [60], there are real barriers for crewmembers to adhere to the same stringent hand hygiene practices required for most on-ground food settings. For cabin crew to be able to apply good handwashing practice in-flight depends on (1) the number of facilities available, (2) whether handwashing facilities are in close proximity to work stations [62] and (3) whether washrooms are vacant or galley sinks are suitable for handwashing.

Food preparation often correlates with high use of toilets by passengers (e.g., just after take-off), providing limited opportunity for crewmembers to wash their hands prior to beverage and meal service. Moreover, the combination of time pressure and lack of adequate facilities is a barrier for compliance with handwashing [63]. Cabin crew may get caught in role conflicts between safety and service tasks, which can lead to unsafe behaviour due to time constraints [64]. Similar to the way that constricted space for food handlers in small restaurants impedes adherence to good hygiene practice [65], the constraints of the aircraft galley, too, increase the risk of food safety lapses. In addition, most sinks in aircraft galleys are not designed for handwashing, as the faucet design requires one hand to operate the faucet handle [33].

There is much debate about the use of hand sanitizer products in food handling settings, with arguments such as: handwashing with soap and water is more effective for pathogen removal from hands [66, 67]; hand sanitizers should ideally be used after handwashing, but not as a substitute [68]; and hand sanitizers have no impact on hand hygiene compliance [69]. In particular, hand sanitizers are ineffective on viruses such as norovirus. Vinyl gloves can provide some protection from contamination, but they can also create a false sense of security and encourage high-risk behaviours when people are not adequately trained. Improper glove use was reported by Gaynor et al. [46] where flight catering employees touched door handles and carts with gloved hands before handling raw vegetables with gloved hands. Moreover, whether gloves can be used during service is dependent on airline-specific policy [70].

Scenarios

The following hypothetical scenarios illustrate the implications of in-flight food safety lapses, such as direct contamination by food handler hands, and opportunistic pathogen transmission through secondary sources. While these circumstances are conjectural, they represent plausible real-life events in the context of confined space conditions, limited handwashing opportunities, multitasking, role conflicts, as well as shared facilities among staff and customers. Similar to in-flight airborne disease transmission described by Han et al. [71] we assume that the movement and contact activities of cabin crew, passengers, and potentially the index case can significantly increase their personal infection risks, as well as the risk for disease transmission.

Scenario 1: Norovirus

Noroviruses are highly infectious and easily transmitted by multiple routes in confined settings, resistant to most disinfectants, and thus hard to contain using conventional sanitary measures [43]. Although typically self-limiting, severe disease cases occur in young children, the elderly, and the immunocompromised. Outbreaks of norovirus have been traced to in-flight incidents of vomiting in the cabin and lavatories [45]. On a full flight carrying 467 passengers, and a scheduled flight time of 13h 40m, a crewmember prepared four sandwich trays for premium class when she was intermittently called to the cabin for rubbish collection. Unable to wash her hands as all lavatories were occupied, she turned back to service preparations. The sandwiches were later displayed in the aircraft kitchen for self-service. Two vomiting events outside of a washroom were reported during the flight, but no disinfection of specific areas occurred. Eighteen business class passengers were part of a soccer team who resided in the same hotel as the crew during the three-day layover at the destination. Two days after arrival, vomiting and diarrhoea occurred among two crewmembers and seven soccer players. Norovirus was confirmed as causative agent in all cases. In-flight food items were no longer available for disease tracing. Laboratory testing of retained meals at the catering kitchen showed no signs of contamination.

This scenario demonstrates the ease with which viruses can transfer between a contamination source and food items, and the potential to spread infections among people. Dissemination of norovirus is facilitated by substandard sanitary conditions and vomiting events [42], with lavatory use being a significant risk factor [59]. The pattern of norovirus outbreaks highlights the potential of aerosol transmission as well as surface contamination in confined settings [72]. Ho et al. [73] note how during a cruise ship outbreak a link could not be established to food consumption. However, the risk of gastroenteritis among passengers using shared toilet facilities was twice that of passengers who had a private facility. Consequently, the number of passengers sharing toilets was related to the rate of illness. Because 18 passengers and the crew stayed at the same location post-flight, investigative efforts were able to determine the causative agent, and to establish a likely linkage to a common contamination source. This is not usually the case. Passengers typically disperse in different directions before falling ill. Data on suspected norovirus transmission in-flight support the view that contaminated areas are rarely successfully identified and adequately treated [42, 59].

Contamination from initial vomiting events can cause infections for several days, even after routine cleaning [43, 56]. Post-flight measures dictate notification to ground staff of areas contaminated with vomit [74]. This was omitted in the scenario, implying a lack of recognition of the severity of vomiting events among crew. Only few reports of norovirus-related transmission risk exist that are associated with aircraft [45, 59, 72].

Scenario 2: Salmonella

Salmonella are resilient bacteria that can survive several weeks in dry environments and several months in water. The illness salmonellosis causes acute onset of abdominal pain, diarrhea, fever, and nausea. Children and the immunocompromised are more likely to develop severe disease. Burslem et al. [30] reported salmonella outbreaks that affected nearly 1000 passengers, aircrew and ground staff. A full flight with 352 passengers departed late. Scheduled flight time was 14h 20m. Crewmembers prepared bread baskets for premium class and stored eight hot pork dishes in the oven for sleeping passengers. Two crewmembers had been suffering from diarrhea following a previous trip but reported for work despite feeling unwell. Approximately 10 hours after the first meal was served, 12 premium class passengers, six economy class passengers, and one pilot developed symptoms of abdominal cramps and diarrhea. Five passengers and the pilot were admitted to hospital after landing. Salmonella enterotoxin was detected in all stool samples.

The source of contamination in this scenario could have been contaminated hands handling bread rolls, or inadequate storage of heated meals where bacteria multiply. In an assessment of the hygienic quality of airline meals, the most prominent contributing factors for salmonella outbreaks were found to be infected food handlers and inadequate refrigeration [75]. Salmonella bacteria have been repeatedly found in meat products [14, 76]. While bread is seen as an unusual outbreak vehicle for salmonella [77], poor personal hygiene could have contributed to the contamination. Temperatures achieved during the baking process would typically destroy any pathogen in bread, but in this scenario the bread rolls were handled after heating the bread. Delays extend the time lag between food production and consumption and increase opportunities for pathogen growth. While poor practices can involve inadequate storage at inappropriate temperatures, cabin crew may also be asymptomatic carriers of food poisoning pathogens [78]. Travel to worldwide locations over the course of just one month puts crewmembers at heightened risk of eating or drinking contaminated food or water [52].

Discussion

Illness may not develop for days or weeks after exposure to contaminants, rendering outbreak investigation in aircraft settings extremely difficult. Passengers and crews disperse quickly, and food samples are unlikely to be available as leftover food is thrown away after a flight. Determining the real number of food poisoning incidences and contamination events on aircraft is further hampered by limited access to customer complaints and food safety-related records [52, 79].

Multi-tasking with limited access to handwashing facilities was problematic in both scenarios. Cabin crew had to smooth out service disruptions at the expense of safe handling practices. As airlines increasingly reduce space for lavatories in favour of revenue-generating seats, aircraft cabins largely remain unmodified in terms of basic hand hygiene requirements. Quantity and design of aircraft galleys and washrooms is not down to aircraft type, but to airline choice [80]. The limited space for sanitary facilities may lead to splash exposure from small wash basins, and also increase the risk of coming into contact with soiled surfaces. The scenarios underscore the importance of preventive measures such as appropriate handwashing, and proper handling and storage of food.

There is a serious lack of data regarding crew hand hygiene, or of the merits of using gloves or hand sanitisers. This presents a significant barrier to identifying the true incidence of inflight food contamination and the urgent need to evaluate the usage of provided measures such as hand sanitizers, and to adequately train crewmembers in safe food handling. While improved hygiene may not be sufficient to break the chain of person-to-person transmission, enhanced hygiene measures are likely to reduce the transmission of norovirus during an outbreak [81]. Commercial pressures to maximise passenger numbers should not be at the expense of allowing space for adequate hygiene measures. Profits must not undermine safety. The incorporation of the internationally recognised HACCP system should become standard. Trials in the airline catering industry have been found to be cost-effective [82] and it could prove highly beneficial for onboard food safety.

Conclusion and recommendations

Food handling processes are governed by the same universal rules, whether they take place in on-ground settings or onboard aircraft. Yet attempts to contain the spread of foodborne disease via aircraft are constrained by a lack of basic hygiene infrastructure and concepts of profit over health and safety. Trends of densification mean fewer and more compact washrooms and galleys, alongside increasing passenger loads. The operation of ultra long-haul flights means increased handling of food over an extended period of time, bringing more opportunity for food safety lapses. Extended flight times also increase the risk of disease transmission and pilot incapacitation, because there is an increased risk for the sudden collapse of a crewmember resulting from food poisoning with a short incubation period.

Ensuring better adherence to in-flight food hygiene rules requires assessment of the cabin layout. Mirroring the stringent hygiene standards of on-ground food settings, there needs to be identification of those elements of the cabin layout which pose a risk to food safety and hinder personal hygiene measures. Researchers could help develop new sanitary techniques by studying what factors most influence handwashing onboard, and also look at the effectiveness of hand sanitizer gels in the cabin workspace, as well as the acceptance of hand sanitizers by cabin crew as a substitute for handwashing. Better insight can then identify areas of weakness to design operationally feasible approaches. Airline training on hand hygiene should focus on understanding when hand hygiene is most critical, and which sanitary options are most beneficial and conducive to compliance. Developing aircraft-specific food safety plans could further serve as guidance for crew, and also raise awareness of their role as food handlers, and their importance in outbreak investigations.

