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Original article

How professional pilots perceive interactions of working conditions, rosters, stress, sleep problems, fatigue and mental health. A qualitative content analysis



Comment les pilotes professionnels perçoivent les interactions entre les conditions de travail, les emplois du temps, le stress, les problèmes de sommeil, la fatigue et la santé mentale. Une analyse de contenu qualitative

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ABSTRACT

Introduction. – So far, no qualitative content analysis (QCA) has analysed pilots' experiences and perceptions regarding weaknesses of fatigue risk management (FRM), flight time limitations (FTL), rosters, fatigue-severity, sleep problems, and how they relate to pilots' mental health and well-being.

Objective. – This research analyses pilots' described perceptions of stress, fatigue, aviation safety and how regulations like FTL can affect their health and well-being.

Method. – In total, 119 international pilots described their perceptions of FTL, rosters, aviation safety, and how they relate to fatigue and health. The QCA was conducted to analyse interactions of working conditions, stressors, fatigue, sleep problems and mental health of EASA-based and Australian pilots.

Results. – Although pilots were rostered for only 60.8% to 62.5% of the legally allowed duty and flight hours/month, 78.6% reported severe or very high fatigue, 22.8% significant depression, 12.3% significant anxiety symptoms, 10.5% reported significant depression *and* anxiety symptoms. Pilots uttered severe concerns about FTL, sleep restrictions associated with early starts, minimum rest, etc. Pilots also expressed distinct fears regarding more fatigue-related crashes, and how adverse working conditions, work-related and psychosocial stress could impair their health.

Conclusions. – This QCA provided valuable insights into interactions of working conditions, fatigue, sleep restrictions, physical and mental health. Progressive health impairment due to lack of sleep and accumulated fatigue promote burnout, mental and physical health problems, which not only threaten flight safety, but also sustainability of aviation.

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R É S U M É

Jusqu'à présent, aucune analyse qualitative de contenu (QCA) n'a analysé les expériences et les perceptions des pilotes concernant les faiblesses de la gestion des risques de fatigue (FRM), les limitations de temps de vol (FTL), les tableaux de service, la gravité de la fatigue, les problèmes de sommeil et leur lien avec la santé mentale et le bien-être des pilotes. Cette recherche analyse les perceptions décrites par les pilotes concernant le stress, la fatigue, la sécurité aérienne et comment des réglementations telles que les limitations de temps de vol (FTL) peuvent affecter leur santé mentale et leur bien-être. Au total, 119 pilotes internationaux ont décrit leurs perceptions du FTL, des tableaux de service, de la sécurité aérienne et de leur lien avec la fatigue et la santé. Le QCA a été réalisé pour analyser les interactions entre les conditions de travail, les facteurs de stress, la fatigue, les problèmes de sommeil et la santé mentale des pilotes basés

Keywords :

Professional pilots
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 Mental health
 Well-being

Mots clés :

Pilotes professionnels
 Stress

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psychosocial
Problèmes de sommeil
Fatigue
Santé mentale
Bien-être

à l'Agence européenne de la sécurité aérienne et des pilotes australiens. Bien que les pilotes n'aient été inscrits que pour 60,8 % à 62,5 % des heures de service et de vol légalement autorisées par mois, 78,6 % ont signalé une fatigue grave ou élevée, 22,8 % une dépression importante, 12,3 % des symptômes d'anxiété importants, 10,5 % ont signalé des symptômes de dépression et d'anxiété importants. Les pilotes ont exprimé de graves inquiétudes concernant le FTL, les restrictions de sommeil associées aux démarrages précoces, le repos minimum, etc. Les pilotes ont également exprimé des craintes distinctes concernant davantage d'accidents liés à la fatigue et la façon dont les conditions de travail, le stress lié au travail et le stress psychosocial pourraient nuire à leur santé. Cette QCA a fourni des informations précieuses sur les interactions entre les conditions de travail, la fatigue, les restrictions de sommeil, la santé physique et mentale. Les problèmes de santé progressifs dus au manque de sommeil et à la fatigue accumulée favorisent l'épuisement professionnel, les problèmes de santé mentale et physique, qui menacent non seulement la sécurité des vols, mais aussi la durabilité de l'aviation.

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Abbreviations

| | |
|----------|--|
| FTL | flight time limitations |
| FRM | fatigue risk management |
| CMD | common mental disorders |
| EASA | European Aviation Safety Agency |
| CASA | Civil Aviation Safety Authority |
| FAA | Federal Aviation Administration |
| ICAO | International Civil Aviation Authority |
| Part-MED | Medical Requirements for Aircrew |

1. Introduction

Pilots spend most of their work time at an altitude of several kilometers above ground (Venus & grosse Holtforth, 2021b, 2022a, 2022b), with an outside temperature of around minus 60 degrees Celsius, where there is not enough oxygen to survive. In this hostile environment, commercial pilots manage complex, cutting-edge avionics and flight management systems to fly their passengers safely and on time to their destinations. Flying has become very safe, but system failures like the Lion Air (KNKT, 2019) and Ethiopian Airlines (2020) crashes of the newly released Boeing 737 Max or the Air France crash (BEA, 2016) still happen. Fatigue has become a threat to flight safety and pilots' performance (Bandeira et al., 2018; Bourgeois-Bougrine, 2020; Coombes et al., 2020; Goode, 2003; Hartzler, 2014). While pilots reported only an average of 45.7 flight hours per month in the 1980s (Sloan & Cooper, 1986), current flight time limitations (FTL, Table 1) allow up to 100 flight hours per month (CASA FTL, 2013; EASA FTL, 2014). According to aircraft accident reports, severe fatigue and excessive duty and flight hours have led to several crashes and serious incidents such as China-Airlines 006 (NTSB, 1987), Korean-Air 801 (NTSB, 2000), American-Airlines 1420 (NTSB, 2001), TransAsia crashes (ASC, 2015, 2016), while fatigue and precarious working conditions contributed to the Colgan-Air 3407 crash (NTSB, 2010). These accidents or incidents resulted in 380 fatalities; 170 people were injured. Fatigue has become a significant threat to flight safety (Aljurf et al., 2018; Bandeira et al., 2018; Bendak and Rashid, 2020; Bourgeois-Bougrine, 2020; Goode, 2003; Reis et al., 2013; Williamson & Friswell, 2017). Pilots' mental health received more attention after the Germanwings crash (BEA, 2016), although estimated seventeen commercial aviation accidents and incidents, in which mental health problems or negative life events played a substantial role, caused 576 fatalities (Mulder & de Rooy, 2018). In this paper, we typically refer to *professional pilots*, in contrast to private or glider pilots. In line with Shahid et al. (2010) we differ between *fatigue-severity* and *alertness/sleepiness*.

The International Civil Aviation Organization (ICAO, 2015a) defines fatigue as "A physiological state of reduced mental or physical performance capability resulting from sleep loss, extended wakefulness, circadian phase, and/or workload (mental and/or physical activity) that can impair a person's alertness and ability to adequately perform safety-related operational duties." We typically refer to the definition of fatigue of the International Classification of Diseases (ICD-11), which matches 'accumulated fatigue' (ICAO, 2015b) and emphasizes Fatigue (MG22) as "Feeling of exhaustion, lethargy, or decreased energy, usually experienced as a weakening or depletion of one's physical or mental resource and characterized by a decreased capacity for work and reduced efficiency in responding to stimuli. Fatigue is normal following a period of exertion, mental or physical."

1.1. Stress, high fatigue among pilots, and safety relevant fatigue consequences

Recent research reported high levels of fatigue for 68.5% to 93% pilots (Aljurf et al., 2018; Bourgeois-Bougrine et al., 2003; Reis et al., 2013, 2016b; Venus & grosse Holtforth, 2021b, 2021a; Williamson & Friswell, 2017). Clinically relevant sleep problems were reported by 24% to 34% pilots (Aljurf et al., 2018; Reis et al., 2013, 2016a; Venus & grosse Holtforth, 2021a). For short haul pilots, restricted rest periods, long, irregular shifts with multiple sectors (Jackson & Earl, 2006; Roach et al., 2012; Vejvoda et al., 2014; Venus & grosse Holtforth, 2021b), for long haul pilots circadian disruptions, inconsistent roster patterns on trans-meridian long haul flights and many night flights (Bendak & Rashid, 2020; Bourgeois-Bougrine et al., 2003; Gander et al., 2015; Reis et al., 2016a; Venus & grosse Holtforth, 2021b) contributed to high levels of fatigue. Insufficient rest on board and minimum legal rest on ground (CASA FTL, 2013; EASA FTL, 2014) can also increase problematic fatigue (Venus & grosse Holtforth, 2021b; Williamson & Friswell, 2017). Safety relevant micro-sleeps in the cockpit were reported by 45% to 76% of the investigated pilots (Aljurf et al., 2018; Venus & grosse Holtforth, 2021a; Williamson & Friswell, 2017). Two of three pilots reported fatigue-related errors, 20% had fallen asleep on the flight-deck without prior coordination (Williamson & Friswell, 2017).

Fatigue Risk Management (FRM) should prevent fatigue and is mandatory in Australia (CASA FTL, 2013) and in EASA member states (EASA FTL, 2014), when operators want to deviate from FTL because of operational or economic reasons. Air operators must prove, that their rosters are safe and prevent fatigue, even though they infringe on the legal FTL. Looking at the high prevalence of severe and very high fatigue among pilots, FTL and FRM seem less successful than expected (Aljurf et al., 2018; Bendak & Rashid, 2020; Bourgeois-Bougrine, 2020; Reis et al., 2016b; Venus & grosse Holtforth, 2021a). Neither high on-duty sleepiness nor

Table 1

Overview over the most basic FTL rules of EASA and CASA, relevant for the investigated EASA-based and Australian pilots. These FTL were in effect at the time of data collection for this research from June 2018 until March 2019 (Venus & grosse Holtforth, 2021a, p. 33).

| | Flight time limitations in effect until March 2019 | | |
|---|--|---|--|
| | EASA FTL: ORO.FTL.210 | CASA FTL 48.1 | FAA Part 121 |
| Duty period or duty hours ^a /pilot (multi pilot operation) | | | |
| Max. duty hours | 13 duty hours | 14 duty hours | 14 duty hours |
| Max. duty hours/month | 190 duty hours | 200 duty hours | |
| Commander's discretion (extension of max. duty hours) | Max. 13 duty hours Plus max. 2 duty hours | Max. 14 duty hours Plus max. 1 duty hour | Max. 14 duty hours Plus max. 2 duty hours |
| Augmented crews ^b | | | |
| Depending on time of day | FDP > 9 to 13 duty hours | FDP > 8 to 14 duty hours | FDP > 9 to 14 duty hours |
| Flight hours ^c /pilot (multi pilot operation) | | | |
| In any 28 consecutive days | 100 flight hours | 100 flight hours | 100 flight hours |
| In any calendar year | 900 flight hours | | 1000 flight hours |
| In any 12 consecutive months | 1000 flight hours | 1000 flight hours | |
| Minimum rest ^d | | | |
| Before flight duty | 10 hours (exceptions) | 10 hours (exceptions) | 10 hours |

All definitions from EASA FTL (2014, p. 21–22).

FDP: flight duty period.

^a "Duty period" [duty hours] means a period which starts when a crew member is required by an operator to report for or to commence a duty and ends when that person is free of all duties, including post-flight duty.

^b "Augmented flight crew" means a flight crew which comprises more than the minimum number required to operate the aircraft, allowing each flight crew member to leave the assigned post, for the purpose of in-flight rest, and to be replaced by another appropriately qualified flight crew member.

^c "Flight time" [flight hours] means the time between an aircraft first moving from its parking place for the purpose of taking off until it comes to rest on the designated parking position and all engines or propellers are shut down.

