

**PILOTS' STRESS,  
SLEEP, FATIGUE &  
MENTAL HEALTH**

**MARION VENUS**



**Correlations and Interactions of  
Professional Pilots'  
Duty Rosters,  
Work-related and Psychosocial Stress,  
Sleep Problems,  
Fatigue,  
Mental Health  
and Well-being**

New insights into known threats to  
flight safety

**Inauguraldissertation**

der philosophisch-humanwissenschaftlichen Fakultät der  
Universität Bern  
zur Erlangung der Doktorwürde  
vorgelegt von

BA Mag. rer. nat. Marion Venus  
Matrikelnr.: 17-135-153

Bern, August 2022

© 2023 Dr. Marion Venus

ISBN	Softcover:	978-3-347-72205-7
ISBN	Hardcover:	978-3-347-72206-4
ISBN E-Book:		978-3-347-72212-5

Printing and distribution on behalf of the author:  
tredition GmbH, An der Strusbek 10, 22926 Ahrensburg, Germany

The work including its parts is protected by copyright. The author is responsible for the content. Any use is not permitted without your consent. The publication and distribution are carried out on behalf of the author, who can be reached at: tredition GmbH, "Imprint Service" department, An der Strusbek 10, 22926 Ahrensburg, Germany.

From the Faculty of Philosophy and Human Sciences at the University of Bern at the request of Prof. Dr. Martin Große Holtforth (main reviewer) and Prof. Dr. Achim Elfering (second reviewer) accepted.

Berne, November 22, 2022  
The dean: Prof. Dr. Stefan Troche

*Ich widme meine gesamte Arbeit meiner  
innig geliebten Omi, Maria Venus  
In ewiger Liebe und Dankbarkeit*



## Preface

Over 100 years ago, flying was an adventure with many fatalities. Later, flying became an absolute luxury. Pilots cultivated an amazing lifestyle, enjoyed high reputation, very pleasant working hours, lots of free time, long stays in fantastic holiday destinations and high income. That changed quickly when politicians and regulators liberalized aviation, and alongside the luxurious, expensive flag or network carriers (NWC, e.g., British Airways, Qantas, Lufthansa), low-cost airlines (LCC) launched a revolutionary new business model with new management strategies (Alamdari & Fagan, 2005; Hunter, 2006; ITF, 2002; Pate & Beaumont, 2006; Štimac et al., 2012; Vidović et al., 2013). LCC opened new markets, offered cheap airline tickets and made aviation accessible not only to the rich, but also to ordinary people. Commercial air operators had to minimize their costs, e.g., hire as few pilots as possible and keep them on flight duty for as long as possible. Also, planes must fly as much as possible, to earn money and maximize productivity, to remain competitive. Pilots' working conditions eroded, and aircrews (i.e., pilots and cabin crew members) had to work more and more hours per month and per year, based on lower salaries due to new work contracts after airline mergers (i.e., merger of Swissair and Crossair, then Lufthansa bought Swiss and Austrian Airlines, with the option for pilots to quit or accept a new contract with lower and lower salaries). LCC started with atypical, precarious work contracts, based on bogus self-employment or employment via an intermediary manning agency (Brannigan et al., 2019; Reader et al., 2016).

After the Germanwings crash, airline management, regulators, passengers and aircrews (incl. pilots) were shocked: Who is the other person on the flightdeck? Can I trust him/her? What happens when I go to the bathroom or rest on the bunk bed? At the same time, every pilot feared long time grounding and finally losing his/her medical class 1 certificate, if their responsible aeromedical examiner (AME) suspected or diagnosed any mental impairment. A German pilot representative told me, "The [AME's] gut feeling is enough. If the AME thinks a pilot might hide some life event or mental health issue: Instead of diagnostics, just a healthy mistrust or a gut feeling that the pilot is almost certainly hiding something, is enough for aeromedical examiners to suspend the medical certification. Often for six months, and nobody knew, why". Attending continuing peer support and CISM trainings at the Mayday Foundation, I heard many background stories regarding the copilot, who intentionally crashed the Germanwings Airbus. When I presented at several scientific meetings of aerospace physicians and aeromedical examiners, I also attended the whole conference and social events. There I had many opportunities to gain insights into AME's mindset, and the reasons for their distrust in pilots. Professional ethics implies, that AMEs, who call their customers (pilots) "*criminal liars and cheaters*" should quit and work with other clients or patient groups. The same for aviation psychologists, which are usually only in charge of pilot selection. Those, who I met at congresses in Sydney or Bangkok