Achieving onboard food safety will require a multi-pronged approach involving increased research, improved cabin design, improvements in aircrew training and behaviours, and harmonised governance. [See Box 2] The latter would require collaborative efforts of bodies such as the ICAO, IATA, IFSA and WHO. Future efforts should focus on quantifying the relative importance of in-flight disease transmission to public health. But most importantly, aircraft design should be bound to regulations that determine health and safety priorities. Just as ergonomics in galley design play an important role in preventing fatigue and injury, design should also ensure adequate handwashing opportunities. Such seemingly basic initiatives can provide a powerful means to improved food safety in aviation. Only by fixing the system of adequate facilities, regulations and inspections, and by performing the rituals of hygiene practices, can the airline industry gain the status of a 'safe' food handler.

Box 2

SUGGESTIONS TO IMPROVE ON-BOARD FOOD SAFETY

Research

- More data are required on disease transmission, including modelling and full disease tracing
- Hazard Analysis and Critical Control Point (HACCP) Analysis

Design

- Adequate sanitary facilities, e.g., sufficient toilets and wash basins
- Adequate space for good hygiene practice
- Ergonomic design, e.g., water taps

Behaviours/training

- Handwashing, including use of hand sanitisers
- Food handling practice
- Management of conflicting requirements of food preparation and service provision

Governance

Collaboration between regulatory bodies to develop harmonised governance, e.g:

- Aircraft food safety plans
- Harmonised cleaning standards and policies
- Regulatory and monitoring systems

Chapter summary

Based on the blog analysis and the insights gained from chapter 2 where passengers' cultural diversity (namely customs and language) can create unique barriers to food hygiene, these publications further examined the interconnected situations that can arise, and which have the potential to increase the risk of food contamination inflight. This chapter revealed the associations between health-status constructs and cabin crew food handling behaviours, and demonstrated the need to fully understand all factors underlying these behaviour, including their operational fitness-to-fly. Any positive effects gained from food hygiene training programmes are thus ephemeral.

In the next chapter, I extend the traditional notion of fitness-to-fly towards building a conceptual framework based on contemporary flight operations, and inclusive of pre-flight health checks. I illustrate the importance of a conceptual expansion for fitness-to-fly by using the ongoing COVID-19 pandemic as context and reference point. In arguing that an improved conceptual basis for fitness-to-fly could enable disaggregation of health constructs into analytical subunits or “regulatory chains”, the aim of chapter 6 is to signal that each flight operation contributes to, and affects, the self-assessment process.

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CHAPTER 6

Conceptualisation of Fitness-to-fly

Thesis structure

Chapter 1: The Role of Air Cabin Crew: Literature Review

Chapter 2: The Role of Cabin Crew: Service Aspects

Chapter 3: Online Blog Analysis: Cabin Crew Health, Safety, and Fitness-to-fly

Chapter 4: The Cabin Crew Role and Infectious Disease Control: Aircraft Disinsection

Chapter 5: The Cabin Crew Role and Infectious Disease Control: Aviation Food Safety

Chapter 6: Conceptualisation of Fitness-to-fly

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Overview

The metaphor of 'fitness-to-fly' suggests that cabin crew fitness is organised by pre-existing purposive principles that are either grounded in federal regulations or airline-internal rules, or both. Assessment strategies are designed by organisations and aeromedical services for particular purposes, and act upon and through operational requirements. So far, this thesis has shown that past research output in cabin crew health has only been weakly matched to the demands of aviation regulators and aviation medicine. Despite the use of the term fitness-to-fly in aeromedical assessments, there is little consensus in relation to theory, definition and measurement. Although current assessment systems play a role in the determination of overall fitness and thus suitability at a given point in time, they cannot explain a crewmember's operational functionality.

The previous chapters have identified fitness-to-fly as relevant and aspirational term for cabin crew, for which a conceptualisation is best linked to the dominant areas of perceived influences on individual health. However, the need to assess a crewmember's pre-flight state of health has, to this end, failed to introduce the notion of 'pre-flight fit checks' as useful tool to conceptualise the ad-hoc conditions that define a crewmember's self-evaluated fitness upon reporting for duty. The uncertainty and dynamics of occupational exposure scenarios challenge the principles of fitness-to-fly assurance developed for repetitive operations, and call for operation-tailored solutions. Fitness-to-fly theory serves as an interpretative lens (e.g., to meet statutory requirements) rather than an ontological foundation to inform research in actual flight operations. The basic argument is that fitness-to-fly theory is limited in its ability to frame operational problems, i.e., to only use the existing theory as an interpretive lens is restrictive and limiting.

I identified four attributes of fitness-to-fly which indicate a tension between a mechanistic standpoint of assessment, and the need to incorporate less tangible aspects.

Fitness-to-fly is not a static phenomenon but undergoes constant change in response to the phenomena that it is supposed to regulate.

Fitness-to-fly should manifest in the capacities to recover or expend, in the authority to 'keep going' or to stop, and in all the mechanisms and techniques that assist in doing so.

Fitness-to-fly appears to be a concept of faith in the creed of medical assessment, but it does not fit the facts of contemporary flight operations.

Fitness-to-fly does not 'code for' or 'program' the behaviour of crew.

While it is difficult to contest the empirical ubiquity of fitness-to-fly assessment in questions of social, environmental, and operational organization, it is precisely this ubiquity that bears the risk of turning the scope of fitness-to-fly scholarship into an empty signifier that lacks conceptual coherence and clarity. This chapter attempts to conceptualise operational fitness-to-fly based on the relationship between individual health states, operational context, and organisational pressures. Adaptation of current assessments to operational fitness-to-fly can thus be defined as 'employable drift' from a periodic procedure as cabin crew realise that a pre-flight checklist tool better fits the operational realities (and ultimately flight safety), than standardised medical assessment. In this way, I extend the statutory idea of fitness-to-fly to an operation-based concept which enables disaggregation of health regimes into analytical subunits or 'regulatory chains,' where each operational factor contributes to, and affects the self-assessment process. This conceptual approach ties together existing descriptions and applications of fitness-to-fly for building a comprehensive framework for self-assessment. The proposed model expresses what crewmembers perceive as important elements in the blog analysis to effectively perform the dual role of both safety and service. Key themes from the thesis findings are utilised to tie together the argument of framing fitness-to-fly as a seemingly permanent state that fails to capture the full repercussions of the individual inability to judge actual fitness.

The notion of something being 'new' in the study of fitness-to-fly must not be misunderstood as a claim that connections between health and flying would be novel phenomena. On the contrary, as Bagshaw (2012) and Bagshaw and Illig (2019) describe, flying and states of health have historically always played a crucial role in aviation, while at the same time undergoing transformations due to changing environments, new technologies and changing modes of operation. Acknowledging this fact, the emphasis of the fitness-to-fly paradigm lies not in the static assessment, but in a processual angle that is interested in its production, and in the individual, social, and managerial repercussions generated by poor health states and its underpinning enablers. Powell (2013) further purports that every actual operational occasion is determined by known causes as well as the uncertainties attached to events, and thus cautions against overstating the role of fitness-to-fly as an analytical category. Thinking of assessments as if they act to ensure flight safety is an attempt to overcome this problem, but it is a rhetorical maneuver, not a scientifically testable hypothesis. If fitness-to-fly was seen as a hypothesis, rather than a metaphorical dogma, then fitness-to-fly should be testable.

Assessments should therefore pay more attention to the consequences of seeing fitness-to-fly as "taken-for-granted" state of health. Paying attention to these consequences also gives insight into the process of integrating related problems of scheduling or fear of punishment, and the possibilities averting them. Drawing on these insights, I argue that the combined consequences of a “declaring oneself fit-to-fly” outreach the common description of fitness-to-fly in terms of annual medical clearance and are better framed as “fitness-to-operate.” Fitness-to-operate better encompasses the holistic consequences of reporting for a particular duty until returning to the home base.

Aims of this chapter

Chapter 1 has identified current methods of fitness-to-fly assessment as pre-employment and periodic assessment tools. The aim of this chapter is to explore the dimensions of fitness-to-fly to deepen our understanding of the process dynamics underlying the relationship between the operational context, perception, influential agents, capabilities and performance. To reduce the possibility of having a narrow and potentially flawed view of crew health, and to lay the conceptual groundwork for measuring fitness-to-fly in the form of a self-assessment tool, the aim is to indicate that if researchers are using inadequate conceptualisations, the analysis may be inadequate, too. Advancing fitness-to-fly on a conceptual level can help to support the provision of advice on how to interpret pathological findings in the context of an aeromedical disposition, and develop more specific health provisions for inclusion in fitness-to-fly standards. In addition, it can be a valuable guide for organisations seeking to benchmark fitness-to-fly in daily operations.

Using the current COVID-19 crisis as scenario, I first illustrate its operational purpose in the publication ‘Cabin Crew Health and Fitness-to-fly: Opportunities for Re-evaluation amid COVID-19.’ I then make the case for moving beyond fitness-to-fly as the appropriate framing for the consequences of poor states of health. I outline the ‘fit check’/ as key conceptual tool to frame the pre-flight momentary condition of fitness based on key aspects of this condition referenced through relevant literature in chapter 1.