^d "Rest period" means a continuous, uninterrupted and defined period of time, following duty or prior to duty, during which a crew member is free of all duties, standby and reserve.

severe accumulated fatigue should occur and be reported by pilots. Fatigue reports were originally introduced to give pilots the opportunity to report extremely fatiguing flight duties or flight pairings. However, pilots reported that they had stopped filing fatigue reports, because these reports often led to inquisitions of their private life and sleeping habits, instead of improving flight duties or route pairings, which were frequently reported to be extremely fatiguing (Bourgeois-Bougrine, 2020; Venus, 2020). In addition to that, fatigue reports represent a high effort, with little perceived improvement afterwards, so that there was no incentive to pilots to report fatigue (Bourgeois-Bougrine, 2020; Venus, 2020).

Looking at the imminent risks of working most of the time in a hostile environment, several kilometers above ground, and the pilots' responsibility for the safety of all persons on board, high fatigue in the cockpit is a considerable threat to passengers' and aircrews' safety (Bandeira et al., 2018; Bourgeois-Bougrine, 2020; Goode, 2003; Hartzler, 2014; Venus & grosse Holtforth, 2021b, 2022a, 2022b). Errors, mistakes, and loss of situation awareness can immediately become fatal in all phases of flight: during take-off, cruise, diversion, approach, and landing. Therefore, pilots should be well rested and less fatigued than the general population (Lerdal et al., 2005) or patients with chronic diseases (Valko et al., 2008), but recent research suggests otherwise (Aljurf et al., 2018; Reis et al., 2013, 2016b, 2016a; Venus & grosse Holtforth, 2021b, 2022a, 2022b).

1.2. Germanwings crash & pilot mental health

The Germanwings crash (BEA, 2016) moved pilots' mental health into the focus of the public's, operators' and regulators' attention, while pilots' mental health was a scarce research topic before (Sloan & Cooper, 1986; Widyahening, 2007). Fatigue and psychosocial stress were associated with mental health issues of airline pilots (Sloan & Cooper, 1986). High levels of work-related stress were associated with higher risks of mental or emotional disturbances of pilots, while mental or emotional upset was reported by 39.4% active pilots (Widyahening, 2007). Latest research

suggests that work-related and job imminent stressors can significantly impair pilots' mental health and well-being (Cahill, Cullen, Anwer, Wilson, & Gaynor, 2021; Cullen, Cahill, & Gaynor, 2020; Venus & grosse Holtforth, 2022a,b). Pilots' fatigue and sleep problems are often associated with depression-symptoms, impaired mood and anxiety (Aljurf et al., 2018; O'Hagan et al., 2017, 2019; Wu et al., 2016) or burnout (Demerouti et al., 2019; Fanjoy et al., 2010). The majority of pilots reported 'Inappropriate' or 'Sickness' Presenteeism, i.e., going on flight duty instead of taking sick, or fatigue leave (Johansson & Melin, 2018). Heavy workload was significantly associated with more common mental disorders of active pilots (Feijo et al., 2012), positive depression screening results were reported by 12.6% (Wu et al., 2016), 16% (Cahill et al., 2021), 19% (Venus & grosse Holtforth, 2022b,b), up to 34.5% of the investigated pilots (Aljurf et al., 2018). Significant anxiety symptoms were reported by 8% to 40.2% of the investigated active pilots (Aljurf et al., 2018; Venus & grosse Holtforth, 2021b), while severely fatigued pilots reported even more mental health issues (Aljurf et al., 2018).

1.3. 'Pilot pushing' & burnout

Long flight and duty hours, more responsibilities (e.g. fuel saving, commander's discretion), more time pressure, etc. are often associated with more stress, higher fatigue and burnout of pilots (Demerouti et al., 2019; Fanjoy et al., 2010), which can impair flight safety and safety culture (Bendak & Rashid, 2020; Bourgeois-Bougrine, 2020; Part-MED, 2019). Nevertheless, the 'Chicago-Convention' (written in 1944) still defines the universal personal responsibility of the pilot in command for every aspect of flight safety on every flight (ICAO, 2012, 2018). E.g., the commander of the aircraft must decide, if the flight duty may be extended beyond the maximum 13 or 14 hours per FDP, when delays due to heavy traffic, long holding phases or diversions due to adverse weather conditions, etc. make it impossible to finish a flight duty as planned ("Commander's Discretion" according to regulations like EASA FTL, 2014). Even though harsh competition and economic pressure have led to more duty and flight hours, fewer rest days

and shorter minimum rest, the commander is still responsible for all aspects of flight safety for all persons on board. Fanjoy et al. (2010) described the term 'Pilot Pushing' as implicit air operator management's pressure to fly as many sectors as possible despite threatening weather conditions, high fatigue in the cockpit or technical issues with the aircraft. The air law framework of the Chicago Convention from 1944 regulates the operation of aircrafts, and is still valid according to Annex 6 (ICAO, 2018). Today's high quantitative work demands in terms of longer flight duties and shorter rest, the universal responsibility for flight safety, etc. were described as important prerequisites for the development of burnout (Demerouti et al., 2019; Fanjoy et al., 2010).

1.4. Research questions

We expected pilots to write about their most important fears and concerns regarding fatigue, FTL and flight safety in the open question. To better understand and interpret the quantitative results of the cross-sectional online survey (Venus, 2020; Venus & grosse Holtforth, 2021a,b,2022a,b), we used pilots' first hand experiences and explanations and conducted an explorative Qualitative Content Analysis (QCA) according to Mayring (2014). Our first research question was: *Which perceptions and experiences were described most often in the open question at the end of the online survey? Higher frequencies of codings imply higher importance of codes, subcategories, and categories.*

Regulators are responsible for the elaboration and execution of aviation safety related regulations. The European Aviation Safety Agency (EASA) does not allow fatigued pilots to go on flight duty (Commission Regulation (EU) 2018/1042): "[...] crew members are not to carry out duties on an aircraft when under the influence of psychoactive substances or when unfit due to injury, fatigue, medication, sickness or other similar causes." In contrast to this, CASA's fatigue specialist refers to Lerdal et al. (2005) and the fatigue-levels of the general population for professional pilots in an email communication. Previous research showed, that most professional pilots were severely fatigued (Aljurf et al., 2018; Reis et al., 2013, 2016b; Venus & grosse Holtforth, 2021a, 2021b). More pilots compared with the general population reported significant symptoms of depression and anxiety (Aljurf et al., 2018; Cahill et al., 2021; Venus & grosse Holtforth, 2021b; Wu et al., 2016). Differences between EASA's (EASA FTL, 2014) and the Australian Civil Aviation Authority's (CASA) (CASA FTL, 2013) could result in different rosters and could affect pilots' answers. So, we set out to test the following hypothesis: *Do EASA-based pilots address different experiences, perceptions, or contexts, compared with Australian pilots?*

To recognize pilots' efforts to write about their personal experiences and perceptions, we decided to go beyond the formal results of the QCA and cited authentic examples of pilots' texts, to illustrate the content of the categories or codings. Some whole statements are presented as verbatim quotes, they show the full authentic text. We added positive screening scores for fatigue, sleep problems, mental health and well-being for the pilot, whose statement is presented in full. Thus, important context and content of pilots' original texts were preserved. Additionally, we present tables with the most relevant codings in pilots' authentic words, which could deliver important input for fatigue research, FRM and FTL development. We corrected a few simple misspellings or punctuation marks to improve readability. If an answer contained two or more identical codings, they were displayed in one cell (Tables 4–19).

A summary of the most important quantitative results of the 119 pilots analysed with QCA and the whole sample of 406 international pilots are presented as introduction of the results part.

2. Method

2.1. Procedure

For this research ethical approval No. 2018 05 00008 was granted by the Ethics Commission of the Philosophisch Humanwissenschaftlichen Fakultät of the University of Bern, Switzerland. Written informed consent was not required, because we guaranteed and protected confidentiality of the data collected with the anonymous online survey. Pilots did not receive any compensation for their participation. This research analysed the open answers of professional pilots, who had completed a comprehensive cross-sectional online survey. The same online survey collected comparable data of professional pilots based in EASA member states and Australia with different FTL (CASA FTL, 2013; EASA FTL, 2014) and regulations. In phase one EASA-based pilots completed the online survey during peak flight season from June to October 2018. In phase two, Australian pilots completed the survey from December 2018 to March 2019, also during their peak flight season. We wanted to see, how operators apply FTL and if they roster their pilots for the maximum legal duty and flight hours. This would show, how operators use FTL to eventually maximize productivity. The inclusion criterion was being a professional pilot flying for a commercial air operator in the last year. The online survey was programmed with Lime Survey®. Australian and European pilot unions emailed the link to the online survey to their members included in newsletters.

2.2. Participants

Pilots were asked to complete the survey on a rest day, 192 EASA-based and 180 Australian pilots completed the online-survey within $M = 38 \pm 18$ minutes ($M \pm SD$). The last open question was answered by 119 pilots, of whom 56.3% were commanders, 43.7% were first officers. Type of operator/employer was similar to the total sample (Venus & grosse Holtforth, 2021a): most of the participating pilots were flying for network-carriers (53.8%), 31.1% for low-cost-carriers (LCC), 10.1% for charter- and 5% for cargo-operators. 15.9% of the pilots reported flying only short haul (sectors < 2 hours), 59.7% short- and medium-haul (sectors < 6 hours), 11.8% medium- and long-haul and 12.6% only long-haul (> 6 hours/sector).

2.3. Description of the cross-sectional online survey

Pilots reported their age, gender and other sociodemographic data. The online survey was based on previous research (Aljurf et al., 2018; O'Hagan et al., 2017; Williamson & Friswell, 2017; Wu et al., 2016) to obtain comparable data. Pilots' fatigue was self-assessed with the nine items Fatigue Severity Scale (Krupp et al., 1989), scale means, standard deviations (SD), Cronbach's Alpha for internal consistency/reliability in this and in previous research for all used standard questionnaires are displayed in Table 2. Common mental disorders (CMD) were assessed with the Self Reporting Questionnaire (SRQ20) (Beusenbergh et al., 1994; Feijo et al., 2012). The Patient Health Questionnaire 8 (PHQ8) was used for self-assessment of depression symptoms. The Generalized Anxiety Disorder 7 questionnaire (GAD7) assessed symptoms of anxiety. To measure psychosocial stress, the respective items of the Brief Patient Health Questionnaire (PHQ, Table 2) were used (Spitzer & Williams, 2005; Venus & grosse Holtforth, 2021b). Sleep problems were self-assessed with the Jenkins Sleep Scale (JSS) (Jenkins et al., 1988). Pilots' well-being was assessed with the Well-being Index 5 (WHO5, Krieger et al., 2014; Winther Topp et al., 2015). All items are cited in Venus & grosse Holtforth (2021b). To identify positive screening results, the published cut-off values

Table 2

Scale means (M), standard deviations (SD), published cut-off-values, Cronbach's Alpha for reliability/internal consistency in this research and in previous studies (Venus & grosse Holtforth, 2021b).

| Scale | Cut-off | Mean | SD | Cronbach's alpha | Cronbach's Alpha (previous research) |
|-------------------------------------|-------------------|-------|-------------|------------------|--|
| Well-being WHO5 | $\leq 50 \leq 28$ | 52.10 | ± 21.54 | 0.89 | 0.83 to 0.95 (Krieger et al., 2014), cut-off (Winther Topp et al., 2015) |
| Common mental disorders (CMD) SRQ20 | ≥ 8 | 4.61 | ± 4.62 | 0.087 | 0.81 (Beusenbergh et al., 1994), cut-off (Feijo et al., 2012) |
| Depression-screening (PHQ8) | ≥ 10 | 6.47 | ± 4.97 | 0.90 | 0.82 (Pressler et al., 2011), cut-off (Kroenke et al., 2009) |
| Anxiety screening (GAD7) | ≥ 10 | 4.45 | ± 4.17 | 0.90 | 0.92 (Spitzer et al., 2006) |
| Fatigue Severity Scale (FSS) | $\geq 4 \geq 5$ | 4.57 | ± 0.10 | 0.82 | 0.89 (Löwe et al., 2008) |
| Jenkins Sleep Scale (JSS) | ≥ 3 | 2.19 | ± 1.24 | 0.85 | 0.93 (Valko et al., 2008) |
| Psychosocial stress (PHQ-Stress) | | 5.29 | ± 3.72 | 0.81 | 0.88 (Lerdal et al., 2005) 0.84 (Reis, 2014) |

were used (Aljurf et al., 2018; Kroenke et al., 2009; Lerdal et al., 2005; Reis et al., 2016b; Spitzer et al., 2006; Winther Topp et al., 2015).