uttered the same ‘compliment’ about their customers, professional pilots of airlines in Australia, the USA and the Middle East. One of them works for a big company, which selects pilots for Australian, Middle Eastern and US carriers. He said something to the effect, *‘It has become popular for pilots to complain that they are suffering from fatigue and sleep problems, while they are simply hiding a pathological anxiety disorder. Pilots are criminal liars and cheaters.’* Quite unethical to talk like that about his clients or patients. Of course, just his opinion, not based on any facts or published scientific evidence. He had heard my presentation, and this was what he wanted to tell me. I was appalled but kept this unethical and – in my professional opinion – simply wrong conclusion in mind, to see if I could prove him wrong, based on my data.

I was deeply interested in the present working-conditions of professional pilots, who fly for different types of carriers (airlines or NWC, LCC, cargo and charter operators), and different types of flight operations (short-haul, medium, and long-haul). I spent hundreds of hours listening to pilots describing their own experiences, analyzing fatigue and mental health issues associated with short-haul and long-haul flight ops, based on their psychological background or long years of self-experience in both areas. I also heard how they managed emergencies and situations like engine failure combined with a collapse of all electronic systems on a skill-check-flight, or stories of severe fatigue in the cockpit, where one or both pilots had fallen asleep without prior coordination.

The Germanwings crash in 2015 (BEA, 2016) was a wakeup call for the aviation system, air operators as well as regulators and passengers. Suddenly we had to realize that pilots were human beings, not just superior computers with brains, operators of avionics and flight systems, the eyes, ears, brain, arms, feet etc. of huge passenger jets. Right after the Germanwings crash, I attended my first aviation safety conference of the European Aviation Safety Agency (EASA). When EASA started to develop new measures to better monitor pilots’ mental health, I could watch and contribute as an expert for clinical and aviation psychology, health and safety management, and being a pilot myself. As pilot I met many senior commanders and pilot representatives. They explained my how aviation has been changing in the last 20 to 30 years. Low-Cost Carriers like e.g., Ryanair usually do not even offer employment contracts to their pilots, but pay pilots per flight hour, not per month. Great from an economic point of view because the air operator does not have to pay pilots when they are ill, on vacation or absent due to extreme fatigue or exhaustion. Not so great for new pilots who start their careers with high loans for self-financed pilot training (costs from 100'000 to 130'000 €). New pilots must fly as much as possible, so that they can cover their living expenses, and survive winter, with only few flight hours, while having to pay back their loan installments, while no unemployment insurance pays. From November until March – beyond peak flight season – pilots can rest and recover a bit, with minimum regular income, and no performance-based additional income due to almost no flight hours off season. Under enormous economic pressure, more duty and flight hours and shorter minimum rests, many psychosocial stressors from low income to high job insecurity, high fatigue may not be pilots’ only problem, as more and more pilots reported high burnout levels (Demerouti et al., 2019; Fanjoy et al., 2010).

I would like to thank my dear friends who have supported my research gratuitously in their meager free time, to name a few: Commander MSc HF Pete Wilson, Commander Michael Gruber BA BSc MA, MSc, PhD Cand. Commander Chris Smith (Senior Lecturer University of Southern Queensland), Prof. Dr. Samira Bourgeoise-Bougrine, Senior

First Officer Michèle Finger, Commander Bastien Kynast (TRI, TRE, CRM), Commander Daya Rishy-Maharaj (Cargo), and Commander Dirk Polloczek (former President of the European Pilots Association), Lachlan Gray (AFAP; flight safety).