<u>Publication:</u> Cabin Crew Health and Fitness-to-fly: Opportunities for Re-evaluation amid COVID-19

Key Words: Cabin crew, fitness-to-fly, health, safety, aviation, occupational risks, COVID-19

Abstract

Aircrew fitness-to-fly is among the elements that make aviation the safest form of long-distance transport. The health of cabin crew is a crucial determinant in carrying out safety-related duties. ‘Fitness-to-fly’ is associated with defined workplace conditions, for which airlines have a legal duty to ensure fitness for employment. We explored the literature on fitness-to-fly to obtain a pragmatic assessment of the challenges for aeromedical examinations. Regulations promulgated by aviation regulatory authorities and airline-internal policies have similar status and meaning, yet there is no harmonised approach internationally, and an inability to conform periodic medical assessments to actual operational fitness. The COVID-19 pandemic has highlighted the need to better understand fitness-to-fly criteria. Fitness-to-fly measures are mainly based on self-reported data and there is a need for a ‘safety’ factor for self-reports. Aeromedical evaluations should evolve from meeting medical standards to include pandemics as an element of the overall risk of aircraft operations. Re-evaluating criteria for fitness-to-fly assessment will further the goal of linking research to the actual needs of public health decisionmakers. If airlines are to resume operations at pre-pandemic levels, they must demonstrate to the public and public health agencies that fitness-to-fly assessment is appropriate and effective.

Introduction

Cabin crew play a key role in maintaining passenger and operational safety in commercial aviation. Prior to the COVID-19 pandemic, cabin crew were a fast-growing occupation, with demand for new recruits expected to rise between 2018 and 2038 to over 300.000 crewmembers in regions such as the Asia Pacific [1]. Similar to the activities involved in the work of police officers, paramedics, and fire fighters [2], there are public health issues associated with the activities of cabin crew. Although good health is a crucial determinant in carrying out safety-related duties, the critical public safety role of cabin crew and the concomitant demands for good health often go unrecognised [3]. Through identifying the effective skills and knowledge required to ensure cabin safety, fitness-to-fly standards aim to contribute to continuous safe flight operations, and to protect the health and safety of passengers.

Cabin crew work in a high-risk environment and are exposed to a multitude of occupational risks and hazards. Although many occupational settings harbour risks to employee health, Powell [4] notes how the cabin environment concentrates risk to individual health. Examples of exposures that occur in routine flight operations include poor cabin air quality from a number of sources; fatigue; cosmic ionising radiation; circadian rhythm disruption; high levels of occupational noise, pesticides; and infectious disease agents [3, 5-7]. Cabin crew share the same workspace as pilots and are connected through interlinking roles. However, they remain an understudied field in the aviation / aerospace medicine and occupational health and safety literature [3, 6, 8, 9].

Assessment of fitness for work is typically defined as “the evaluation of a worker’s capacity to work without risk to their own or others’ health and safety” [10]. The purpose of fitness-to-fly assessment is to describe the individual health state necessary for the performance of cabin crew duties, synthesising guidelines and regulations from national aviation administrative bodies [e.g. the U.S. Federal Aviation Administration (FAA)] and international agencies [e.g. the International Civil Aviation Organization (ICAO), and the International Air Transport Association (IATA)], as well as incorporating evidence-based and current scientific findings [11]. These medical standards aim to prevent the inability to perform the assigned duties and functions during flight operations that could be caused by the physical, medical and psychological disorders held by a crewmember [12, 13]**.** To reflect working conditions and for the protection of the safety of the flight, airlines have a legal duty to ensure fitness for employment and to establish medical clearance procedures that are consistent and based on accepted physiological principles [14-16].
To ensure consistency with required medical standards, fitness-to-fly evaluations seek to detect existing medical conditions in pre-employment assessment and in recurrent medical checks for the existing workforce. Cabin crew must declare any new medical problem with potential safety ramifications, which develops during the period of

employment [6, 16]. Although fitness-to-fly attestation must specify the state of cabin crew health as a precondition for performing their work role [17], there are no current resources across the industry that provide harmonised tools for aviation medical examination, including guidelines for cabin crew to confirm point-of-time fitness.

Over the last two decades, the airline industry has undergone major reorganisation, and risks have changed. For cabin crew, the operational environment has undergone significant changes regarding extended flight times, increasing passenger loads, job insecurity, and exposure to new or re-emerging health risks [18, 19]. For example, ultra-long-haul (ULH) flights have extended the time crew are exposed to a potential hazard, which in turn may pose greater risks. e.g. infectious disease transmission [20]. The detection of a novel coronavirus (SARS-CoV-2) leading to the illness COVID-19 demonstrated the rationale for adequate assessment for crew fitness-to-fly. For example, reports about cabin crew with COVID-19 operating domestic and international flights have raised questions about the safety of the exemption of the 14-day self-isolation rule [21]. Although clusters of confirmed cases are thought to have contracted COVID-19 while overseas rather than inflight, reports of in-flight transmission of respiratory infectious disease exist [22, 23]. Importantly, Olsen et al. [24] note how a passenger travelling from Hong Kong to Beijing infected people well outside the WHO’s two-row boundary, indicating that airborne transmission was likely the main transmission route for severe acute respiratory syndrome coronavirus 1 (SARS-CoV-1) in aircraft cabins. These reports further illustrate how air travel is an enabler of the rapid spread of newly emerging infections with pandemic potential. In the case of COVID-19 transmission may have occurred; either from passengers to crewmembers, among crewmembers, or infected crew members may have spread the infection to passengers and the wider public.

The airline industry and occupational health and aerospace medicine professionals need to be aware of the remitting nature of many health conditions, as well as the foreseeability of future states of poor fitness-to-fly. Past studies of the health of cabin crew have only been weakly matched to the demands of aviation regulators and aerospace medicine. For example, Mangili et al. [22] reported that cabin crew frequently fly when ill and typically have low vaccination rates. Substantial disparities exist between aircrews flying for U.S. regional carriers and European flag carriers

relating to self-declaration when ill and routine influenza vaccination, with the rate of annual influenza vaccination ranging between 21 – 27% among aircrew [25].
Although the Centers for Disease Control and Prevention (CDC) and IATA consider it essential that aircrew are vaccinated against the common endemic diseases (such as measles-mumps-rubella, diphtheria-tetanus-pertussis, varicella, polio, and the seasonal influenza vaccine), and to keep vaccination records current [16, 26], there are no established requirements for vaccinations in aircrew. Compulsory vaccinations may be based on country-specific entry requirements and include yellow fever [16, 26]. Under the airline industry's plan to restart international air travel, Qantas further stated that vaccination for COVID-19 will be mandatory for travel for aircrew and passengers [27], raising the question of whether a similar policy will be administered industry-wide.

Several authors noted that stringent fitness-to-fly criteria, which apply to pilots, should also apply to cabin crew [7, 17]; and that assessment criteria must be cognisant of the need to maintain flight safety [28]. Correspondingly, Griffiths and Powell [6] question whether statutory fitness-to-fly assessment will benefit either flight safety or occupational health, indicating that evaluations are deficient in the essential resources and components required to be effective. These views hinge on the notion that flight safety anchors on the success of uniform medical clearance, standardised training programmes, and a solid understanding of workplace exposure to hazards, for which the evidence base is currently insufficient and/or inconclusive. With passenger confidence largely resting on the assurance of hygienic conditions and healthy staff [29], auditing fitness-to-fly requirements amid the COVID-19 crisis is an opportunity to assess the operational usefulness of fitness-to-fly examinations; the scope and elements in flight operations; to implement changes; and to introduce remedial measures.

In this commentary, we present a novel viewpoint on fitness-to-fly to highlight externally imposed, and individually and socially generated factors that shape fitness-to-fly decisions. We discuss the implications of the rapidly evolving situation and future directions of the COVID-19 pandemic, including conceptual tensions that exist when managing operational fitness in cabin crew. In questioning whether selected medical criteria truly represent an impact on health and safety outcomes that matter most to flight safety and public health, we aim to promote scientific discourse that challenges the current approaches to fitness-to-fly evaluation. Derived from consistent themes in the aeromedical literature, the following sections discuss six major areas which require consideration to support existing fitness-to-fly evaluation.

Discussion

1. *Statutory fitness-to-fly medical assessment*

The requirements for fitness-to-fly assessment are based upon Standards and Recommended Practices (SARPs). These include recommendations published in the World Health Organisation (WHO) International Health Regulations (IHR); national legislation and regulations; airline-internal standards for medical assessments; and a fitness-to-fly medical guide for pilots, which is also applicable to cabin crew [11]. While the responsibility for cabin crew fitness is shared among the airline, aviation regulatory bodies and the crewmember, national aviation agencies are to ensure that airlines comply with their responsibilities in providing fit crewmembers. These agencies typically set requirements for aviation medical examiners (AMEs) to conduct fitness-to-fly evaluations. New cabin crew recruits require an initial medical examination, followed by periodic medical assessments at intervals of no more than 60 months [30].

If the purpose of fitness-to-fly is to achieve a balance between minimising any operation-related flight safety risks for the individual and the community posed by the crewmember's state of health, and maintaining the crewmember's occupational health, then any emerging risk to health should be accounted for. Given that international standards differ both within and between jurisdictions, as national airline regulators (such as the FAA) determine medical standards from their own jurisdictions [12, 31], then this new assemblage of risks implies that new vulnerabilities are created that must be addressed through several medical dimensions that are underpinned by safety considerations.