The last question was open, "Is there anything you would like to tell us?" We consider professional pilots as experts for flight safety and rely on their expertise, when they describe their experiences and perceptions, as written down in the open question. We used the technique 'Qualitative Content Analysis' (QCA) developed by Mayring (2014) to better understand described associations between working conditions, rosters, stress, sleep problems, fatigue and (mental) health.

2.4. Qualitative content analysis (QCA) by Mayring (2014)

2.4.1. QCA: process description and data evaluation

The Qualitative Content Analysis was conducted with the program MAXQDA (VERBI Software, 2019). Our written, qualitative data was processed, coded, organized, visualized, and analysed with MAXQDA. The pilots' 119 anonymized open answers were imported into MAXQDA, each answer was saved as a single document including the most important personal variables gender, age, and regulator (pilots subject to EASA vs. CASA regulations).

The individual text components are called *coding*. In a bottom-up-process these codings were assigned to the best fitting codes, which then were divided/assigned into two levels of subcategories and the main categories at the top level. A pilot's original answer looked like this.

"I often find fatigue a taboo topic. There is pressure to not call in fatigued prior to a duty and often the company will ask you to come to work and 'see how you feel' (no personal experience but have heard of this happening). They do this in the hope that the person will be guilted into working. Also, if you call in unfit for duty due to fatigue before work it is marked as a 'sick' day not a fatigue day. It is not really recognized unless you are at work. I feel like there is no support if you were to call in fatigued and that management will most likely call you to 'investigate' but I fear a focus on my personal life will be the center on attention not the fact that I've worked 13 of the last 12 days rostered. Honestly it is easier to call in sick than it is to call in fatigued because nobody asks any questions. It's simply let us know when you can come back to work."

We used the Qualitative Content Analysis (QCA) according to Mayring (2014) as theoretical foundation. QCA allows the interpretation of material within its context, in a systematic, rule-bound procedure, focusing on categories, also integrating quantitative steps. Frequency analyses were conducted, to find the most important codes and categories for the whole sample and the groups of EASA-based vs. Australian pilots.

Mayring (2014) developed a general procedural model for QCA (Fig. 1), our Coding Guidelines are displayed in Appendix 1. More details about the conduction of the QCA, on which this paper is based, are described in the respective master thesis of Danja Greder (Greder, 2020). The first author's expertise as certified clinical and work psychologist, occupational health, and safety manager, with sound aviation expertise as pilot, supported the development of the coding and category system. Following Mayring (2014), we used context and surrounding clauses to correctly allocate codes.

An experienced Australian pilot reviewed the category system and applied minor modifications. The final category system was complemented with definitions and anchor examples (Appendix 2). Finally, 526 codings were assigned to eight main categories with 36 subcategories on the first and 35 subcategories on the second level. The reliability of the final version of the category system was tested by measuring the Inter-Coder Reliability (Table 3). Frequencies of all 79 categories were listed in Appendix 3.

2.4.2. Inter-coder and intra-coder reliability of QCA

The Inter-Coder Reliability was calculated with MAXQDA, based on a minimum code overlapping rate of 95% at the segment level. The indicator of the Inter-Coder reliability used by the program was Kappa according to Brennan and Prediger (1981), and interpreted values according to the evaluation criteria of Landis and Koch (1977). Within QCA, reliability means Intra-Coder agreement or stability (Mayring, 2014), comparable with Retest Reliability (Table 3). Total Inter-Coder reliability (0.78) was high (Landis & Koch, 1977) and almost perfect for the categories C1 Working Conditions, C4 Stress, C6 Sleep and C8 Organizational Issues (Landis & Koch, 1977), high for the categories C3 Roster and C5 Safety Culture, and still moderate for the categories C2 Fatigue and C7 Regulator.

Intra-Coder reliability for the categories C2 Fatigue, C4 Stress, C5 Safety Culture, C6 Sleep and C8 Organizational Issues and the total Intra-Coder Reliability were almost perfect (Landis & Koch, 1977), high for the categories C1 Working Conditions and C3 Roster, and low for only C7 Regulator, an universally underlying factor regarding regulations and their execution.

3. Results

3.1. Summary of the quantitative results

3.1.1. Sample of the international pilots analysed in this QCA

The pilots analysed in this QCA ($n = 119$) were rostered for on average 62.5 ± 20.4 flight hours/month and 115.2 ± 37.9 duty hours/month ($M \pm SD$). Although pilots were on average rostered for only 60.8% to 62.5% of the legally allowed maximum duty and flight hours/month, 34.8% pilots reported very high fatigue ($FSS \geq 5$), additional 43.8% severe fatigue ($FSS 4-4.9$). Considerable

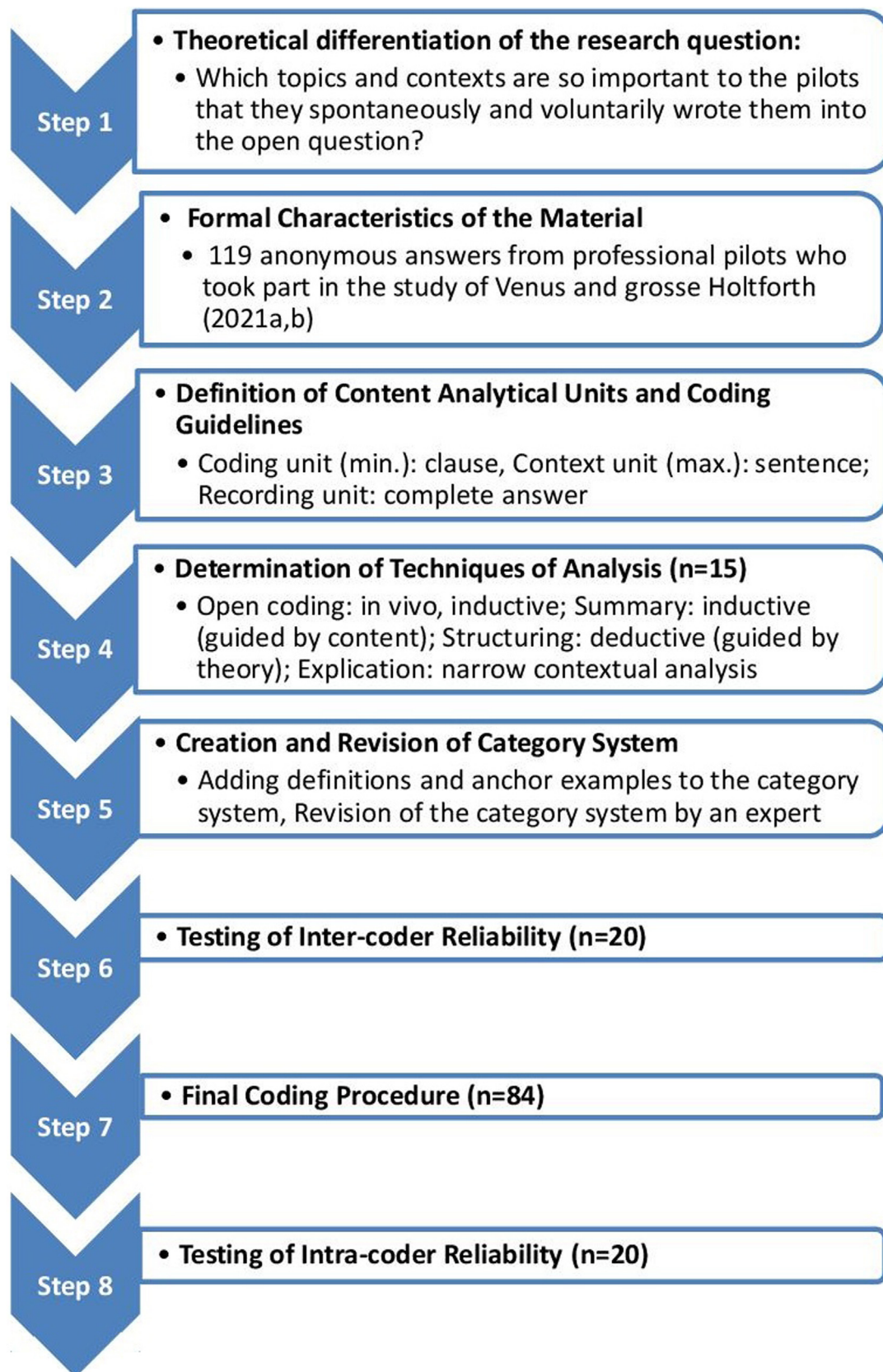


Fig. 1. Adapted procedural model of the qualitative content analysis. Theoretical foundation, basic procedures and software solution (Mayring, 2014, p. 54).

Table 3
Inter- and intra-coder reliability coefficients Kappa (Brennan & Prediger, 1981).

| Category | Inter-coder reliability | Intra-coder reliability |
|--------------------------|-------------------------|-------------------------|
| C1 Working conditions | .91 | .67 |
| C2 Fatigue | .52 | .88 |
| C3 Roster | .68 | .75 |
| C4 Stress | .89 | 1.00 |
| C5 Safety culture | .73 | 1.00 |
| C6 Sleep | 1.00 | .90 |
| C7 Regulator | .59 | .33 |
| C8 Organizational issues | 1.00 | 1.00 |
| Total | .78 | .86 |

sleep problems in 15 or more nights/month were reported by 11.4% pilots. Positive depression and anxiety screening results were reported by 22.8% and 12.3% pilots respectively, 10.5% reported significant depression and anxiety symptoms. 25.9% pilots reported eight or more symptoms of common mental disorders (SRQ20 \geq 8), 17.7% pilots reported severely impaired well-being (WHO5 \leq 28), 23% impaired well-being (WHO5 29 to 50).

3.1.2. Results of the pilots, who completed the online survey

Severe fatigue (FSS 4–4.9) was reported by 42.6% pilots, high fatigue (FSS \geq 5) by 33.4%, although pilots were on average scheduled for 51% to 65% of the legally allowed duty and flight hours/month (Venus & grosse Holtforth, 2021a). Intercorrelations between psychosocial stress, fatigue, sleep problems and mental health dimensions were highly significant (Venus & grosse Holtforth, 2022b). Pilots reported feeling on average equally good or better than 54% of the general population, 26.3% reported WHO5 scores 29–50, 12.4% WHO5 \leq 28. Overall, 20% pilots reported positive depression or anxiety screenings, 7.23% reported GAD7 and PHQ8 \geq 10 (Venus & grosse Holtforth, 2021b). When the PHQ8 Algorithm (Kroenke et al., 2009) was used, 7.9% pilots reported suspected major depression, additional 7.9% pilots other depressive disorders, which should be confirmed or rejected diagnostically. In the whole pilot sample ($n = 406$), slightly fewer pilots reported severe or high fatigue or mental health issues than the 119 pilots analysed in the QCA.

3.2. Frequency analysis

The frequency table (Appendix 3) shows that the main category C1 Working Conditions received the most codings, C2 Fatigue was second, followed by C3 Roster, C4 Stress and C8 Organizational Issues. In the main category C1 Working Conditions the most frequently used subcategory was C1.2 Flight Time Limitations (FTL), the most frequent second level subcategory was C1.2.2 Dysfunctional. Other frequently chosen second level subcategories were C2.1 Fatigue Risk Management (FRM), C3.2 Type of Roster as a Challenge, C3.4 Pushing the Limits and C9.2 Feedback regarding the C9.2.2 Questionnaire. The minimum and maximum frequencies in Appendix 3 show that some participants had used certain codes up to ten times in one answer. The main category C1 Working Conditions was mentioned by 54 pilots, the second level subcategory C1.2 Flight Time Limitations (FTL) was mentioned by 32 pilots.