My special thanks go to my PhD supervisor Prof. Dr. Martin grosse Holtforth, who was immediately interested in my complex and complicated, multidimensional PhD topic. He patiently guided me through my rough and hot topic and results, which introduced him to the dire, ugly aspects of modern aviation. Two papers won awards in 2021, 1<sup>st</sup> Runner Up of the “Young Investigator’s Award” YIA of the Aerospace Medical Association (AsMA) for “How professional pilots perceive interactions of working conditions, rosters, stress, sleep problems, fatigue and mental health. A qualitative content analysis”, and the 2<sup>nd</sup> place of the Aerospace Medical Association (ASMA) Fellows Scholarship for my presentation at the AsMA meeting 2021 and the publication “Short and Long-Haul Pilots’ Rosters, Stress, Sleep Problems, Fatigue, Mental Health and Wellbeing”



# Content

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	A short History of Pilots' Fatigue and Mental Health Research	3
1.2	Pilot Mental Health or the Pilots' Human Side	3
1.3	A Short History of Fatigue Research	4
1.4	What if FTL and FRM have failed ...?	5
1.4.1	Research Questions of Traditional Fatigue Studies	6
1.4.2	Potential Modification of Behavior and the 'Hawthorne', or 'Rosenthal Effect'	7
1.4.3	Representativity of the Investigated Pilot Samples	7
1.4.4	Fatigue and Sleepiness Self-Reports	8
1.4.5	Measuring the Symptom Sleepiness vs. the Complex Construct of Fatigue	9
1.4.6	The Use of Actigraphy to Measure Sleep	10
1.4.7	Biomathematical Models (BMM)	11
1.4.8	Psychomotor Vigilance Test (PVT) to Measure Fatigue Related Performance Decremens	12
1.4.9	Flight Time Limitations and Working Time Arrangements in General	12
1.4.10	Conclusions	12
1.5	The Relevance of Pilots' Physical and Mental Health for Flight Safety and Regulatory Authorities	13
1.6	A Pilot's Life – Decades ago and Today	14
1.6.1	Examples of Work-related Stressors for Pilots	14
1.6.2	Examples of Psychosocial Stressors Especially for Pilots	16
<b>2</b>	<b>Summary of the Submitted Articles</b>	<b>17</b>
2.1	How Duty Rosters and Stress Relate to Sleep Problems and Fatigue of International Pilots.	21
2.1.1	Aims and Questions	21
2.1.2	Procedure	23
2.1.3	Material	23
2.1.4	Statistical Analyses	25
2.1.5	Participants	25
2.1.6	Results	26
2.2	Interactions of International Pilots' Stress, Fatigue, Symptoms of Depression, Anxiety, Common Mental Disorders and Wellbeing	27
2.2.1	Aims and Questions	27
2.2.2	Participants	28
2.2.3	Procedure	28
2.2.4	Material	28
2.2.5	Statistical Analyses	30
2.2.6	Results	30
2.3	How Professional Pilots Perceive Interactions of Working Conditions, Rosters, Stress, Sleep Problems, Fatigue and Mental Health. A Qualitative Content Analysis (QCA)	31
2.3.1	Aims and Questions	31