Box 1

Fitness-to-fly assessment in the context of COVID-19

Adequate responses amid the COVID-19 crisis require cabin crew and airlines to know what employment actions are lawful in the face of a pandemic, and how staff can protect themselves as well as passengers. Until recently, the priority of travel health advice has not focussed on preventing the spread of infectious disease [32]. To prevent cases of infected cabin crew operating flights, IATA [33] recommends inclusion of self-certification statements from cabin crew, certifying the absence of COVID-19 symptoms when reporting for duty, or providing evidence of recent negative test results, "where rapid testing is available". The challenge is to ensure that recommendations are a) adopted, b) implemented consistently by the airline industry, and c) do not carry any disciplinary actions if a crewmember reports unfit for duty. According to European Union Aviation Safety Agency (EASA) guidelines, aircrew should be exempt from an airport's COVID-19 screening procedures [34]; however. some Australian states now require aircrews to take a COVID-19 test on arrival before self-isolating at home [35]. Other country-specific testing requirements include:

- Cabin crew employed at Singapore carriers will be routinely tested for COVID-19 upon their return from overseas flights [36], and Singaporean aircrew travelling to China are required to undergo a pre-departure COVID-19 PCR test and IgM serology test [37];
- Delta Airlines requires routine testing for COVID-19 before each tour of duty, using a rapid-response PCR test [38];
- International aircrew arriving in New Zealand are mostly exempt from a 14-day isolation or quarantine period provided they meet certain conditions both inflight and during layover [39].

In addition, airlines will need to consider local requirements in the country of departure and arrival, and monitor local practices as they evolve with respect to immunity certificates or passports, or contact-tracking apps. While COVID-19 in and of itself will generally not affect fitness-to-fly, the mental effects of lockdown-related measures may impact a crewmember's decision-making ability and fatigue level [40].

2. Cabin crew: Exposure to risks and hazards and general health concerns

For cabin crew, reported occupational injuries and illnesses represent only a fraction of the true events [41, 42]. The impact of work-related psychosocial factors is even less understood [43, 44]. Risk assessment frameworks toward cumulative risk assessment have recognised that exposure to a single hazard rarely occurs in isolation [45]. Examples for exposure risks include:

a. Pesticide use in aircraft cabins to control the spread of vector-borne diseases

Although Pang et al. [46] found no evidence of an association between crew exposure to certain insecticides and negative health impact, uncertainty remains about the potential adverse health effects on human health in the absence of longitudinal exposure assessment that correlate insecticide exposure (including carrier substances) and physiological uptake of insecticides to possible toxicity [20]. In addition to cumulative exposure to contaminants, researchers must explicitly measure the association between different types and levels of exposure and ill-health symptoms [47]

b. ULH operations

The longer crews are exposed to a hazard, the greater the likelihood that harm may result. This also applies to determinants of fatigue. Originally designed to accommodate unpredictable factors such as delays or weather conditions, reduced-rest patterns under 'exceptional conditions' have become increasingly common [18]. This requires consideration and management of the interactive effects of workload and fatigue [48]

c. Foodborne and respiratory disease

Reports of likely transmission of norovirus from symptomatic cabin crewmembers to passengers [49] illustrate how crewmembers may also act as reservoir for pathogen transmission, such as in their role as food handlers [50]. Similarly, an ill cabin crewmember could pass on a respiratory illness to passengers or to other crewmembers. For example, for influenza A (H1N1), the potential for inflight transmission has been calculated at five to ten infections which could occur during an 11-hr flight, if the index case travels in economy class [51]. WHO guidance purports that the primary inflight transmission risk for most respiratory infectious diseases is sitting within two rows of an infectious passenger [52, 53]. However, this guidance does not directly take into account the biological bases of droplet transmission and indirect contact via fomites, and does not account for the movement activities of seated passengers and crew which can significantly increase infection risks [54]. Depending on their movements and interactions with passengers, Hertzberg and Weiss [23, 55] note the probability of an infectious crewmember to infect several passengers.

Potential modes of transmission include contact occurring in waiting areas (e.g. near galleys where cabin crew work), indirectly through contact with contaminated fomites, or through airborne transmission which was likely the main transmission route for SARS-CoV-1 in aircraft cabins [24].

Box 2

Health concerns and risks of exposure amid COVID-19

Cabin crew are at risk of contracting and/or transmitting infectious diseases. The high contact rates with interior aircraft surfaces among cabin crew and passengers can put crewmembers at infection risk and present a risk for public health [56]. Although the risk of onboard transmission remains unclear, transmission of SARS may have occurred inflight, when infected persons travelled during the symptomatic phase of illness [24]. High-efficiency particulate air (HEPA) filters may effectively limit the risk of airborne disease transmission inflight, but person-to-person transmission may carry the potential of causing clusters of infections such as influenza, SARS, tuberculosis and measles [22], and now potentially COVID-19 [57]. In addition, cabin crew must be able to recognise, characterise, and respond to various types of fumes, smoke or haze in the cabin environment [58]. For crewmembers that recovered from COVID-19, airlines must consider the impact of anosmia on their ability to identify atypical smells (e.g. chemicals or burning) [33]. Partial or complete smell recovery can last several weeks [59]. Elements to consider for fitness-to-fly assessment thus include novel types of diseases, which can imply previously unknown health risks.

3. *Fitness-to-fly self-assessment: to fly or not to fly?*

Reporting fit-for-work is an individual responsibility [60]. Similar to how a designated physician can refuse transport to a person with acute illness that might compromise the overall safety of the flight [61], cabin crew become their own assessor upon reporting for duty – directed by their perceptions of what makes them fit or unfit for work. Cabin crew showed a higher prevalence of work-related upper respiratory tract symptoms, colds and influenza compared to the general working population, and were less likely to report medically diagnosed asthma [62]. For mental health symptoms, self-disclosure is often affected by fear of stigma and discrimination [63]. Calling in “sick” also interrupts the planned schedule, which can create new disruptions elsewhere in the schedule [64], and potentially invite undesirable changes. If reporting fit-to-fly is an individual responsibility, then discussions require a hands-on definition of the aspects of fitness-to-fly that appear to be signifiers of flight safety, including potential implications on flight operations and the health of others in the case of unfitness-to-fly. Table 1 presents examples of cabin crew perceptions on fitness-to-fly, extracted from an online blog analysis.

Table 1. Fitness-to-fly: Cabin crew perspectives and resulting questions for research

Online blog results	Research questions
Crewmembers perceived fitness to fly assessment an activity in its own right; "an inconvenient annual procedure that just has to be ticked off"	Are decisions about which health issues are risky enough to justify 'unfitness' driven by safety considerations? What procedural changes in assessment would increase crewmembers' confidence in fit-to-fly attestation? Does 'good overall health' resemble fitness-to-fly?
Cabin crew form a health perception score of a particular flight based on their perception of flight-specific risk attributes. To arrive at a decision of reporting fit or unfit to fly, this score is in turn traded-off against other flight operational attributes, such as type of layover or potential schedule disruption	Would self-reported health-related incidents provide some evidence as to the effectiveness of the scheduling tool? What motivates crewmembers to exhibit safe or unsafe behaviour?
Crewmembers often override concerns over making a poor decision with a "can do" attitude, despite the presence of ambiguous cues, goal conflicts, and uncertain outcomes by presenting for work	What can improve crewmembers' ability to judge their fitness upon reporting for work? Through which processes do cabin crew assess their fitness, report or not report for work, and consequently adopt curative and/or preventive measures?
Organisational norms, values, safety culture and punitive measures influence cabin crew's decision-making when reporting for work	What aspects of an organisational safety culture and scheduling practices could foster 'genuine' decision-making? Would supportive re-scheduling reduce triggers towards what crewmembers term "organisational punishment?"
Cabin crew largely perceive occupational hazards and associated risks to be beyond their control	Would scientific clarity over exposure to risks improve cabin crew attitudes

	towards the controllability of health and safety? What knowledge do cabin crew have about disease transmission and what is their perception of severity and risk of certain infectious diseases?
Cabin crew have poor trust in scientific evidence airlines use to address exposure to hazards and concerns about staff health	Would crew participation in research efforts improve trust issues?
The pervasive culture of fear and punishment at some airlines creates a bias against disclosing a medical issue to the organisation	At what point do attestations from general practitioners declaring a crewmember unfit to work have to be shared with the airline's medical department to get a sense of the severity of a condition? When to AMEs need to disclose the nature or intensity of a health condition?

Box 3

Fitness-to-fly self-assessment and COVID-19

By reporting for work, crewmembers declare themselves as fit-to-fly. Amid emerging public health threats, such as COVID-19, questions arise as to what extent do crewmembers consider their own risk factors in terms of early disclosure of underlying symptoms. IATA [33] has issued guidance for crew health precautions during pandemic noting that:

"Crew members must not report for training or flying duties if they:

• Are within a mandated period of isolation or quarantine related to previous travel and/or duty;

• Have tested positive for COVID-19 regardless of symptoms evident;

• Know that they have been exposed to a person having, or suspected of having, symptoms of COVID-19;

• Are experiencing symptoms of COVID-19;

• Have recovered from COVID-19 symptoms but have not been assessed by the local Health Authority or the airline's occupational health program" (page 5).

IATA [33] further cautions against additional human factor concerns throughout the COVID-19 crisis, some of which may adversely affect crewmember health and performance, as well as introduce additional safety risks. For example, ongoing fear around employment uncertainty, infection, and protection may induce increased risk-taking to protect the operation, and lead to reduced reporting of noncompliance with procedures. For cabin crew, the difficulty in self-declaration may be in distinguishing between 'compliance', meaning they perceive themselves as being able to function (albeit at the expense of their own health), and 'non-compliance' that potentially compromises flight safety or public health by not being able to foresee the consequences of their impaired state of health.

In addition, EASA [34] has advised airlines to provide operational recommendations to minimise the risk of infection of cabin crew during layovers. Airlines should further inform crewmembers that the most efficient preventive measure to limit the potential transmission of SARS-CoV-2 from contaminated surfaces is frequent handwashing [65]. In practice, this may prove challenging due to the lack of designated crew handwashing facilities [66, 67]. While crewmembers may carry their own disinfectants to ensure an additional layer of protection, the EASA has advised against the use of personal disinfectants in the aircraft cabin. Surfaces disinfected with self-provided products may cause corrosive reactions with chemicals used for general disinfection agents which can have damaging effects on the aircraft or lead to adverse health effects for passengers and crew [68]. Cabin crew must therefore rely on company enforcement and appropriate application of disinfection procedures.