The main category C2 Fatigue showed the widest range between minimum (0) and maximum (10) codings in this category. The widest range in a second level subcategory was C2.1 Fatigue Risk Management (FRM) (0–10) in the main category C2 Fatigue. All the other second level subcategories were used minimum 0 and maximum five times. The other often mentioned main categories were C2 Fatigue ($n = 47$), C3 Roster ($n = 45$) and C8 Organizational Issues ($n = 43$). Regarding second level subcategories, C3.2 Type of Roster as Challenge was mentioned by 28 pilots, right behind C1.2 FTL (Appendix 3).

In the following part the most important codes and codings are displayed in the tables 4 to 19, to illustrate the formal results.

3.3. Content of the most relevant codings

3.3.1. Most frequently used main category C1 working conditions

3.3.1.1. Employer, FTL, health issues.

The main category C1 Working Conditions pertained to subcategories like employer, FTL and type of operations. The subcategory employer included e.g., 'roster requests', 'profit over safety'. In the subcategory FTL, many pilots uttered severe concerns. The FTL subcategories were labelled 'dysfunctional' (Table 4), 'no monitoring or penalty', 'diffusion of responsibility', 'not considering private life'. The FTL of EASA and CASA seem to greatly benefit the aviation industry, but also contribute to pilots' stress, sleep problems, fatigue, and mental health issues.

Several pilots commented that regulators failed to monitor operators regarding FTL, and that they did not see any punishment for operators who did not adhere to FTL and regulations. Some pilots also commented, that the present FTL did not consider pilots' life outside their jobs and irregular shifts (Table 5).

3.3.1.2. Economic competition, rosters, fatigue and safety.

In times of tough competition and economic pressure, airlines struggle to survive with minimal profit margins. Pilots have understood this and do their best to support their employer, often ignoring their fatigue, impaired health and well-being. However, many pilots see that their employers put profit above safety and transfer responsibility for day-to-day flight operations and economic pressure to their pilots (Table 6).

3.3.1.3. How working conditions can affect physical and mental health.

Several pilots associated their working conditions with physical or mental health (Table 7). An EASA-based low-cost carrier pilot (#192) reported extremely impaired well-being (WHO5 PR = 8), significant depression symptoms (PHQ8 = 17), high psychosocial stress (PHQ-Stress = 11), high fatigue (FSS = 6.22) and considerable sleep problems (JSS = 3.25) and described his/her experiences as follows.

"Using extension to make long days 13 hours with 4 sectors should be limited to 2 sectors long trips. Also cut down long days when check in is before 0800, everybody wakes up more two hours before that to perform a 13-hour day. CAA don't care, blames just EASA. Check-in at 0610 you have been awake since 0410, why finish late afternoon/evening real tired, it's insane. Standby is used for flexi schedule. The last years it's all much worse. Actually, not looking forward to work anymore to sit in a chair buckled in for 13 hours is no fun. Starting to feel it's bad for my health, thin dry air, radiation, no place to move around. Eating bad nutrition without possibility to change food. Also, very noisy cockpit. This combined with long days and bad weather is a challenge and sometimes I wish I had called NFF when decision is to be made, and you are feeling slow and tired, getting afraid of mistakes due fatigue I get irritated on the system at work. . . Worst is no one is taking us seriously, they think it's just a battle for more time off. It actually makes me think that the safety culture we used to take so seriously is no longer justified. Being fatigued is like being influenced of alcohol. One puts you to jail, the other is legal keep going or call NFF and send minimum 180 pax to hotel-, crazy, that's pressure EASA have not seen. Thanks for good questions"

FTL and FRM refer to duty, flight hours and rest times, sleepiness and fatigue, etc., while they widely ignore how demanding rosters and accumulated fatigue relate to pilots' well-being, physical and mental health. Operators may think and pilots must accept: "If it is legal, it must be ok" (Table 7).

Table 4
Examples of comments regarding dysfunctional FTL.

| Working-conditions\flight time limitations\dysfunctional | Pilot # |
|---|---------|
| "Even if it's within subpart Q [EASA FTL] it's too hard duty." | 33 |
| "FTL can be, and is abused, in some companies to create unbearable schedules." | 43 |
| "The EASA FTL rules are a joke, and the CAAs of the European countries do not take this seriously." | 84 |
| "I don't think FTL are there to protect passengers or flight-crew" | 92 |
| "The EASA flight time limitations were the worst development in European aviation in the last 20 years" | 165 |
| "The FTL as they are, are a severe hazard to flight safety." | 169 |
| "But I have great concerns about fatigue with the current FTL when people fly it to the maximum." | 227 |
| "EASA FTL are not sufficient to stop fatigue" | 296 |
| "imho, the introduction of EASA FTL has been a massive mistake" | 336 |
| "In Europe even truckers have a more restrictive rest requirements." | 422 |
| "Perhaps it is time that ICAO revises FTL because although many pilots fly within legal limits it is still leading to fatigue throughout the entire industry." | 450 |
| "One of my biggest concern is the GREY areas in the FTL what my airline can use to disrupt my schedule." | 474 |
| "The current Australian CAO 48.0 rules are over 40 years old and useless." | 570 |
| "But rules old. Things have changed." | 606 |
| "The current set of rules seem tailored around the supposed "average" person, and would suit some much better than others" | 684 |
| "The current fatigue rules do not account for this type of operation therefore crews have to adopt the general category rules which for the most part are irrelevant and inadequate." | 989 |

Table 5
Examples of comments regarding superficial monitoring of FTL compliance, and FTL vs. pilots' private life.

| Working-conditions\flight time limitations\no monitoring or penalty | Pilot # |
|--|---------|
| "It's solely up to each airline to do whatever it prefers within a regulation which does not mentioning form of pilot employment." | 95 |
| "There is very minor supervision from the Hungarian CAA." | 474 |
| "The scariest thing is that there is no penalty for or proper monitoring of pilots exceeding their duty limits!" | 751 |
| "Company, and regulators, apparent lack of fatigue monitoring and management." | 820 |
| "This is not happening, and the companies get away with their crazy roster patterns" | 1093 |
| Working-conditions\flight time limitations\not considering private life | |
| "Employee life especially in the long-term is not considered nearly enough." | 96 |
| "The FTL don't consider your daily tasks and commitments as a father or partner." | 161 |
| "Current FTL from CASA and the FRMS/EBA limits on duty and flight times do not take into account life outside of work" | 667 |

Table 6
Examples of comments regarding "profit over safety" and passing economic pressure on to pilots.

| Working-conditions/employer/operator/profit over safety | Pilot # |
|--|---------|
| "But protect the interests of the airlines. I fear the mighty aviation lobbies are too strong" | 92 |
| "Competition in the air is tighter than ever" | 95 |
| "The current EU ruling on FTL is way too focused on the employer." | 96 |
| "Yes, it satisfied the airline lobby (competitiveness, profitability) and EU politicians (jobs)" | 336 |
| "Money drives the world unfortunately, even if the price is (or putting) the human life (into risk) itself." | 375 |
| "Our senior managers have told us that pilots will never win because they control the system and that is how it will work for the company. They have zero ability to manage fatigue or roster issues as it is a burden and cost to the company." | 570 |
| "Generating income, kick-backs, lobbying is priority, lack of transparency, honesty" | 657 |
| "Commercial interests (understandably) always come first to the airline." | 811 |
| "The company understands that we are all professionals who want to get the job done, not wanting to leave our colleagues and passengers stranded when we remove ourselves from duty. So more often than not we complete these duties." | 826 |
| "Unfortunately, contractual obligations come first in this day and age." | 829 |
| "The supposed reasons and supporting arguments for the changes are easily rebutted by science-based argument. This has been done, by (for example) AFAP – a pilot union here in Australia." | 1070 |

Table 7
Examples of comments about how pilots' mental and physical health could be affected by their working conditions.

| Working-conditions\health\mental health | Pilot # |
|--|---------|
| "Clinically diagnosed with 'Adjustment disorder with depressed mood' (DSMV), stable on antidepressants." | 624 |
| "I have experienced burnout from flying duties and life over last four years" | 1012 |
| Working-conditions\health\physical health | |
| "I believe many of us flight crew want to continue working in this industry however, regulators must help employees take care of their health." | 450 |
| "When it comes to regulating aviation. Health effects from toxic fumes caused by the bleed system and the effects of altitude never seem to be accounted for." | 567 |
| "I'm not as fit as I used to be." | 811 |
| "Last week have been unwell" | 920 |
| "And most significantly negative health impacts." | 1080 |

When pilots were asked for their rosters, psychosocial stress, sleep problems, fatigue and mental health issues, several pilots reported having noticed interactions of these variables. Pilots referred more often to physical than to mental health issues. An Australian low-cost carrier pilot (#817) reported impaired well-being (WHO5 = 40), high psychosocial stress, significant symptoms of common mental disorders (SRQ20 = 10), considerable sleep problems (JSS = 3.5) and described his/her fears.

"I feel fatigue is the biggest single risk to pilots in Australia. It is a constant battle by all pilots here in the airlines, the work life balance is not there and one other threat is we are required to do theory courses and work at home on line, which is not rostered – this is duty and impacts family life but all unpaid. The cost of living keeps increasing and the pay remains the same, pilots take on extra shifts against their better judgment even though it is fatiguing because we need to earn enough income to make ends meet. The airlines need to employ more pilots and work their existing pilots less so fatigue becomes less a risk. Pilots will never say they have mental illness or problems as pilots we are expected to be a superior breed of human by the travelling public and all pilots know the minute you mention your sad or unhappy you risk your career but of course pilots are human. The regulator here tries to regulate fatigue but it's not as good as it should be, ultimately what keeps the skies safe in Australia is the pilots keeping each other awake and removing themselves from duty when the fatigue just becomes too much of a safety threat for the individual."

3.3.2. Main category C2 Fatigue

The second most mentioned topic was fatigue. The assessment of fatigue and thus fitness to fly might often be difficult before commencing a long FDP, since sleepiness can set in during a long multi sector day. Sleepiness is a key symptom of fatigue, while pilots with accumulated fatigue or beginning burnout would sooner and more often develop high levels of sleepiness during flight duties, especially during the 'Window of Circadian Low' (WOCL) (CASA FTL, 2013; EASA FTL, 2014).

3.3.2.1. Accumulated fatigue and related impairment. Pilots reported impairment due to fatigue, in terms of fear of making mistakes, not being able to perform at the highest possible levels, although pilots' vigilance is vital for safe flight operations. Pilots also reported long-term cumulative effects of fatigue, which cannot be recovered during scheduled rest periods (Table 8). Absence due to fatigue was reported to be frequently masked as sick leave, to avoid negative consequences.

Pilots described that severe fatigue or 'not fit to fly' (NFF) could develop during a long FDP or a multi sector day, when it is usually impossible to leave flight duty and to replace an unfit pilot, especially in understaffed pilot departments at LCC or on not augmented long-haul flights. Fatigue often occurs during FDPs, including micro-sleeps. A severely fatigued (FSS = 5.56), but otherwise healthy captain (#145) of a network carrier expressed his severe concerns, fears, and incidents.