2.3.2	Participants	32
2.3.3	Procedure	32
2.3.4	Results	36
2.4	Short and Long-Haul Pilots' Rosters, Stress, Sleep Problems, Fatigue, Mental Health and Wellbeing	48
2.4.1	Aims and Questions	48
2.4.2	Participants	50
2.4.3	Procedure and Material	50
2.4.4	Statistical Analyses	51
2.4.5	Results	51
2.5	Australian and EASA-based pilots' duty schedules, stress, sleep difficulties, fatigue, wellbeing, symptoms of depression and anxiety	52
2.5.1	Participants	55
2.5.2	Procedure and Material	56
2.5.3	Statistical Analyses	56
2.5.4	Results	56
2.6	Comparison of Schedules, Stress, Sleep Problems, Fatigue, Mental Health and Well-being of Low Cost and Network Carrier Pilots	59
2.6.1	Aims and Questions	59
2.6.2	Participants	62
2.6.3	Procedure and Material	62
2.6.4	Statistical Analyses	62
2.6.5	Results	62
<b>3</b>	<b>Discussion</b>	<b>66</b>
3.1	General Discussion	66
3.2	Interactions of International Pilots' Rosters, Stress, Sleep problems, Fatigue, Symptoms of Depression, Anxiety, Common Mental Disorders and Wellbeing (Studies 1 and 2)	67
3.3	How professional pilots perceive interactions of working conditions, rosters, stress, sleep problems, fatigue and mental health. A qualitative content analysis	68
3.4	Short and Long-Haul Pilots' Rosters, Stress, Sleep Problems, Fatigue, Mental Health and Wellbeing	71
3.5	Australian and EASA-based pilots' duty schedules, stress, sleep difficulties, fatigue, wellbeing, symptoms of depression and anxiety	72
3.6	Comparison of Schedules, Stress, Sleep Problems, Fatigue, Mental Health and Well-being of Low Cost and Network Carrier Pilots	72
3.7	Implications for Pilots Fatigue and Mental Health	73
3.8	Limitations	75
3.9	Strengths	77
3.10	Research Implications and Conclusions	77
<b>4</b>	<b>How Duty Rosters and Stress Relate to Sleep Problems and Fatigue of International Pilots</b>	<b>81</b>
4.1	Introduction	85
4.1.1	Flight Time Limitations and Fatigue Prevention	85
4.1.2	Homeostasis, Stress, Allostasis and Allostatic Load	85
4.2	Problem and Purpose	89

4.2.1	Biomathematical Models (BMM), Fatigue Risk Management (FRM) & Resulting Rosters	89
4.2.2	Fatigue & Safety	90
4.2.3	Differentiation Between Sleepiness and Fatigue	90
4.2.4	Stress, Sleep & Fatigue	90
4.3	Method	91
4.3.1	Design and Procedure	91
4.3.2	Subjects	92
4.3.3	Description of the Online Survey	93
4.3.4	Statistical Evaluation	93
4.4	Results	94
4.4.1	Roster Data	94
4.4.2	Fatigue Risks Associated with Flight Duties, Micro-Sleep in the Cockpit and Concerns regarding FTL	95
4.4.3	Pilots' Fatigue Levels and Sleep Problems	97
4.4.4	Intercorrelations of Stress, Fatigue and Sleep Problems	98
4.4.5	Predictors of Sleep Problems	98
4.4.6	Predictors of Fatigue	99
4.5	Discussion	99
4.5.1	Fatigue and Sleep Problems	99
4.5.2	Comparison of our Results with Previous Research	100
4.5.3	Stress, Allostatic Load, Sleep Problems and Fatigue	100
4.5.4	Fatigue and Micro-Sleep in the Cockpit	101
4.5.5	Limitations	102
4.5.6	Strengths	102
4.5.7	Research Implications	103
4.5.8	Conclusions	104
5	<b>Interactions of International Pilots' Stress, Fatigue, Symptoms of Depression, Anxiety, Common Mental Disorders and Wellbeing</b>	105
5.1	Introduction	109
5.1.1	Workload, Stress, Fatigue, Mental Health and Wellbeing	109
5.1.2	Homeostasis, Stress, Allostasis and Allostatic Load	110
5.1.3	Stress and Sleep	110
5.1.4	Flight Time Limitations and Economic Pressure	112
5.1.5	Research Questions	113
5.2	Method	115
5.2.1	Design and Procedure	115
5.2.2	Procedure	119
5.2.3	Subjects	119
5.2.4	Statistical Analysis	120
5.3	Results	121
5.3.1	Pilots' Mental Health and Wellbeing	121
5.3.2	Intercorrelations between Stress, Sleep, Fatigue, Mental Health and Wellbeing	122
5.4	Discussion and Conclusions	123
5.4.1	Pilots' Rosters and Fatigue	123
5.4.2	Pilots' Sleep Problems	123
5.4.3	Pilots' Mental Health and Wellbeing	123
5.4.4	Differentiation of Sleepiness and Fatigue, Fatigue and Mental Health	124