For crewmembers reporting fit-for-duty, questions include whether and how IATA and EASA recommendations are communicated to cabin staff, and what monitoring systems are in place to check crewmembers' reporting behaviour. Importantly, could reporting for duty resemble a safety breach in the case of a knowingly unwell state of health? Reporting for duty behaviour may largely be based on individual perception of health and safety, which resonates that perceptions may influence reporting or not reporting for work decisions stronger that objective variables. Depending on the type and length of flight sectors, or type and length of layover, other factors may also influence the decision of reporting fit-for-duty (e.g., the quality of health services available at a layover destination). The self-declaration form developed by the Collaborative Arrangement for the Prevention and management of Public Health

Events in Civil Aviation (CAPSCA) [69], and the “I’m safe checklist” developed by the FAA for pilots [70] could be useful tools to help with self-assessment. In this way, cabin crew may become more aware of their innate capacity to report fit-to-fly, and could better recognise the importance of safety and regulatory concepts deemed important not only for their own health, put for the wider public.

4. *Public expectations of cabin crew health*

Fitness-to-fly is a conceptual construct that can also be employed in the interests of the public. Airline safety and reliability are the most important determinants in passengers’ airline choice and travel behaviour [71, 72]. Passengers are the stakeholders most concerned with the outcomes of the aviation medical assessment system; they generally trust that airlines place value on the health and safety of its workforce [73]. Health assessments must therefore exceed standard practices and move beyond mere compliance with regulations (designed to prevent failure), to a best practice approach based on trust *and* verification. For example, research could explore whether additional health screening procedures (such as testing cabin crew for COVID-19), or requirements for crew to wear masks, would make passengers feel safer.

Box 4

Public perfections of a healthy workforce amid COVID-19

One purpose of fitness-to-fly is its social value, understood as its ability to produce the conditions needed to ensure safe flight operations. The return to air travel hinges on trust, and will fall on the airlines to reassure air travellers that it is safe to fly. Although IATA recommendations bear no legal grounds for enforcement, they make a strong claim to best practice and authority relating to IATA's core principles on passenger protection [74]. Another component is feasibility: Fitness-to-fly must have a credible prospect of meeting its purpose while scientific evidence is still lacking. The historical distinction between work and non-work exposures has become less useful in understanding risks. As globalization has exacerbated poor regulatory oversight [75], airlines must re-consider their own risk assessment processes and compliance mechanisms for fitness-to-fly reporting to ensure cabin crew do not report for work unwell. With passenger confidence largely hinging on the assurance of hygienic conditions and healthy staff amid the COVID-19 pandemic [29], airlines should further monitor whether any COVID-19 control measures have introduced new problems, e.g. the use of gloves and masks when responding to an inflight medical case.

5. What is beneficial to all stakeholders?

All stakeholders want and need the cabin crew to be truly fit-to-fly. Fitness-to-fly assessment must therefore remain responsive to addressing the concerns all of stakeholders. While airlines may be primarily interested in meeting the statutory requirements of establishing a point-of-time medical clearance procedure, Griffiths and Powell [6] call for an evidence-based, international approach to fitness-to-fly concerns so that priorities and responsibilities can be set in a transparent manner, and parameters made internationally uniform. If a crewmember can be either fit or unfit-to-fly, then the identification of threats in the full operational context becomes paramount for policymaking. This requires determining effective risk mitigation processes which support the cabin workforce and passenger confidence. Examples include the increasing the evidence base on inflight transmission risks for infectious diseases [32, 76], and identification of methods for crew to validate their status upon reporting for duty. In addition, health authorities should ensure to include cabin crew in the case of disease tracing and not restrict contact tracing based on seating proximity or flight duration [77].

Box 5

What is beneficial to all stakeholders amid COVID-19

How far the ideal of fitness-to-fly standards corresponds to the practices of self-assessment during the COVID-19 pandemic remains debatable. Airlines should consider the possibility that reporting behaviours may reflect an underlying dimension of response to a work situation. Illnesses, or patterns of illnesses, are typically picked up by frequent supervisory observations or work performance checklists, providing an indication of a health issue [10]. However, these are difficult to observe in the cabin crew workforce due to frequent changes in crew formation. Ground supervisors for cabin crew typically do not see crewmembers very often, putting the bulk of responsibility on the individual to be self-critical and to manage their health well. To ensure that unfitness does not escape regulation altogether, airlines and crewmembers could further benefit from systematic response systems to address individual health issues that require monitoring. Holistic approaches that examine all potential factors that can influence cabin crew health, alongside the promotion of a non-punitive reporting culture to not sabotage their own health, will go a long way towards maintaining a healthy workforce, which can benefit all stakeholders.

AMEs vouch for a crewmember's flightworthiness [11]. Consequently, careful health assessment of cabin crew is of the same vital importance as that of pilots, and would benefit from an improved understanding of the social and legal contexts affecting cabin crew health. This would involve incorporating information related to the economic context of airline organisation; impact of health on business sustainability; the relationship between flight operations and health disparities into existing fitness-to-fly evaluations; and putting into place improved oversight frameworks for examiners to balance medical confidentiality and safety. By allowing connection of medical records to the aviation medical examination process (beyond self-reporting), privacy may have to take a backseat to safety in some cases to allow reassurance of good health.

For the public, fitness-to-fly requires demonstration rather than mere assertion. Failure to protect the public from unfit staff can entail significant liability for airlines [78]. Medical evaluation should include assessments of the safety risks associated with a crewmember reporting for duty unwell, be proportionate to the public health risk, and be reconsidered regularly as new hazards evolve. Follow-up measures such as performing cabin crew testing after an illness, or after rehabilitation measures, could act as additional layer to benefit flight safety. Significant benefits may be gained from developing perspectives on fitness-to-fly that focus not only on physical functions, but on the protection of public health.

Environmental and operational contexts attract causal factors that go beyond current knowledge. To maintain a healthy workforce, which can benefit all stakeholders, integration of up-do-date scientific evidence and continuous dialogue with all stakeholders is essential to further strengthen the aeromedical assessment system. Such research can further assist in gaining a better understanding of how passengers perceive the need for a healthy workforce.

6. Conceptual considerations

From an aeromedical perspective, it is helpful to conceptualise the potential impact of any risk associated with poor fitness that could result in the potential for harm [79]. Fitness-to-fly can be conceptualised as defining element of both professionalism and error; involving complex, layered constellations that have resulted in novel empirical processes that are productive of unfitness-to-fly. As such, fitness-to-fly appears to be a concept of faith in the individual's medical assessment, one that exists in a virtual realm, rather than an operational reality. The problem with this application is that it does not explain the purposiveness of fitness-to-fly assessment; it presupposes it. Theoretical motives behind fitness-to-fly should thus be formed by factors that pull toward potential and foreseeable events, rather than pushing from an experienced past. Such approaches move from statutory medical clearance, which carries the risk for fitness-to-fly to be perceived as symbolic attestation of a "blank cheque for a certain period's worth of good health", to an extension of assessment protocols in the form of a pre-flight fit check. The conceptual spheres for fitness-to-fly are depicted in Figure 1.

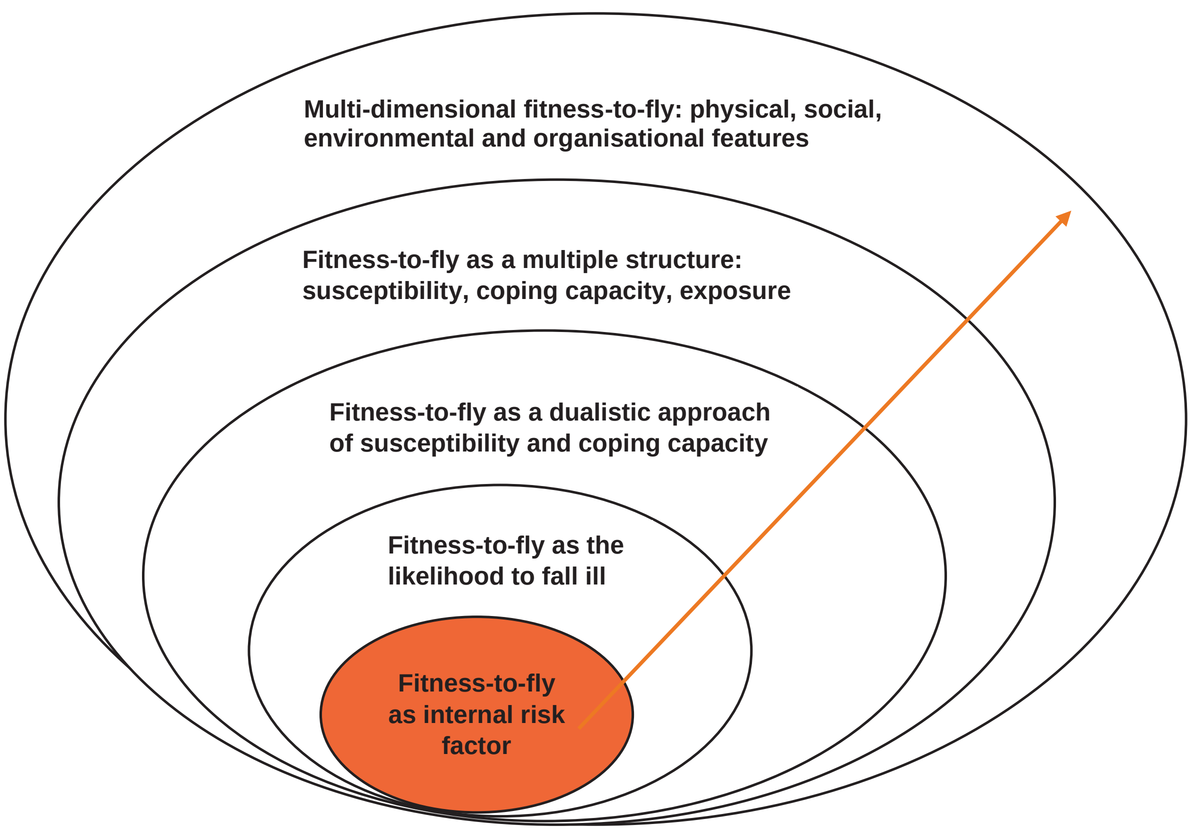

Figure 1. Key spheres of the concept of Fitness-to-fly

In addition, we suggest five thematic intersections between fitness-to-fly, occupational and public health, and flight safety:
(1) National regulation;
(2) Spaces of airline-specific regulation and assessment;
(3) Health monitoring and maintenance;
(4) Environmental factors; and
(5) Individual vulnerability and coping capacity.
To support a harmonised approach, these intersections require formal mutual acknowledgment of national regulatory bodies, airlines, and AMEs.