"Company talks a lot about fatigue, and I have done many reports. I get the same standard answer back that they know it is a tough schedule bla bla, - nothing happens. I have filed 2 major reports with concern. The first on was both pilots sleeping during night flight, - long company investigation and then the report disappeared. 2 years later I talked to an administrative pilot who send me the report with the words: You would never have found it. !!! The second was a serious incident due fatigue, - just got the std answer back. No action. I believe that it is a problem that we no longer have line pilots in top administration. The Current managers how no deep understanding of flight safety. They are managers, not leaders and are mostly interested in spreadsheets and short-term

goals. There is disturbing evidence that more and more incidents are covered up to avoid hitting the press. They don't understand that all incidents (the facts!) have to be shared as fast as possible, so we all learn. That is the essence flying safety – that is why less than 1000 is killed in aviation industry (compared to problems with doctors on hospitals) And since we pilots feel that reporting is not investigated and not taking seriously there is likely less reports submitted. It is my believe that we are sliding down a dangerous path. best regards"

3.3.2.2. From 'pilot pushing' to fatigue and burnout. Not Fit to Fly (NFF) refers to health related or other impairment, which threatens the safe execution of flight duties. Several pilots reported 'Pilot Pushing', feeling the pressure to go on flight duty, although they were actually sick or fatigued or unfit to fly due to other reasons. Pilots reported perceived and immediate economic pressure and the fear to lose their job (Tables 16 and 17). Some pilots described, how operators put profit over safety (Table 12), others referred to work-related stressors associated with 'Pilot Pushing' (Table 14).

3.3.2.3. Safety management (SMS) and fatigue risk management (FRM). Safety management has always been taken very seriously in aviation, but according to pilots' reports, fatigue represents a significant threat to flight safety. Safety management systems (SMS) live from pilots' honesty and trust into Just Culture (Reason, 2016). Legal FTL and mandatory FRM should prevent fatigue. If fatigue or high on duty sleepiness should nevertheless occur, pilots should report their fatigue, so that safety and fatigue critical flight duties or pairings can be improved. Nevertheless, FRM may be less successful than expected, when operators exceed the utmost limits of FTL (Bourgeois-Bougrine, 2020). A short-haul low-cost carrier pilot (#129) with severe fatigue (FSS = 4.56) described his/her experiences.

"It is my belief my employer has no tolerance to fatigue as in their eyes it simply does not exist in the Ryanair network. Pilots are called to HQ offices in Swords to 'explain themselves' having filed fatigue reports. I believe this leads to a culture of fear and a fear of filing fatigue reports as the consequences of such reports can be 'punishment' in the form of denial of annual leave, base transfer, temporary out of base assignments, etc. Plenty of pilots have filed reports with CHIRP but nothing ever comes of this as the company's response is always the same, and that is, 'our rosters are designed in such a way that fatigue simply cannot occur. All our rosters comply with current EASA/ICAO FTL regulations', etc. I have been repeatedly called inside rest periods. This is apparently acceptable to my airline and the authorities as a phone call does not count as disturbed rest if I do not answer. FTLs in my airline are used as targets and just because there are limits does not make them safe."

Many pilots have become reluctant to file fatigue reports (Table 9), because of potential negative consequences, and lack of improvement after fatigue reports. Therefore, the lack of filed fatigue reports does not imply prevented fatigue, but pilots' reluctance to speak up and report high fatigue. Some pilots only file fatigue reports, when they are convinced, they cannot execute their next scheduled flight duty.

More pilots preferred sick leave, because of manifold potential negative consequences after fatigue reports (Table 10), and no questions would be asked in context with sick leave.

3.3.3. Main category C3 Rosters

3.3.3.1. Pushing the limits. Many pilots criticized rostering practices and other methods, how pilots can legally be exploited. E.g., pilots on part-time contracts, whose rest periods are mostly rostered during unpaid time off duty, were rostered in legal but very

Table 8
Examples of comments regarding accumulated fatigue, fatigue-related impairment, fatigue on duty, etc.

| Fatigue\impairment | Pilot # |
|---|---------|
| "When you get home after a long-duty day, every small problem seems to be greater, anything annoys you more than it should. [. . .] because as you get home more tired, it takes more time to recover" | 264 |
| "I often wonder at the end of a long day like that how sharp and precise I would be, and the truth is I would not be close to 100%. I would be lucky to be at 60%. This might still be good enough to deal with the problem, but then again, it might not" | 573 |
| "However even after good sleep I am less alert for some shifts in these circumstances." | 931 |
| Fatigue\long-term cumulative effects | |
| "Associated high workload (multiple sectors, slot delays, pax issues, weather, complex airports, busy skies, tech issues, early starts, late finishes) followed by minimum rest is now more than ever taking its toll on crew well-being and cumulative fatigue levels." | 336 |
| "These things contribute to daily fatigue which I live with, and have to work with, as a basic ongoing level of exhaustion" | 624 |
| "The number of nights of sleep lost during the month builds up or you do not have at least two nights sleep after to recover is when fatigue affects me." | 807 |
| "As I've also been on leave for 3 weeks, I already feel exhausted after being at work for only a week." | 868 |
| "I think this leads to chronic Fatigue with associated health problems." | 1047 |
| "The most concerning thing for me is not the short-term nature of fatigue – it is the long-term cumulative effects of the nature of the work, and irregular hours, shift work, etc. the real insidious risk (with regards to both safety and operational issues, as well as health and well-being) is more related to the month on month and year on year effects, rather than the more manageable daily and weekly time frames." | 1080 |
| Fatigue\NFF\absence due to fatigue | |
| "So, when things start to go wrong during the day of operations the operator do not have enough manpower to solve the problems." | 167 |
| "Resulting fatigue levels going through the roof and more absence due to fatigue than ever before." | 336 |
| "Also, if you call in unfit for duty due to fatigue before work it is marked as a 'sick' day not a fatigue day. Honestly, it is easier to call in sick than it is to call in fatigued because nobody asks any questions. It's simply let us know when you can come back to work." | 973 |
| Fatigue\NFF\fatigue on duty | |
| "This creates pressure on the captains to carry out the duty even without being fit to fly." | 167 |
| "I believe micro-sleeps are quite common in our single pilot operation." | 829 |
| "They do this in the hope that the person will be guilted into working." | 973 |

Table 9
Examples of comments regarding negative experiences with filing fatigue reports and concerning (in)consequences after fatigue reports.

| Fatigue\fatigue risk management\filing reports | Pilot # |
|---|---------|
| "As much as crew is not bothering to write reports as there seems to be no effect in writing them." | 45 |
| "Our Ops. dpt. and Safety dpt. are strongly recommending us to fill in systematic fatigue reports as we are doing ACMI operations worldwide and they are very concerned about their operating crew health condition." | 346 |
| Fatigue\fatigue risk management\no action after report | |
| "In my airline it appears that there are no changes after reports," | 45 |
| "And having no way to address fatigue amongst pilots to the company and authority is why this has become an issue!" | 657 |
| "And filling out a fatigue report has NO effect on subsequent rosters, i.e., the same duties will be rostered, again and again." | 826 |

Table 10
Examples of comments regarding negative consequences after fatigue reports, and failing FRM.

| Fatigue\fatigue risk management\fear of negative consequences | Pilot # |
|---|---------|
| "However, you are severely questioned if you call in fatigued." | 43 |
| "Most pilots out of fear for jobs and becoming a target will call in sick rather than fatigued!!!!" | 657 |
| "We have a safety system but no one I know reports fatigue due to backlash and docking of sick leave for fatigue hours." | 682 |
| "There is pressure to not call in fatigued prior to a duty and often the company will ask you to come to work and 'see how you feel' (no personal experience but have heard of this happening). I feel like there is no support if you were to call in fatigued and that management will most likely call you to 'investigate'" | 973 |
| "For this reason, I feel like there is a chance that not signing on due to fatigue can be viewed as a 'protest' or something like that. It would likely have no 'visible, immediate' consequence, but might not be completely free of consequence." | 1070 |
| Fatigue\fatigue risk management\pro forma solution | |
| "Airlines and local CAAs say the focus on pilots' health and that they take fatigue seriously. But it appears that it's only on paper" | 45 |
| "The fatigue risk model used to calculate risk by cargolux is not representing real life at all, it is well off in both directions giving warnings when well rested and giving no warning when severely fatigued." | 165 |
| "Also, on paper a rather solid FRMS system is in place. But then as long as the operator runs an FRMS system to satisfy the regulator, all is well, and everybody just carries on. . ." | 336 |
| "From a Companies point of view fatigue and FRMS programs, exams and courses are mainly to avoid litigation." | 657 |
| "Operators in Australia have their own FRMS which to me is laughable." | 811 |
| Fatigue\fatigue risk management\“affordable safety”: offloading responsibility | |
| "The company often says that fatigue is a joint responsibility, i.e. that if you are fatigued, take yourself off duty, fill out a report and there will be no consequences. It allows them to roster fatiguing duties, and then offload the responsibility to remove oneself to the pilot." | 826 |

Table 11

Examples of comments regarding irregular rosters, pushing the limits and 'always maxing out'.

| Code roster\irregular rosters | Pilot # |
|---|---------|
| "It is just not working for our type of operation flying extended chains of duties through all time zones and circumnavigating [cargo ops]" | 165 |
| "Whilst we are viewed as shift workers, we do not have consistent early or late start times that last over a fixed period." | 667 |
| "I tell people outside the industry the type of duties I perform, and they are shocked." | 826 |
| Roster\pushing the limits\always maxing out | |
| "Duties rostered as such that with few minutes delay you 'need' to use Commander's Discretion, leading to fatigue" | 64 |
| "The problem with the EASA FTL is that the operator only takes into consideration the prescriptive ruleset. The effect of this is that the operator pushes as much duty as possible into every duty day causing the need for pilots for that production to be as low as possible" | 167 |
| "However, with the introduction of EASA FTL the everyday business of scheduling crew up to max FDP – crew working up to 20% longer hours accommodated by EASA (!)" | 336 |
| "At times, many pilots are flying too many hours although within the ICAO FTL." | 450 |
| "And my airline uses all the grey areas!" | 474 |
| "Operators use them [FTL] to the maximum limits." | 570 |
| "Company and CASA say the rules are there so that's what they roster pilots for." | 606 |
| "Aside from regulatory limits, I note an inappropriate awareness and thus appreciation by company rostering teams for particular combinations of flight-sector pairings, which have the potential to contribute to increased tiredness and possibly fatigue." | 643 |
| "And pilots in my airline are rostered to maximum efficiency, i.e., max duty/min rest, etc." | 667 |
| "Several 12-hour duties are rostered in a month as if it's normal. . . in amongst other 4 sector days with 10.5-hour duties that quite often go over limits due weather-related delays" | 750 |
| "It's legal, so it's OK". | 820 |
| "In general, my employer constantly rosters duties that can only be described as fatiguing." | 826 |
| "We are all being asked to do more with less, for longer and longer while conditions are eroded." | 990 |
| "If they can't get crew in the short time, operators are simply going to try to get more from the existing crew compliment." | 1070 |
| "Fatiguing rostering is a serious issue in today's low-cost model." | 1093 |

intense and fatiguing flight duties (Table 7). Many pilots of operators, who roster their aircrews for maximum duty and flight hours, reduced to part time, with questionable outcomes. A pilot (#154) with impaired well-being (WHO5 = 36) described his/her experiences.

“A way to be able to work in this business for more than a decade is to work part time. I have done so for 8 out of the last 20 years. My duty and block hours however are not limited to 80%, just the days off. This means extreme long and intense days when I am at work. My company historically never had to take any responsibility in the crew fatigue and well-being matters. The unions did that through the negotiation process. Now however the union has given away everything and it is the FTL that rules all the way. What makes this so dangerous is that the company, SAS, hasn’t taken over the responsibility of our health and well-being from the unions. On 80% part time, I can still work 190 duty hours and 90 block hours per month and 900 h per years. Just last week on a for day sling I did 18 sectors and 46 duty hours. This is what we do all the time these days. For me this means that neither the authorities or my company cares about my health or well-being.”

3.3.3.2. Irregular rosters and ‘always maxing out’. Other pilots reported having to study online in their spare time. Economically driven operators and crew planners schedule their pilots of understaffed pilot departments more than healthy or sustainable (Table 11).