5.4.5	Stress, Sleep and Burnout	124
5.4.6	Research Implications	124
5.4.7	Limitations	125
5.4.8	Strengths	126
5.4.9	Conclusions	127
<b>6</b>	<b>How Professional Pilots Perceive Interactions of Working Conditions, Rosters, Stress, Sleep Problems, Fatigue and Mental Health. A Qualitative Content Analysis</b>	<b>129</b>
6.1	Introduction	135
6.1.1	High Fatigue among Pilots, Stress and Safety relevant Fatigue Consequences	136
6.1.2	Germanwings Crash & Pilot Mental Health	136
6.1.3	'Pilot Pushing' & Burnout	137
6.1.4	Research Questions	137
6.2	Method	138
6.2.1	Procedure	138
6.2.2	Participants	139
6.2.3	Description of the Cross-Sectional Online Survey	139
6.2.4	Qualitative Content Analysis (QCA) by Mayring (2014)	140
6.2.5	Inter-Coder and Intra-Coder Reliability of QCA	141
6.3	Results	143
6.3.1	Summary of the Quantitative Results	143
6.3.2	Frequency Analysis	144
6.3.3	Content of the most relevant Codings	144
6.3.4	QCA: Comparison of Australian vs. EASA-based Pilots	159
6.4	Discussion	160
6.4.1	Limitations	164
6.4.2	Strengths: Advantages of QCA	164
6.4.3	Research Implications	164
6.4.4	Conclusions	165
<b>7</b>	<b>Short and Long-Haul Pilots' Rosters, Stress, Sleep Problems, Fatigue, Mental Health and Wellbeing</b>	<b>167</b>
7.1	Introduction	171
7.2	Method	174
7.2.1	Procedure	174
7.2.2	Subjects	174
7.2.3	Material: Cross Sectional Online Survey and Used Questionnaires	175
7.2.4	Statistical Analyses	176
7.3	Results	177
7.4	Discussion	182
<b>8</b>	<b>Australian and EASA Based Pilots' Duty Schedules, Stress, Sleep Difficulties, Fatigue, Wellbeing, Symptoms of Depression and Anxiety</b>	<b>189</b>
8.1	Introduction	193
8.1.1	Definitions of Sleepiness and Fatigue	193
8.1.2	Stress, Sleep and Health	194
8.1.3	High Fatigue and Micro-sleep despite Fatigue Risk Management and FTL	196
8.2	Research Questions	197
8.2.1	Fatigue, Fatigue Related Performance Decrement and Flight Safety	197
8.2.2	Stress, Sleep, Fatigue and Mental Health	198