BOX 6

Fitness-to-fly theory in the context of COVID-19

To better understand the inherent dynamics of fitness-to-fly amid COVID-19, we distinguish basic constituents of the assessment system and the drivers of operational features, as well as occupational and environmental change. This relates to technological development that has often outpaced scientific knowledge related to the determinants of health [80], as well as the nature of the operational setting and physical condition of a crewmember that may modify susceptibility to exposures inherent to their activities [81]. While this theory may explain why the alignment of fitness-to-fly with medical standards and operational practice is not absolute, it may imply that crewmembers compensate for any fitness deficits by retreating into non-compliance spaces divorced from the safety concept. Consequently, the collective basis of fitness-to-fly and thus the capacity for operational resistance is abstracted from the employment relationship rather than being integral to its contested nature. We see the essential feature of fitness-to-fly as the notion of risk due to unforeseen events and ad-hoc changes which should incorporate more precise operationalisation of the probability of harm and better explain the relationship between fitness, illness and perception of health status. This approach does not ascribe to any belief system but offers powerful ways for self-assessment: pre-flight fit-check analysis engages the knowledge production about fitness-to-fly on which many aspects of contemporary assessment practices are predicated. Fit checks thus aim to act as vehicle for cabin crew to minimise chances of reporting for work unwell, and to give them a feeling of serenity, especially in the sphere of uncertainty. The fit check can be used to parsimoniously engage, educate and promote proactive, positive fitness-to-fly activities to cabin crew.

Conclusion

Through the COVID-19, crisis the airline industry illustrated the operational purpose for fitness-to-fly, and how changes in hazards alter the nature of risk to the cabin crew workforce and the travelling public. Significant gaps in risk assessment for known risks remain unaccounted for and the emergence of new occupational risks requires a review of risk assessment. The uncertainty created by the COVID-19 pandemic is a reminder that fitness-to-fly evaluations require an observant state of mind. To achieve a sustainable decision on fitness-to-fly is not primarily a medical responsibility, but requires globally harmonised, and mutually accepted criteria for evaluation. These criteria should be compatible with safety requirements; proportionate to the exposure to occupational hazards and risks; flexible where appropriate to allow for a specific exception; and safeguarded not to discriminate.

The analytical angle of fitness-to-fly is informed by various disciplines, rendering it valuable to scholars from medical to aviation studies, as well as to those from tourism. Exploring the operational make-up of fitness-to-fly makes an important contribution to the literature. It enlarges the remit of aviation risk management research to a more complicated field constituted not just by the most visible outcomes (i.e., incidents and accidents), but also by a host of covert health threats. Just as how safety in aviation has consolidated standards among international airlines, the arrangement of ancillary functions such as 'health safety' must likewise be recognised for its indispensable role in supporting fitness-to-fly and safety goals towards safe travel outcomes. It is by tracing these complex spaces for fitness-to-fly that the true pervasiveness of global air travel can be apprehended, along with a fuller appreciation of its impacts on populations in terms of disease transmission and spread. Delineating the pragmatics of fitness-to-fly production affords added insight into recent analyses depicting air transport as main driver in the frequency and reach of infectious disease epidemics.

Author contributions

Andrea Grout: Conceptualisation, Methodology, Literature search, Writing- Original draft preparation.
Peter A. Leggat: Writing - Reviewing and Editing

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Note: References for the following conceptual approach are at the end of the chapter

Conceptual Approach: Building a framework for the fit check

This section proposes three holistic approaches:

- *First*, theory must aspire to build new kinds of models of "emergent properties", but implicitly assume that only known kinds of risks and forces are involved;
- *Second*, research should look for ultimate explanations in quantifiable forms and structures;
- *Third*, environmental and occupational contexts attract causal factors that go beyond current knowledge. The motives behind fitness-to-fly should be formed by elements that pull toward potential events, rather than pushing from an experienced past.

This new assemblage implies that new vulnerabilities are created that need to be addressed through several assessment dimensions that are underpinned by safety considerations. To better understand the inherent dynamics of fitness-to-fly, I distinguish basic constituents of the assessment system and the drivers of operational features, as well as occupational and environmental change. This relates to technological development that has often outpaced scientific knowledge related to the determinants of health (Chan, 2018), as well as the nature of the operational setting and physical condition of a crewmember that may modify susceptibility to exposures inherent to their activities (Sweeney et al., 2020). While this theory may explain why the alignment of fitness-to-fly with medical standards and operational practice is not absolute, it may imply that crewmembers compensate for any fitness deficits by retreating into non-compliance spaces divorced from the safety concept. Consequently, the collective basis of fitness-to-fly and thus the capacity for operational resistance is abstracted from the employment relationship rather than being integral to its contested nature. This separation becomes particularly untenable in the context of intensified service pressures and pursuit of coping strategies in role conflicts.

I propose an operationalisation of fitness-to-fly which resonates that perceptions often influence reporting or not reporting-for-work decisions stronger than objective variables. I conceptualise that cabin crew form a health perception score of a particular flight based on their perception of flight-specific risk attributes and that this score in turn is traded-off against other flight operational attributes (such as type of layover or potential schedule disruption), to arrive at a pre-assessment choice of either fit or unfit-to-fly. The “fitness-to-operate” approach presupposes that the capacity for regulatory fitness-to-fly is dispersed among a variety of actors, none of which holds such a central position in the regulatory arena that it can unequivocally determine outcomes. In other words, fitness-to-fly assessment is not the product of a single regulator, but is the outcome of a process involving a multitude of regulatory actors or different sites of regulation that interact in complex ways.

I see the essential feature of fitness-to-fly as the notion of risk due to unforeseen events and ad-hoc changes which should incorporate more precise operationalisation of the probability of harm and better explain the relationship between fitness, illness and perception of health status. This approach does not ascribe to any belief system but offers powerful ways for self-assessment. Moreover, a new conceptual framework can provide a basis to determine the effectiveness of adjustments or interventions in contemporary aviation operation settings.

The framework is designed to understand and capture uncertainties. There are three important factors to consider:

1. *Dynamic exposure* is time-specific (daily, weekly, monthly, seasonal). Fitness-to-fly can be measured as exposure to hazards or as the potential basis for executing safety tasks. Consequently, there can be no single definition of fitness-to-fly without consideration of the context in which the assessment is taking place.
2. *Susceptibility* refers to risk perception and other factors that determine safety-related decisions. It is necessary to have different understandings and definitions of fitness-to-fly when dealing with different elements of risk.
3. *Coping Capacity* relates to potential compliance behaviour and capability, including factors that determine responses in emergency.

Fit check

Fit check analysis engages the knowledge production about fitness-to-fly on which many aspects of contemporary assessment practices are predicated. Pre-flight fit checks act as vehicle for cabin crew to minimise chances of reporting for work unwell, and give them a feeling of serenity, especially in the sphere of uncertainty. If a crewmember can be fit and unfit-to-fly, then the identification of threats in everyday operational context becomes paramount for policy-making. The fit check can be used to parsimoniously engage, educate and promote proactive, positive fitness-to-fly activities to cabin crew.

The conceptual variations between fitness-to-fly and the fit check as tool to determine fitness-to-operate are listed in figure 11.