Pilots were concerned about their rosters, which must comply with FTL, but often cause work-related and psychosocial stress, sleep restrictions and sleep problems, as well as acute and accumulated fatigue. Pilots described in detail, which schedules were hardest to bear (Table 12).

Many pilots provided insights, how early starts, late shifts, night flight duties and legal long FDPs feel, and described potential risks associated with regulations and resulting rosters (Table 13).

3.3.4. Main category C4 Stress

3.3.4.1. Work-related, psychosocial stress and pilots’ realistic fears. Pilots mentioned many different sources of work-related stress, e.g., frequent time pressure, high debts from self-funded pilot training associated with low income as junior first officer, with or without an employment contract at a LCC, crew planners disturbing rest periods, long commutes, long FDPs, and ‘pilot pushing’ (Table 14).

Pilots’ psychosocial stressors mainly referred to lack of work-life-balance (Table 15), having to sacrifice family time to sleep and rest, and resulting psychosocial and family problems. From the pilots’ perspective, strong interactions of work-related and psychosocial stressors were described, based on the nature of the pilots’ job and due to irregular shift work in demanding working conditions. Consequently, pilots reported often being irritated and fatigued, which was also visible in the respective items of the anxiety screening.

3.3.4.2. Pilots’ realistic fears and perception of threats. Pilots are highly qualified, well-trained professionals who safely perform flights several kilometers above ground. On a regular basis, pilots must train and perform emergency procedures to recover life threatening situations in their simulator trainings. Pilots must remain calm in dangerous and life-threatening situations, in the simulator and in real life. They must pass their skill checks to keep their pilot license, in addition to their valid medical certification. Nevertheless, several pilots explicitly expressed their realistic fears associated with high levels of fatigue, potentially fatal crashes, and other threats. Many other comments implied considerable realistic fears (Table 16).

Many EASA-based LCC do not have work-contracts with their pilots, so that they do not have to pay for their pilots’ sick leave, or absence due to fatigue. Several pilots expressed concerns, their working conditions and accumulated fatigue could deteriorate even further, “from bad to worse in the future” (Table 17).

3.3.5. Main category C6 Sleep

3.3.5.1. Sleep & sleep problems. When pilots were flying on average 46 hours per month in the 1980’s (Sloan and Cooper, 1986), pilots had enough time for sleep, rest, recovery and their families. Today, many pilots are obliged to rest according to the standard operational procedures (SOPs) of their operators, or according to FTL. After flight duties, pilots are often very tired and immediately need sleep or rest, while their families must be quiet and respect that their absent parent/partner is back home, but still unavailable. This can enhance psychosocial stress and represents an additional burden for aircrews (Table 18).

In line with the quantitative results, pilots reported frequent sleep restrictions associated with flight duties (Table 19), especially before early starts. In addition to sleep restrictions, many pilots reported considerable sleep problems. Sleep restrictions and other fatigue risks on flight duty should actually be avoided by FTL and FRM, but many pilots reported otherwise (Table 19).

Pilots reported multiple sources of work-related and psychosocial stress. Only nine hours minimum rest – as allowed in Australia, if covered by FRM – are not enough to restore alertness in already fatigued pilots before a long FDP. Moreover, the assigned sleep or rest time does not guarantee sufficient sleep, especially after stressful flights. A severely fatigued (FSS = 4.56) Australian pilot (#590) reported:

“I feel that there are some issues with split duties in Australia as it stands and having a 4-hour break in the middle of a 16-hour shift doesn’t guarantee a good rest and will often leave you feeling more fatigued if you had little sleep opportunity the night before. 3 am wakeup to be at work by 4 am for a 5:30 departure with a 10:00 duty finish and a break to go home and come back for a 14:00 start for a 2100 finish is not good enough factoring commute times to and from base”

3.4. QCA: Comparison of Australian vs. EASA-based pilots

A total of 244 codings were assigned to the 57 EASA-based pilots, 253 codings to the answers of the 52 Australian pilots. Answers of ten pilots were excluded here, because they were not flying for EASA-based or Australian operators. In total, 497 codings were assigned to 109 pilots in both groups.

EASA-based pilots had the highest number of codings in the main category C1 Working Conditions and C2 Fatigue. The highest number of codings for Australian pilots was in main category C2 Fatigue, closely followed by C3 Roster and C1 Working Conditions. Among Australian pilots, the first three main categories C1 Working Conditions, C2 Fatigue and C3 Roster were clearly standing out with not only the highest number of codings, but also the highest number of pilots mentioned those categories in their individual answers. Among EASA-based pilots, the main category C8 Organizational Issues was used in most answers, followed by C1 Working Conditions. The least used category for both groups was C5 Safety Culture (Table 20).

4. Discussion

Looking at the pilots’ open answers in this study, pilots paint a dire picture of flight safety, fatigue, sleep restrictions, fatigue risks associated with flight duties. Pilots can already feel, how the

Table 12
Examples of pilots' comments regarding minimum rest, back-to-back rostering, multi sector days up to violations of rules.

| Roster\pushing the limits\minimum rest | Pilot # |
|---|---------|
| "The company will give you the minimum rest required by law, which is 9 hours, but this starts when you leave the airport and ends when you arrive back at the airport the next day." | 573 |
| "Our 28-day rosters are a mix of early and late starts with min rest time between the change." | 667 |
| "Minimum rest, single rostered days off." | 820 |
| "The biggest problem I (and others in my company) have found is minimal rest periods. For example, finishing a duty at about 2030 on a layover and starting the next day at 0600" | 1024 |
| "Significant fatigue sets in when a pilot has minimum rest in home base (9 hours) between flight duties." | 1039 |
| Roster\type of roster as challenge\back-to-back rostering (layover) | |
| "Another scenario in which I often feel fatigued is when you do an 8- or 9-hour day and then spend the night away from home base. I often feel fatigued by the end of the 2nd days flying." | 573 |
| "Multiple, run of the mill max duty days (up to 13.5 hours of multiple short sectors), back-to-back are the most fatiguing." | 645 |
| "Similar issues exist when over-nighting away from home. The typical layover is 9–10 hours. When the second day starts early and then exceeds 6 hours duty fatigue becomes significant." | 1039 |
| Roster\type of roster as challenge\multi sector day | |
| "High numbers of sectors day (up to 6) usually rostered in sequence increase the likelihood of fatigue" | 64 |
| "And fly 4 sectors with 12-hour duty" | 92 |
| "And this may involve 4 to 5 sectors of flying." | 573 |
| "They say that flying a single sector of 12 hours is much easier than flying multiple short busy sectors." | 1024 |
| Roster\violation of rules | |
| "Domestic pilots in Australia are doing long haul duties. . . i.e., BNE-PER-BNE and BNE-DRW-BNE-NTL!!" | 751 |

Table 13
Examples of comments regarding early starts, late shifts, night flight duties and legal long flight duty days.

| Roster\type of roster as challenge\early starts | Pilot # |
|--|---------|
| "Repetitive early check ins and disruptive rosters are cause of great concern to my health and safety of our passengers. How is it legal to have 5 days in a row 03:00 a.m. local time wake ups" | 92 |
| "e.g., if I had regular 6 am starts but shorter duties, I'd feel more tired" | 684 |
| Roster\type of roster as challenge\long duty day | |
| "My employer combines long duty with 4–5 sectors" | 33 |
| "To work in our environment for 11+ (Up to 16. . .) hours is dangerous (unless long-haul with augmented crew)." | 46 |
| "Max duty time at night is way too long. . ." | 149 |
| "The main problem I find is when I have an especially long duty on any day (duty > 10 hours). No matter how much sleep I have had the night before or even if I had a couple days off before this kind of duty, I will still be feeling tired and fatigued by the end of it and my concentration will be suffering." | 573 |
| "We seem to have protections around early and late starts, BOC, etc., but 'normal' day flights at continual max duty take a massive toll." | 645 |
| "My main issue; long duty periods" | 820 |
| "My concerns with fatigue are that when I return from a big trip with big days" | 995 |
| Roster\type of roster as challenge\night flights | |
| "Night flights are an absolute pain." | 136 |
| "The biggest factor is staying awake during the WOCL period." | 807 |
| "There is no hesitation or thought given to conducting missions that involve back-of-the-clock operations." | 829 |
| "My company flies from 1920 till 0430 in the morning with no augmented crew in an A320." | 868 |
| "So, 25% of Night Ops of which about 2/3 consists of operations between 0200 and 0600." | 1047 |
| "Industry uses wrong definition for late night operation" | 1096 |
| Roster\type of roster as challenge\switch early/late shifts | |
| "The biggest problem with my roster is the changing from morning to night duty." | 259 |
| "To shift from late working pattern to early or the opposite within the same working block is a major factor effecting your rhythm and alertness seriously, like having scheduled time zones in your schedule, not good." | 268 |
| "My biggest concern in relation to rostering is varied shift times with little chance for circadian rhythms to readjust." | 931 |
| "I am most fatigued when going from late duties into early duties." | 966 |
| "The biggest problem with duty limits and fatigue has to do with working early mornings for a few days and being put straight on to evenings/afternoons to avoid duty restrictions." | 1013 |
| "This pattern can and does occur when pilots finish duty in the evening, and then start next day early. (Typically finish around 2000–2100, and then start at 0600–0630)." | 1039 |

present working-conditions and rosters, which are legally based on FTL and FRM, impair their health. Not enough time to sleep and to maintain a healthy family life, accumulated fatigue, which cannot be recovered during legal rest times or vacation, beginning or full developed burnout, in line with previous research (Demerouti et al., 2018, Fanjoy et al., 2010).

Previous fatigue studies considered pilots' fatigue simply as threat to pilot performance and aviation safety (Bandeira et al.,

2018; Bendak & Rashid, 2020; Bourgeois-Bougrine, 2020; Goode, 2003), only associating fatigue with rest times and implied, estimated sleep times. Only latest research examined associations between fatigue, sleep problems and mood, symptoms of depression and anxiety (Aljurf et al., 2018; O'Hagan et al., 2017, 2019; Venus & grosse Holtforth, 2021b, 2022b), and how work-related stress and fatigue can affect pilots' biopsychosocial well-being (Cahill et al., 2021; Cullen et al., 2020).

Table 14
Examples of comments regarding work-related stress.

| Segment stress\work-related stress | Pilot # |
|--|---------|
| "Crap schedules, extreme duty times esp. extremely early or late schedules (Airports are often far from where people live. . .) make life tough in this business." | 46 |
| "Operator calling during the rest period" | 64 |
| "As I get older, I need more rest between flights and get more tired during long workdays." | 136 |
| "Some pilots are qualified to fly as captain or copilot. So, get more calls on standby, etc." | 161 |
| "Airline pilots are under huge pressure from the airlines. Combined with reduced remuneration, unfortunately, I would not recommend becoming and airline pilot today!" | 234 |
| "Repaying the debts for my flight training with my net income is not easy. The net income is not good enough taking this into consideration." | 290 |
| "In general, I feel over worked" | 422 |
| "I could handle this when I was 30, but not at 50+. Not looking forward to 60+. Will be flying with minimum time MPL holders soon, that translates into increased workload for me." | 439 |
| "Frequent change in operational documentation creates a stressful environment where one is always studying." | 525 |
| "If there was really bad weather and a serious aircraft malfunction" | 573 |
| "The work can be mentally as well as physically taxing dependent upon the theatre of operation. You can rarely switch off from the job when involved on a deployment especially when operating in a foreign location." | 989 |
| "The other aspect is the drive to work is not considered. Once you drive to work then you need to catch a bus and this needs around a 20-minute allowance." | 995 |
| "When you take into account transport from airport to hotel, the need to prepare for the next day (ironing shirt, shower, etc.) and the time that it is necessary to rise in the morning for transport to the airport to arrive by 0600" | 1024 |

Table 15
Examples of comments regarding pilots' psychosocial stress.