<b>8.3 Method</b>	<b>199</b>
8.3.1 Procedure	199
8.3.2 Participants	200
8.3.3 Description of the Cross-Sectional Online Survey	200
8.3.4 Statistical Analyses	202
<b>8.4 Findings</b>	<b>202</b>
8.4.1 Descriptive Results	202
8.4.2 Hypothesis Testing	204
<b>8.5 Discussion</b>	<b>207</b>
8.5.1 Pilots' Mental Health & Wellbeing	208
8.5.2 Fatigue Risks, FTL and Flight Safety	209
8.5.3 Limitations	211
8.5.4 Strengths	212
8.5.5 Research Implications	212
8.5.6 Conclusions	213
<b>9 Comparison of Schedules, Stress, Sleep Problems, Fatigue, Mental Health and Well-being of Low Cost and Network Carrier Pilots</b>	<b>215</b>
<b>9.1 Introduction</b>	<b>219</b>
9.1.1 Problem	219
9.1.2 Definitions of Fatigue	220
9.1.3 Fatigue and Mental Health Issues Among Pilots	220
9.1.4 Accumulated Fatigue and Micro-Sleep in the Cockpit	221
9.1.5 Multiple Stressors for Aircrews	222
9.1.6 Research Questions and Hypotheses	222
<b>9.2 Material and Method</b>	<b>223</b>
9.2.1 Procedure	223
9.2.2 Participants	224
9.2.3 Material	224
9.2.4 Statistical Analysis	226
<b>9.3 Results</b>	<b>227</b>
<b>9.4 Discussion</b>	<b>232</b>
9.4.1 Limitations	234
9.4.2 Strengths	235
9.4.3 Conclusions	235
<b>10 List of Figures</b>	<b>237</b>
<b>11 List of Tables</b>	<b>239</b>
<b>12 Supplemental Materials</b>	<b>244</b>
12.1 Used Standardized Questionnaires	244
12.2 Supplemental Material Study 3	246
12.2.1 Coding Guidelines	246
12.2.2 Category System	251
12.3 Supplemental Material Study 5	257
12.4 Supplemental Material Study 6	258
<b>13 References</b>	<b>259</b>
<b>14 Statement of Authorship</b>	<b>273</b>



## **List of Abbreviations**

FTL	Flight time limitations
FRM	FRM
BMM	Biomathematical Models
FDP	Flight duty period
EASA	European Aviation Safety Agency
ICAO	Civil Aviation Safety Authority
FAA	Federal Aviation Administration
CMD	Common mental disorders
ICAO	International Civil Aviation Organization
CMD	Common mental disorders
SOP	Standard Operational Procedures
PHQ8	Patient-Health-Questionnaire-8
GAD7	Generalized Anxiety Disorder-7
SRQ20	Self-Reporting-Questionnaire-20
PHQ-Stress	Patient-Health-Questionnaire-Stress
FSS	Fatigue Severity Scale
JSS	Jenkins Sleep Scale
WHO5	World Health Organization -5 Well-being Index
Flight ops	Flight operations



## **Abstract**

The aim of this dissertation was to examine two so far separately considered complex constructs, fatigue and mental health, concerning a target group that has to cope with high stress, extraordinary workload, high risks and responsibility: professional pilots. The complexity of the psychophysiological construct fatigue should be highlighted. Potential correlations and interactions of stress with fatigue, sleep problems, mental health and well-being should be investigated. It seemed necessary to consider pilot fatigue not only in the context of sleep medicine, but also in context with the Theory of Allostasis, clinical, work psychology and burnout research. Studies one and two investigated, if our comprehensive dataset of 406 pilots would support the Theory of Allostasis. Complex analyses confirmed that acute and chronic work-related and psychosocial stress were significantly associated with more psychophysiological wear and tear processes like high fatigue, sleep problems, impaired well-being and more symptoms of depression, anxiety, and CMD. The third study was a Qualitative Content Analysis of pilots' experiences, which perfectly confirmed the quantitative results of all five studies and the Theory of Allostasis. Studies 4, 5 and 6 compared groups of pilots. Australian pilots were slightly more affected than EASA-based pilots. Short-haul pilots of low-cost-carriers were most affected, reporting excessive fatigue, the most sleep problems, the most symptoms of depression, anxiety and CMD, and the most impaired well-being. These first six exploratory studies have not received any funding but have identified important new research topics. These complex, new results should be the basis of future research regarding pilots' fatigue, health and flight safety in general.