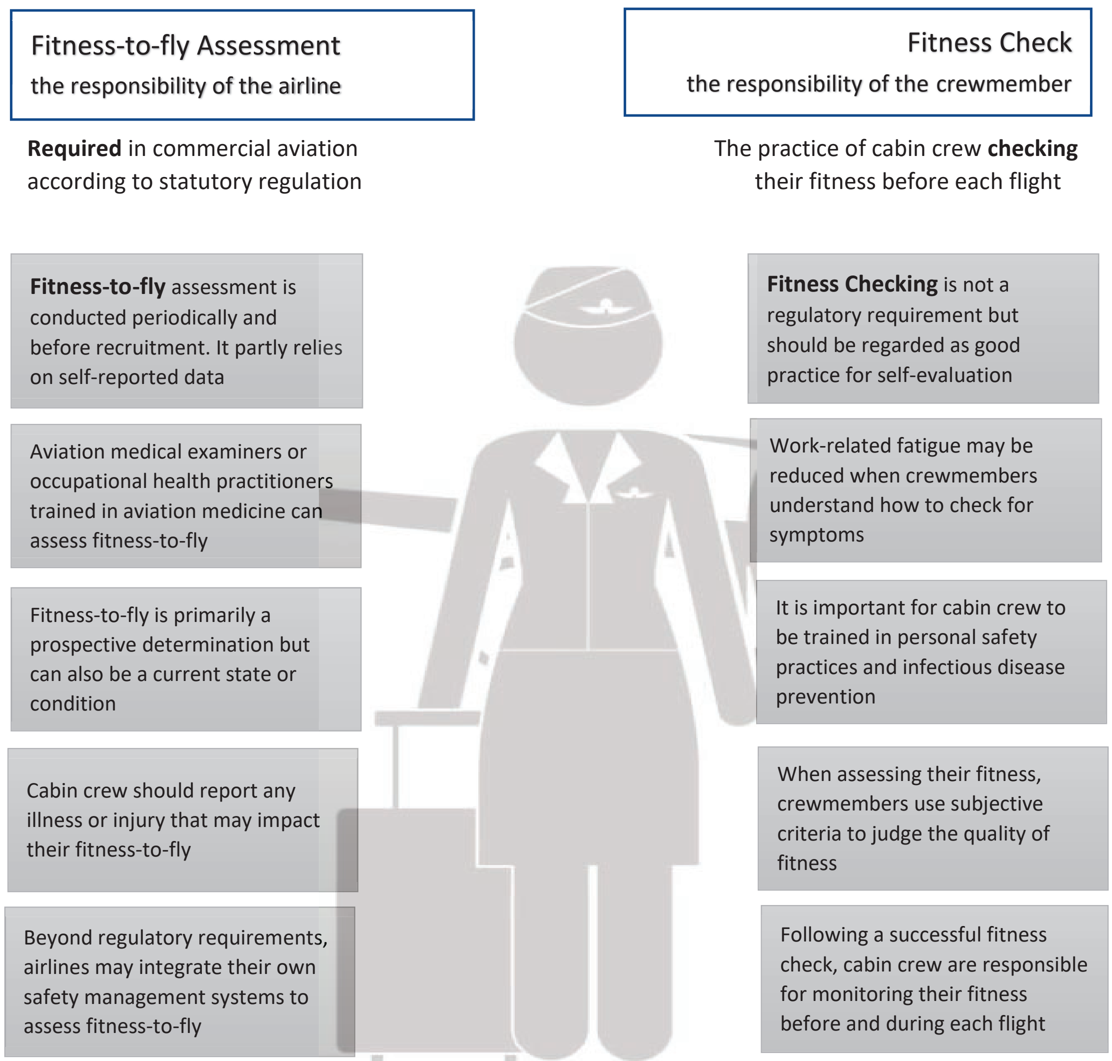

Figure 11. Conceptual framework: Differences in the conceptual approaches between fitness-to-fly and fitness-to-operate

Similar to the "IM SAFE" Checklist for pilots (Federal Aviation Administration, 2009), self-assessment should be guided by the opposite ideal, that is, to ask what constitutes “unfitness.” Any of the following factors individually or in combination, significantly degrade decision making and performance abilities:

Illness Do I have any symptoms?

For example, sinus block can damage ears and nasal passage, which could render unfit-to-fly.

Medication Have I been taking medication?

Tranquilizers, sedatives, strong pain relievers, muscle relaxants, and cough-suppressants may impair judgment, memory, alertness, and coordination.

Stress Am I under any psychological pressure

For example, money or family problems. Stress decreases alertness and interferes with judgment. Stress and fatigue can be a hazardous combination. Inflight occurrences can exacerbate stress levels.

Alcohol Have I been drinking within 8 hours? Within 24 hours?

Alcohol causes impaired judgment, increased reaction time, and increased susceptibility to hypoxia.

Fatigue Am I tired and not adequately rested?

Fatigue produces reduced alertness, coordination, and a decline in performance similar to the effects of alcohol intoxication. The level of fatigue cannot be measured. Chronic fatigue occurs from a lack of full recovery between periods of acute fatigue, and is a combination of both physiological and psychological issues. Circadian rhythm disruption induces unpredictable levels of fatigue and performance degradation, and reduced sleep efficiency.

Eating/Emotion Have I eaten enough of the proper foods to keep adequately nourished during the entire flight? Is my head in the right place?

Upsetting events (e.g., a death or break-up) can lead to risks which render cabin crew unfit for duty.

In addition to the IM SAFE template, cabin crew should further think through the questions in box 1.

Box 1

List of additional questions for self-assessment

- What are my flight-specific concerns (e.g. flight duration, intensity of service)
- What are the environmental attributes of the destination (e.g., smog, political unrest)?
- What quality of health service can I expect at the layover destination?
- When feeling unwell upon check-in, am I able to judge whether my condition is likely to worsen (during the flight or during the layover)?
- What are the health trade-offs if I report fit / unfit-to-fly?
- What are the schedule trade-offs if I report fit / unfit-to-fly?
- What is the main factor in my decision-making?
- Would I decide differently if the destination / line / layover were different?
- Would I decide differently if I was ensured that my schedule remains unchanged?

The final definition of fitness-to-operate can be described as the modifiable capacity to utilise resources and skills to flexibly adapt to challenges or changes, while enabling resilience and adaptation.

In contrast, the final overarching principles for fitness-to-fly are:

(a) fitness-to-fly is a positive term without connotations of illness implied by physiological or mental illness;

(b) fitness-to-fly could be understood by the public in a similar way to physical fitness;

(c) fitness-to-fly is a point-in time measure; and

(d) fitness-to-fly can be improved, in a similar way to physical fitness.

Building on cabin crew's needs identified in the blog analysis (chapter 3), Figure 12 illustrates the building blocks for reaching a fit-to-operate decision.

Figure 12. Fitness-to-fly as overarching regulatory tool

Conceptual contribution to knowledge

Operationalising the fitness-to-fly philosophy makes two important contributions to knowledge. First, the extended concept broadens the scope of research and analysis in regulatory fitness-to-fly assessment beyond rulemaking and command-and-control. This is a valuable contribution, as the regulatory space is not populated solely by regulators and actors. Calling attention to real pre-flight assessment opens the black box of regulation and invites investigation into what is really happening; what is involved; and why, how, and where. Above all, the extended concept is a helpful analytical tool in mapping organisational arrangements in complex domains such as flight safety regulation, and in singling out both the safety and service roles cabin crew perform and their relationships with other regulatory regimes. Accordingly, it facilitates the disaggregation of multifaceted regulatory regimes into separate regulatory items, which are manageable analytical subunits for empirical analysis.

Second, this thesis has addressed understandings about the 'production' of fitness-to-fly by re-casting flight safety as a condition that not only incorporates technical purpose, but also requires continuous medical and operational insight, as well as managerial work to (re)produce. Indeed, studies tend to treat air transport means as more or less stable configuration of linkages that ‘simply proceed on auto-pilot until disrupted’ (Birtchnell & Büscher, 2011). This obscures the fact that, even in accident-, incident-, and epidemic-free times, risk management requires intense efforts to resume. Failing to acknowledge these ever-present vulnerabilities downplays the unpredictable emergence of events. It also discounts the resiliency with which cabin crew recover themselves.

Finally, managing the twin developments of expanding air travel and good staff health through fitness-to-fly assessment is a question of internal politics. Consequently, this project advocates a greater sensitivity to the sub-determinants of fitness-to-fly assessment across its multi-layered strata, in order to more comprehensively chart its omissions and abuses.

Limitations

Whilst the arguments presented need further empirical study, this analysis suggests that the policy aims, and initiatives advanced by the fitness-to-fly framework do not eradicate the tensions and ambiguities that have long characterised the cabin crew role. Although I could make some progress by re-considering conceptual ideas, the role of theory is limited in the ensuing research. I relate to Hume (1962) who observed that there is little point in aggregating supportive evidence for a theory. Rather, and in line with de Vaus (2001), this thesis envisages the purpose of theory to try and rule out any sensible alternative explanations. Unease about the fitness-to-fly concept can further be summarised in that its limited use in an operational context is amplified by its growing use in international, regional and national law. As with other legal principles, we still need to understand its fundamental theoretical underpinnings, i.e., its origin and place in aviation occupational health and its ontology and epistemology as both a legal requirement and, more generally, as a form of innovation or new information.

Chapter summary

Theoretical motives behind fitness-to-fly should be formed by factors inclusive of potential and foreseeable events. Fitness-to-fly is the continuous process of fitness creation as flight operations engage in the evolution of individual resources, routines and capabilities in the face of enacted, far-from-equilibrium contexts. Fitness-to-fly is not a static phenomenon but undergoes constant change in response to the phenomena that it is supposed to regulate. Small changes in its definitions can greatly impact the interpretation and implications of fitness-to-fly for flight operations.

This chapter should be understood as an attempt to illuminate the productivity that is inherent in a perspective that critically challenges the current philosophy of fitness-to-fly, as it is empirically being regulated in an inseparably entwined fashion. Operationally inflected perspectives can reveal the hidden imprints of global air travel at a variety of individual health scales. If this chapter could be conceived of as a first step of putting cabin crew fitness-to-fly studies into a productive dialogue, future research projects can bring together scholars from multiple disciplines to foster a shift of perspective. Finally, to consolidate usefulness and practicality, joint publications should go beyond conceptual reflection and engage questions of fitness-to-fly, occupational health, and flight safety in an empirically informed fashion. Only through such work can the conceptual approach I have suggested be filled with meaning. This emphasis also opens a broad research agenda that includes fitness assessment in other workforces.