| Segment stress\psychosocial stress | Pilot # |
|---|---------|
| "Balance between workhours and time off is not sufficient enough." | 46 |
| "We have 1 child (9 years). My wife works 50% on shifts. I go out with friends maybe 3-4 times a year. We have to make it work (our social life), no support from outside, family, etc." | 161 |
| "Since this is extremely frustrating for pilots and their families and brings morale to an all-time low." | 165 |
| "And their families. It is getting harder and harder to manage the work/life balance. Flying is great, but your social life will suffer. . ." | 234 |
| "From my experience as a pilot for 18 years, on short and long haul, tiredness is what makes difficult to have a normal life [. . .] and that always make difficult family life." | 264 |
| "And to know that this will still take me 5-10 years from now on makes me unhappy especially regarding the future financial perspective in the upcoming years." | 290 |
| "Destructed social and family lives" | 336 |
| "For me last two years I have problems with my family life" | 443 |
| "Newborn baby at home (4 weeks old) has affected some of my sleep quality/fatigue responses in the survey. 7 days paternity leave in Australia is inadequate for air crew." | 553 |
| "Have young children at home and partners that also work full time. People have various responsibilities and are required to contribute and have family commitments." | 667 |
| "I now have a wife, 2 kids and a mortgage," | 811 |
| "Lots of sectors I need a couple of days to relax and then get things done with the family. This is often not happening because I'm recovering from duties and then head out again on another trip after 2 days off." | 995 |

Table 16
Examples of comments regarding pilots' realistic fears associated with fatigue-related fatal crashes, etc.

| Segment stress/fear | Pilot # |
|---|---------|
| "Really sad and quite frightening now." | 46 |
| "If today's path continues, we will in Europe see Colgan repeated, no doubt. Only permanent employment is viable." | 95 |
| "Major accidents and deaths directly attributed to fatigue and exhaustion are just a matter of time." | 169 |
| "Do we have to wait for a fatal accident, proven by fatigue, to change our limits in working hours -" | 237 |
| "It frightens me to see that at the same time it's all still business as usual and eventually - shattered careers." | 336 |
| "The new proposed rules for FRMS will be even worse. Until there is a big accident in Australia nothing will ever change in relation to fatigue." | 570 |
| "And I believe it is only a short period of time before a major accident occurs in Australia." | 751 |
| "It's very dangerous and little is being done to address these issues." | 868 |
| "This concerns me greatly." | 1070 |

Table 17
Examples of comments regarding pilots' fear, that the future could be even worse.

| Segment stress/fear "from bad to worse in the future" | Pilot # |
|---|---------|
| "Really sad and quite frightening now." | 46 |
| "It frightens me to see that at the same time it's all still business as usual" | 336 |
| "The new proposed rules for FRMS will be even worse." | 570 |
| "It's very dangerous and little is being done to address these issues." | 868 |
| "This concerns me greatly." | 1070 |

Table 18

Examples of comments regarding sacrificing sleep for quality time because of operational necessities.

| Sleep\sacrificing sleep for quality time | Pilot # |
|---|---------|
| “Although I manage to avoid fatigue, it's a great effort at the expense of our social life, life as a couple, etc.” | 161 |
| “The point is rest period and off days are always combined. So pilots force to choose social life or rest” | 443 |
| “You can't just go home and turn off so that you can achieve the minimum rest allocated to you between duties.” | 667 |

Table 19

Examples of comments regarding sleep restrictions and sleep problems associated with flight duties.

| Sleep\sleep restrictions | Pilot # |
|---|---------|
| "Sleep is depraved everyone in Airlines." | 46 |
| "So you are lucky if you get 7 hours of sleep and then you have to be ready for another full day of flying." | 573 |
| "It is their belief (I am yet to see any evidence) that a 12-hour day can be completed on only 5–6 hours of sleep if managed properly. I am very pessimistic that science supports this." | 671 |
| "And have struggle to get back to normal with the flying regime and environment that keeps on impacting regular sleep patterns for recovery." | 1012 |
| "The amount of sleep is not adequate." | 1024 |
| "This leads to sleep-debt and the habit of post-duty naps." | |
| This typically results in a sleep opportunity of 5 hours in a major city." | 1039 |
| "Anything requiring arousal before sunrise (~6 am) means interrupted sleep." | |
| "It depends on crew abode proximity to airport – but flights before 9 am have sign on before 8 am, requiring departure from accommodation by about 7 am and wake up before 6 am. Similarly, flights after 8 pm have sign off after 8:30 pm then return to accommodation after 9:30 pm so not to sleep by 10 pm." | 1096 |
| Sleep\sleep-problems | |
| "But it's the crew and the crew alone that have to deal with the burden of ruined sleep," | 336 |
| "I have problems sleeping when flying late a lot. I cannot sleep well anymore, I wake up late in the morning and feel tired, sometimes that feeling remains all day. When I fly early, I am tired in the evening and sleep well for at least 6.5 hours. So, my quality of sleep varies with my working schedule." | 371 |
| "Sleep quality on a layover is usually less than that gained at home." | 1039 |

Table 20
Frequencies and descriptive statistics of EASA-based and Australian pilots.

| Main categories | <i>n</i> | Number codings (%) | M | SD | Min.–Max. |
|--|----------|--------------------|------|------|-----------|
| Europe based pilots subject to EASA regulations | | | | | |
| Working conditions | 24 | 51 (20.90) | 0.89 | 1.44 | 0–6 |
| Fatigue | 18 | 47 (19.26) | 0.82 | 1.80 | 0–10 |
| Roster | 18 | 31 (12.70) | 0.54 | 0.98 | 0–4 |
| Stress | 20 | 43 (17.62) | 0.75 | 1.33 | 0–5 |
| Safety culture | 5 | 12 (4.92) | 0.21 | 0.75 | 0–4 |
| Sleep | 7 | 13 (5.33) | 0.23 | 0.73 | 0–4 |
| Regulator | 6 | 12 (4.92) | 0.21 | 0.80 | 0–5 |
| Organizational issues | 25 | 35 (14.34) | 0.61 | 0.80 | 0–3 |
| Australia based pilots subject to CASA regulations | | | | | |
| Working conditions | 26 | 50 (19.76) | 0.96 | 1.25 | 0–5 |
| Fatigue | 26 | 53 (20.95) | 1.02 | 1.43 | 0–8 |
| Roster | 26 | 51 (20.16) | 0.98 | 1.57 | 0–8 |
| Stress | 17 | 28 (11.07) | 0.54 | 0.92 | 0–4 |
| Safety culture | 6 | 8 (3.16) | 0.15 | 0.46 | 0–2 |
| Sleep | 9 | 14 (5.53) | 0.27 | 0.69 | 0–3 |
| Regulator | 15 | 27 (10.67) | 0.52 | 1.04 | 0–5 |
| Organizational issues | 12 | 22 (8.70) | 0.42 | 0.87 | 0–3 |

n: number of people/answers who received a code of this category; M: arithmetic mean; SD: standard deviation; Min. and Max.: minimum/maximum number of codes a single person/answer got in this category.

Although twice as many pilots reported positive depression and anxiety screenings, and two to three times as many pilots reported severe to very high fatigue ($FSS \geq 4$), compared to the general population, most pilots underreport or even try to ignore mental health issues. They do so, because depressive or anxiety disorders or burnout often mark the end of pilot careers. Moreover, most pilots became accustomed to and adapted to longer and more stressful flight duties, accumulated fatigue, impaired mood and concerns about flight safety and their careers. Medical requirements for flight crew licensing like Part-MED (2019) state that pilots must be physically and mentally fit to safely execute flight operations. Pilots' physical health issues are usually reversible, like a broken leg, while mental health issues like depression or burnout usually result in long-term grounding and final layoff.

To maintain physical and mental health, healthy partnerships and families, a minimum of quality time should be spent with children, spouses, or partners, beyond mandatory sleep and rest times before flight duties (Cahill et al., 2021; Cullen et al., 2020). Divorce is a major life event that substantially increases psychosocial stress, while an important asset for coping with stress – a healthy marriage/partnership or family – vanishes. Destroyed families are an additional burden, and additional support – like pilot peer support – is needed for recovery. Accumulated fatigue due to tough rosters and beginning or fully developed burnout (Cullen et al., 2020; Demerouti et al., 2019; Fanjoy et al., 2010) need professional psychological or interdisciplinary support and therapy.

Low-Cost Carriers have fuelled competition, and more and more Network Carriers are adapting their management strategies to the competitive environment. In times of detrimental competition and economic pressure, airlines must survive with minimal profit margins. Pilots have understood this and do their best to support their employer, often ignoring their fatigue, impaired health and well-being (Demerouti et al., 2019; Fanjoy et al., 2010; Johansson & Melin, 2018; Venus & grosse Holtforth, 2021b). Not Fit to Fly (NFF) refers to health related or other impairment, which threatens the safe execution of flight duties. 'Inappropriate Presenteeism' was reported by 63% pilots, i.e., going on flight duty while actually unfit to fly due to mental health issues, fatigue, or significant life events, while 'Sickness Presenteeism', i.e., going on flight duty although sick, was reported by 54% pilots (Johansson & Melin, 2018). This corresponds with 'Pilot Pushing' (Fanjoy et al., 2010), and reflects the perceived and immediate economic pressure on pilots, and their fear to lose their job. Pilots reported an erosion of safety culture and flight safety, and how operators put profit over safety ('Pilot Pushing', as described by Fanjoy et al. (2010)). Pilots reported, that airline managers and crew planners transferred responsibility for day-to-day flight operations and flight safety to their pilots, which are still personally responsible for every aspect of flight safety (ICAO, 2018).

FTL and FRM refer to duty, flight hours and rest times, sleepiness and fatigue, etc., while they widely ignore, how demanding rosters and accumulated fatigue relate to pilots' well-being, physical and mental health (Cullen et al., 2020). Latest research showed that high levels of fatigue were associated with burnout, significant symptoms of depression and anxiety (Aljurf et al., 2018; Demerouti et al., 2019; Fanjoy et al., 2010). Still unpublished research of the authors showed significant to high correlations between psychosocial stress, sleep problems, fatigue, well-being, symptoms of depression, anxiety, and common mental disorders (Venus & grosse Holtforth, 2022a,b). Operators may think and pilots must accept: "If it is legal, it must be ok".

What pilots wrote illustrates perfectly the quantitative results, which have been published before: How duty rosters and stress relate to sleep problems and fatigue (Venus & grosse Holtforth, 2021a), differences between short and long haul pilots (Venus

& grosse Holtforth, 2021b), and quantitative differences between Australian and EASA-based pilots rosters, stress, sleep problems, fatigue, well-being, symptoms of depression and anxiety (Venus & grosse Holtforth, 2022a). Although mental health issues were rarely mentioned, fatigue was the second most mentioned topic. The assessment of fatigue and thus fitness to fly might often be difficult before commencing a long FDP, since sleepiness can set in during a long multi sector day. Sleepiness is a key symptom, but only one symptom of fatigue, while pilots with accumulated fatigue or beginning burnout would sooner and more often develop high levels of sleepiness during flight duties (CASA FTL, 2013; EASA FTL, 2014).

Pilots reported impairments due to fatigue, in terms of fear of making mistakes, getting irritated, especially under adverse weather conditions or late at night, not being able to perform at their highest possible levels on active flight duty (Aljurf et al., 2018; Coombes et al., 2020; Hartzler, 2014; Venus & grosse Holtforth, 2021b). Pilots also reported long-term cumulative effects of fatigue (Cabon et al., 2012; Shahid et al., 2010), which cannot be recovered during scheduled rest periods. Absence due to fatigue was often masked as sick leave, to avoid negative consequences and investigations into the private lives of pilots. Operators and crew planners seem convinced, that flight time limitations and Fatigue Risk Management reliably prevent fatigue, as worktime arrangements should, according to the International Labour Organisation (ILO, 2019b). Therefore, in their opinion, the pilots are to be blamed, when they report fatigue. The results of this and previous research (e.g., Bourgeois-Bougrine, 2020) suggest that this opinion of airline managers and crew planners and also regulators is wrong.