Recommendations and research opportunities

It is anticipated that the ideas in this chapter can stimulate research at the interface of daily operations and ad-hoc health states, and contribute to the development of an evidence-based, theoretically grounded, and operation-based approach to fitness-to-fly. In line with this conceptualisation, future research should capture airline and route attributes in terms of health and safety on a rating scale; and examine how health and safety perception is treated as an attribute and traded-off against other flight attributes to arrive at a fit or unfit-to-fly decision. I propose issues of trust and culture as the first conceptual common ground where critical health and safety studies can productively encounter each other. The interests of aviation medical assessments are currently confined to particular diseases and disabilities. I therefore suggest an experiment that would make widespread employee engagement a reality. Such a venture could be open to democratic input and crew participation, with the aim to decrease feelings of negligence and concern among cabin crew and improve organisational health and safety standards. This would involve no additional expenditure, but could have a big effect on crewmembers' involvement in innovation and science. Given the increasing demand for public health regulation amid the COVID-19 pandemic, and the potential consequences of poor health, it is crucial that research continues to develop theories and measures which capture the complexities of occupational health management as part of work roles.

Summarising the effects of poor physical and mental health on performance (and vice versa) is complicated by the wide spectrum of "poor health" which tends to be covered by different streams of research. The connection between health, safety, and error implies that all three are inextricably bound up with operational circumstances. Research approaches to safety and health must therefore address operational context in a meaningful way. This involves a certain compromise between the reliability of analysis and the richness of the resulting interpretations.

Flight safety inevitably requires the balancing of conflicting norms and ideals. Future research should establish which models of aviation organisation, training, and regulation are most effective at nudging the safety role of air cabin crew in directions that favour mutual understanding, heightened recognition, accountability, and transparency. This includes examining cabin crew motivations for reporting for work when unfit (i.e., presenteeism). Engaging methods of participation include new approaches that could stimulate crew interest in scientific thinking, and help break down the frustrating alienation many crewmembers feel from organisational decision-making. While research may be unable to confidently assess the extent to which poor fitness levels may adversely affect flight safety, longitudinal work on health effects related to occupational exposures, and perceived fitness-to-fly related to role performance, can help describe the contribution of fitness-to-fly features to flight safety and occupational health.

As COVID-19 continues to impact air travel, future analyses could provide a more complete picture by accounting for the indirect effects to the cabin crew role. Examples include how COVID-19 may have exacerbated fatigue from lockdown, and to what extent the pandemic has further challenged the notion of acceptable risk. Although beyond the focus of this thesis, the implications to employment that are tied to the transport of air passengers are vitally important. An accurate account of both the direct and indirect effects would highlight the need to better understand the dynamics of the industry to health-, and safety-related uncertainty such as the COVID-19 pandemic. Future studies could pursue these avenues to stimulate a deeper understanding of the effects of any global health disaster on the role of cabin crew.

Final observations concern the generalisability across the airline industry and more broadly to other industries with a safety-critical core. There is insufficient knowledge of the scope of occupational health, the long-term health consequences of certain workplace exposures, and the depth of an employee's embeddedness in work routines in varying airline organisations to make informed comparative judgement. This implies a need to determine the level of airline collaboration, and to overcome difficulties in accessing cabin crew as study population.

Direction of Research Questions

The following suggestions flow from the preceding comparative and historical analyses:

- What is the current understanding of effective solutions for fitness-to-fly self-assessment?
- What motivates cabin crew to report for work despite not feeling fit-to-fly?
- To what extent have training curricula been adapted to accommodate recent operational changes?
- How do the views of cabin crew regarding attitudes imparted during training indicate a close association between ability and confidence?
- How well-prepared do crews perceive themselves in infectious disease prevention and control?

• How confident do crew feel about their ability to deal effectively with infectious disease case handling?
• To what extent are possible interactive effects between pesticides, toxic fumes and other pollutants being investigated?
• What have airlines done to evaluate the responses of cabin crew to aircraft disinsection, particularly long-term exposure?
• Would longer training courses lead to increased cabin crew confidence levels?
• Would knowing that their reporting behaviour is supported by the organisation make crew feel more confident about reporting for duty fit or unfit?
• How do crewmembers deal with higher levels of fatigue during extended duty times? Do extended duty times change their work strategies?
• What evidence is available of pro-active fatigue risk assessment?

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SUMMARY

Features of the cabin role bear on crewmembers' physical and mental health in important ways. Changes in the industry, as well as environmental and operational changes, have led to increasing risks to health. In turn, these risks have created new occupational health obligations, for which risk assessment and exposure measurement remain key challenges. I have shown that the assumption that fitness-to-fly assessments are uniquely objective makes crewmembers prone to deception and self-deception. With higher odds of adverse effects on health, I illustrated how health concerns among crewmembers have intensified, thus creating a cascading effect of concern of even more exposure. In highlighting how risk perceptions are influenced by emotional responses to health risks and concerns of management collusion, the thesis reaffirms and extends existing literature on how unknown risk factors and perceived lack of control dominate a person's perception of risk. Through identifying sources and indicators of exposure to hazards, the findings support the substantial influence of risk perception on performance behaviour in cabin crew.

On a personal and social level, I have shown how fitness-to-fly is not simply an enabler, but also an outcome of the cabin crew role. Affording fitness-to-fly this dual quality promotes a more nuanced understanding of its place in flight safety, rendering it more than a functional cog of an employment prerequisite. Delving into the logistical make-up of flight safety via fitness-to-fly makes two important contributions to the literature. First, it enlarges the remit of fitness-to-fly research to a more complicated health field constituted not just by good individual health, but also by a host of factors that support public health. The concern lies specifically with the diffused ways in which hazards appear and are activated, each engendering its own risks. This project considered various risk-creating components. Linking these helps researchers extend their enquiries to a wider range of fitness-to-fly formations that precede, or even anticipate, explicit ones. It is by better tracing inflight events that the true pervasiveness of occupational risks can be apprehended, along with a fuller appreciation of their impact on public health.
Second, the project is contributing to a better understanding about the creation of fitness-to-fly by re-casting flight safety as a condition that not only incorporates

technical expertise and social purpose, but also takes continuous managerial work to (re)produce. Safety is not a configuration of relations that proceeds on ‘auto-pilot’ until disrupted. Instead, and as demonstrated in the COVID-19 pandemic, flight safety is closely related to public health and requires intense organisational efforts to resume. Failing to acknowledge the accumulation of novel exposures discounts a crewmember’s ability to build the resilience vital for recovery.

The embeddedness of the cabin crew role in the totality of a crewmember’s personal, social, and working lives, too, helps explain the safety role as rooted in the fitness-to-fly process. Here, agreement is demonstrated between the blog study in chapter 3 and data from the literature: how scientific uncertainty in workplace exposure to hazards interacts with recognition for their role and duty of care affects how these factors influence crewmembers’ discernment as part of the fitness-to-fly equation. Cabin crew cannot determine their pace of work, and they cannot adapt their work to their state of fitness. Crewmembers thus expect the organisation to be more nurturing of personal needs, including good scheduling practices as integral part of occupational health care. In the blog analysis, the most important concerns arising from an unfit state of health were related to personal implications (i.e., reprimands and schedule changes) rather than the potential health consequences of reporting for duty. These implications may negatively impact on reporting unfit-to-fly but may need to be addressed at a managerial rather than medical level.

Cabin crew and passengers share the same environment, and thus common concerns. Appreciating good fitness from a societal viewpoint as an enabler of the safety role - one that ultimately benefits public health and safety - has major implications for the understanding of flight safety in general. Although it is difficult to visualise and assess its wider impact, unfitness induced by any factor can be both an injury and an infringement on flight safety.

On a managerial level, this work contributes a clearer understanding of how airline organisations have a unique responsibility for occupational health and safety, one that involves a wider range of skills than most industries. From a cabin crew perspective, airline management has taken on an increasingly impersonal and calculative form, often neglecting their duty of care obligations to staff to effectively manage their health priorities in operational practice. To enable effective fit-to-fly management, availability of data will depend in part on the maturity of an airline's internal health reporting schemes, and developing a common strategy language that fosters a continuous dialogue with cabin crew and makes them a co-creating team.

The COVID-19 crisis has brought into focus the concerns of the cabin crew role and their fitness-to-fly that have been fermenting for nearly a decade. Here, this work highlighted the range of critical decisional factors of disease transmission and aviation, as well as broadening the occupational health scope to analyse exposure hotspots. For example, by cementing the inflight hygiene structure, COVID-19 can serve as analogue to other types of global emergencies, providing an opportunity to position the pandemic as a catalyst for changes the industry would face anyway. COVID-19 further provides a mirror for conceptualising these shortcomings.

During COVID-19 cabin crew experience illness and disease not only as symptoms, but as an occupational narrative. Online blogs continued to play an important role for cabin crew to disseminate information regarding situations, risks, and to consolidate their team spirit. The COVID-19 pandemic illustrated how crewmembers' perception of risk can be further skewed by emotions that may reflect feelings of mystery and dread provoked by newly arising hazards. In this way, the thesis highlighted how the interpretability of health risks can have important implications for effective health safety instruction.

In demonstrating how structural forces reinforce themselves, in part through failed recognition by airlines and policymakers, the thesis also raises questions as to where the public health infrastructure stands in commercial aviation. Airlines may need to critique their position within the existing structures, examining the ways practices reflect and contribute to the status quo.

That commercial aviation attained a very safe record is a tribute to the effectiveness of its techniques and the dedication of its workforce. If global air travel is growing as predicted, the projected growth must be supported by adequately fit crewmembers dedicated to performing to standards. For the air cabin crew safety role, global events will continue to command attention and require flexibility of response.