Safety management has always been taken very seriously in aviation. Aviation is perceived as the safest mode of transport, but the high standards of safety culture and flight safety seem to be eroding, when we look beyond the technical aspects of flight safety. According to pilots' reports and a sound body of scientific evidence, fatigue represents a significant threat to flight safety (Bandeira et al., 2018; Bendak & Rashid, 2020; Bourgeois-Bougrine, 2020; Goode, 2003; Hartzler, 2014). Fatigue can impair situational awareness, especially when one or both pilots fall asleep without prior coordination (Coombes et al., 2020). Sleep deprivation and fatigue can impair many cognitive functions like short-term memory and decision making, visual perception, etc. (Coombes et al., 2020; Hartzler, 2014). Safety Management Systems (SMS) live from pilots' honesty and trust into Just Culture (Reason, 2016). However, negative consequences or repercussions after fatigue reports were submitted, are increasingly preventing pilots from taking on the great expense of a detailed report, especially when no improvements are being implemented, and pilots get blamed for their own fatigue.

While on-duty sleepiness is difficult to measure reliably, micro-sleeps in the cockpit are valid indicators for high accumulated fatigue and high sleepiness. Several long-haul pilots reported micro-sleeps or accidentally falling asleep at the controls (Aljurf et al., 2018; Coombes et al., 2020; Venus & grosse Holtforth, 2021b), e.g., on long-haul flights back to home-base after short layovers (23 to 48 hours), when the flight back was during home base night-time and circadian WOCL.

Many EASA-based LCC do not have work-contracts with their pilots, so that they do not have to pay for these pilots during their sick leave, vacation or absence due to fatigue. Almost every second pilot (48.8%) reported, they did not feel comfortable leaving their fellow pilot alone in the cockpit (Aljurf et al., 2018; Cullen et al., 2020). Several pilots expressed concerns, their working conditions and accumulated fatigue could deteriorate even further, "from bad to worse in the future".

In line with the quantitative results, pilots reported frequent sleep restrictions associated with flight duties, especially before

early starts (Roach et al., 2012; Vejvoda et al., 2014; Venus & grosse Holtforth, 2021b, 2022a, 2022b). In addition to sleep restrictions, many pilots reported considerable sleep problems, in line with previous research (Reis et al., 2013, 2016a, 2016b; Venus & grosse Holtforth, 2021b). Especially minimum rest, or less than six hours sleep before flight duties cause problems for health and well-being, enhancing accumulated sleep debt and fatigue (Ekstedt et al., 2006; Söderström et al., 2012). Sleep restrictions and fatigue risks on flight duty should actually be avoided by FTL and FRM, but many pilots reported otherwise (Venus & grosse Holtforth, 2021a).

Pilots reported multiple sources of work-related and psychosocial stress, and stress has been proved to impair sleep (Kalmbach et al., 2018, 2020; McEwen & Karatsoreos, 2015; Sapolsky, 2004; Zoccola et al., 2009). Only nine hours minimum rest – as allowed in Australia, if covered by FRM – are not enough to restore alertness in already fatigued pilots before a long FDP. Moreover, the assigned sleep or rest time does not guarantee sufficient sleep, especially after stressful flights through turbulence, nearby thunderstorms, after being blinded by laser pointers or near miss with drones near congested airports and long commuting times. Biomathematical Models should produce safe and fatigue preventing rosters, but may be less successful than promised (Coombes et al., 2020; Dawson et al., 2017; Dorrian et al., 2012; Venus & grosse Holtforth, 2021b).

Quantitative differences between Australian and EASA-based pilots were reported by Venus and grosse Holtforth, 2022a. “Although EASA-based and Australian pilots were scheduled for only 57–62% of maximum duty and flight hours, 71.8% EASA-based vs. 77% Australian pilots reported severe or high fatigue. Significant depression symptoms were reported by 17.2% Australian and 18% EASA-based pilots, 7% pilots reported significant symptoms of depression and anxiety. Australian pilots reported more demanding rosters, significantly more sleep problems and significantly lower well-being.” (Venus and grosse Holtforth, 2022a). Australian pilots reported significantly more demanding rosters with significantly more fatigue risks associated with flight duties and more demanding rosters. In this Qualitative Content Analysis, Australian and EASA-based pilots described dire conditions regarding flight safety, fatigue, stress and health.

4.1. Limitations

The representativity of this sample is difficult to check. Demographic data in this research is similar to previous research (Aljurf et al., 2018; Reis et al., 2016a), e.g., age, gender, proportion of LH/SH pilots, etc. International pilots of different types of operators and flight operations participated. The pilots of this research were scheduled for only 60.8% to 62.5% of the legally allowed duty and flight hours. Pilots scheduled for maximum legal duty and flight hours may have been too busy or too fatigued to participate in this research.

4.2. Strengths: advantages of QCA

The QCA allows to relate pilots' authentic experiences and perceptions with the quantitative results. Thus, the valuable insights of this research can promote pilot fatigue research and help understand how FTL, rosters, sleep problems, fatigue and mental health can interact. Moreover, original answers add a personal note to the quantitative data, emphasizing that actual human beings were behind the results. Taking a subjective perspective can help researchers to better understand thoughts and behaviours of pilots in real life, and to gain new perspectives on the current research subject or shift the attentional focus to new topics.

To obtain reliable, objective, and replicable results with this QCA, we developed very detailed and precise coding guidelines. The inter- and intra-coder reliabilities were good to excellent, granting

high stability according to Mayring (2014). The main research question was explorative, so that the coders wanted to carve out as much information as possible. The tables with the content of codes and codings provide valuable information, which goes beyond the formal QCA and is important for research and development of better FTL.

4.3. Research implications

A next step could be to conduct a Mixed-Methods approach to further integrate qualitative and quantitative data. It was possible to demonstrate that EASA-based and Australian pilots had slightly different priorities, likely being associated with their working conditions and regulations. Further research should identify how FTL could be improved to avoid the consistently measured high levels of fatigue among pilots (Aljurf, Olaish, & BaHamam, 2018; Bourgeois-Bougrine, Carbon, Gounelle, Mollard, & Coblenz, 2003; Reis, Mestre, & Canhão, 2013; Reis, Mestre, Canhão, Gradwell, & Paiva, 2016a; Venus & grosse Holtforth, 2022b,a). Even healthy pilots appreciated this independent research and stated the importance of this new comprehensive research approach, which integrated working conditions, stress, rosters, fatigue, sleep problems, mental health, and well-being. The isolated study of pilots' fatigue and sleep may be insufficient, given that researchers in work psychology have stated, that pilots are similar to other shift-workers: Irregular shifts and stress are associated with sleep problems and accumulated fatigue, which lead to burnout and other mental health issues, when the rest periods are not sufficient in the short- and long-term (Akerstedt & Wright, 2009; Aljurf et al., 2018; Demerouti et al., 2019; Ekstedt et al., 2006; Fanjoy et al., 2010; Söderström et al., 2012).

5. Conclusions

Pilots painted a dire picture of their working conditions, fatigue, sleep restrictions, health, and multiple threats to flight safety in their open answers. On the background of working time laws, which must be designed to support occupational health and safety (ILO, 2019a,b), operators consider legal FTL as healthy and safe. Given our results however, FTL and FRM seem to create an “Illusion of fatigue risk control” (Bourgeois-Bougrine, 2020). Most operators use FTL as goals of productivity to remain competitive under economic pressure. Pilots understand that their jobs are at stake if they do not comply with ‘Pilot Pushing’ and cope with omnipresent pressure. Operators appear to offload responsibility to pilots, who must assess their fitness to fly before every flight duty. Nonetheless, pilots know they risk their jobs, when they speak up as legally required by regulations, FRM and safety management systems. Most pilots (78.6%) reported severe or high fatigue, and many pilots reported sleep restrictions, work-related and psychosocial stress. Compared with the general population more pilots reported significant symptoms of depression, anxiety, or both. Pilots reported comprehensible fears associated with their working conditions and consequent threats to aviation safety. It seems that psychosocial and work-related stress have been underestimated or widely ignored in previous pilot fatigue research, although stress significantly relates to sleep problems, accumulated fatigue, and mental health issues (Venus and grosse Holtforth, 2022b). Pilots may have become reluctant to admit fatigue, burnout, or mental health issues, because they do not want to lose their jobs. Moreover, pilots may have become accustomed to feeling worse and worse due to stress, sleep restrictions and fatigue over the last decades. Several crashes associated with high fatigue or pilots' mental disorders involved almost a thousand fatalities so far. Consequently, pilots' worries, and fears must be taken seriously as more fatal accidents seem

to be foreseeable, given the current safety culture and FTL. If FRM fails, legal rosters have the potential to damage health and endanger flight safety over the years. Our comprehensive results can help to improve future FTL, working conditions and pilots' physical and mental health. High levels of fatigue represent a heavy burden for aircrews at work. How stress and fatigue can impair sleep and health should be integrated in Crew Resource Management, and FRM trainings to improve aviation safety and pilots' health.

Disclosure of interest

The authors declare that they have no competing interest.

Appendix 1. Coding guidelines

The coding guidelines were adapted from "Schreibverhalten und Selbstoffenbarung in einer internetbasierten, angeleiteten Selbsthilfefeintervention für Personen mit Psychose", by Christen, 2019, p. I.

Guideline Nr. 1: Sentences and Clauses

The starting point for coding is always a clause. Thus, the first step always should be the decision in which category each clause in a sentence should fall.

Notes:

- The end of a sentence is marked by a period (.), a question mark (?), an exclamation mark (!) or an ellipsis (...). Periods as part of a bullet point (1., 2., etc.) are not viewed as the end of a sentence.
- Clauses are marked by the words *and/or/but*, a comma (,), a semi-colon (;) or other punctuation marks (- | - |:). Between the text components.
- A code always starts with the first letter of a sentence/clause and ends with the last punctuation mark or letter of the sentence/clause. Blanks at the beginning or end of a sentence/clause are not coded. Bullet points at the beginning of a sentence/clause are not coded.
- The coders do not insert missing punctuation marks. If there is no comma at a spot where there is supposed to be one, the clauses should be coded together.
- In case of completely missing punctuation marks, the coders try to use capital letters at the beginning of a sentence and/or multiple spaces at the end of a sentence to determine the beginning and end of a sentence.

Guideline Nr. 2: Decision to Break Down a Sentence or Not

After the decision of the most fitting category for each clause is made, the whole sentence should be considered. It should be decided if a sentence is going to be broken down in clauses to code (each clause receives its own code) or not (several clauses receive the same code).

Nr. 2a: The sentence is going to be broken down in clauses to code if:

- The individual clauses would fall into different categories.
- The clauses would receive codes of the same main category, but it is definitely clear that they would fall into different subcategories.

Nr. 2b: The sentence is not going to be broken down in clauses to code if:

- The clauses would receive the same code;
- The clauses would receive codes of the same main category, but it is not definitely clear if they would fall into different subcate-

gories. In this case the clauses should be coded together with the most fitting code;

- One of the clauses would fall into the subcategory "Left Over Category". This clause should instead be coded together with the other clause under the same code.

Guideline Nr. 3: Inclusion of Context

Each sentence should be reviewed in isolation. The context of a sentence (surrounding sentences) should only be considered in the process of coding if the sentence is not understandable without the inclusion of the context.

Guideline Nr. 4: Which Order to Follow to Determine the Most Fitting Category

To prevent important text components from falling into less differentiated categories, the coders should follow a certain order to determine the most fitting category. For each code the possible categories should be considered in the following order:

1. C1 Working conditions, C2 Fatigue, C3 Roster, C4 Stress, C8 Organizational Issues (except for C9.3 Left Over Category)
2. C5 Safety Culture, C6 Sleep, C7 Regulator
3. C9.3 Left Over Category

Appendix B. Category system

Supplementary data associated with this article can be found, in the online version, at <http://doi.org/10.1016/j.erap.2022.10.0762>.

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