

Estimating the Impact of Work Related Stress on Pilot Wellbeing and Flight Safety

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Abstract. This paper presents a preliminary account of the relationship between pilot wellbeing, pilot performance and flight safety. Drawing on prior research relating to the biopsychological model of pilot lived experience, three workshops involving the participation of thirty-three commercial pilots were undertaken. Pilot wellness is a significant performance shaping factor in terms of ensuring optimum performance. Overall, pilots are managing wellbeing issues. Pilots try to normalize/adapt to the job. However, there is much variation in relation to coping ability. This variation needs to be considered in relation to modelling performance and safety impact. Six scenarios were identified. Of these, participants suggested that the primary focus should be on the prevention of Scenario 3 (i.e. pilot not coping on the day - impacting on flight safety) and Scenario 5 (i.e. pilot suffering which ends in harm to the person). Overall, pilots need to be trained in relation to (1) coping strategies and (2) risk identifying behavior.

Keywords: Wellness, Work Related Stress, Pilot Performance, Flight Safety

1 Introduction

The local actions of the flight crew are affected by a variety of immediate influences or performance shaping factors (PSF) [1]. This includes external PSFs such as environmental conditions and procedures, and internal PSF's such as emotional state, physical condition and stress levels. PSFs are considered to substantially increase the likelihood of human error [2].

Work Related Stress (WRS) is defined as the response people may have when presented with work demands and pressures that are not matched to their knowledge and abilities, and which challenge their ability to cope [3]. Things outside the workplace, like family problems, or debt can be responsible for stress (personal stressors). A person experiencing stressful life events may find that he/she is less able to cope with the demands of work, even though work is not the cause and/or may not have been a problem before.

Pilots can be considered as both "shift-workers" and "remote-workers". Numerous studies indicate that these types of work can be detrimental to one's wellbeing [4], [5], [6]. Duties consisting of long work hours have also been examined [7-12], and such duties are shown to increase the risk of;

- Anxiety, depression, increased neuroticism and impaired cognitive function
- Reduction in quality and quantity of sleep
- Widespread complaints of fatigue
- Increased risk of adverse cardiovascular effects
- Increased risk of type 2 diabetes
- Possible increase in gastrointestinal effects
- Marital strain, family dysfunction and social marginalization

Psychological problems amongst aircrew present a threat to flight safety, given the ensuing impairments to task performance [13]. Stress (arising from stressors both inside and outside work) impacts on the socio-cognitive dimensions of performance including decision making, teamwork and communication [14].

Recent research has attempted to understand the impact of WRS on pilot wellbeing (including mental health). This research suggests that aspects of the job are impacting on pilot's physical, social, and emotional/psychological health [15], [16], [17]. It is estimated, that 80% of accidents have human error as a causal factor [18]. Since 1982, approximately 1% of fatal accidents (>1,400) have resulted from the deliberate actions of the pilot [19]. Following the Germanwings 9525 accident (2015) [20], the issue of pilot suicide and detecting/managing mental health issues amongst pilots has been gaining increased attention. Surprisingly, there has been less of a focus on (1) understanding/measuring routine suffering amongst pilots, (2) understanding/measuring the relationship between work related stress, pilot wellbeing and safety, (3) understanding how pilots adapt to WRS and identifying pilot coping/self-management techniques and (4) validating existing safety performance indicators in relation to WRS and wellbeing/MH. Potentially, pilot wellbeing can be considered a significant performance shaping factor (PSF) in ensuring safe performance. If (a) like the general population, pilots are at risk of developing wellbeing/MH issues, and (b) wellbeing/MH is a PSF, then wellbeing/MH potentially is a contributory factor to some of the 80% of the 99% of fatal accidents deliberately caused by pilots.

To this end, this paper presents the findings of recent action research with commercial pilots, which attempts to unpack these issues, to estimate the impact of WRS and associated wellbeing issues, on both pilot performance and flight safety. As part of this, it introduces six wellbeing and safety scenarios which form the basis of a preliminary account of the relationship between work related stress, pilot wellbeing, pilot performance and flight safety. First, the background to this research is introduced. An overview of the research methodology is then provided. Following this, the main workshop findings are presented and discussed. Areas for further research and next steps are then outlined. Lastly, some preliminary conclusions are drawn.

2 Background

2.1 Wellbeing

The term "wellbeing" includes various aspects of the way people feel about their lives, including their jobs, and their relationships with the people around them [21]. According to biopsychosocial models of health and wellbeing [22], [23], [24], the cause, manifestation and outcome of wellness and disease are determined by a dynamic interaction between biological, psychological and social factors. None of these factors in isolation are sufficient to lead definitively to wellness or illness. Instead, it is the interrelationships between all three pillars that leads to a given outcome.

It is estimated that 33% of the population experience mental health issues at some stage in their life [25] while 16% will experience mental health issues at any given time [26].

2.2 Pilot Job, Types of Operations & Lived Experience

In many ways, pilots are in a unique occupational group. The job of a commercial pilot is challenging, both physically, mentally and socially.

Working hours in a typical week can vary greatly from week to week and are regulated in accordance with several parameters, such as Duty Time and Block Time, as defined by the European Aviation Safety Agency (EASA). Duty Time is the time the pilot spends at the disposal of the airline, whereas Block Time is the time spent when the aircraft is moving. Duty Time restrictions tend to apply more on a daily basis. European pilots are generally restricted to a 13-hour duty limit, which can be reduced depending on how many flights are flown and by how much the duty overlaps the Window of Circadian Low (WOCL). This limit can also be increased if an additional pilot is carried, thus allowing in-flight rest. Block Time limits generally are longer term limits, with pilots limited to 100 hours in a rolling 28-day period, 900 hours in a rolling 365 days and 1,000 hours in a calendar year. The overall intensity of the operation can also vary greatly, typically with busier Summers and quieter periods during the Winter.

The particular working routines of pilots vary according to the type of operations they fly. Three types of operations can be distinguished - namely short, medium and long range. These different types of options pose diverse wellbeing challenges. For example, pilots working long range are more likely to spend periods of time away from home – impacting on the home/work interface and their ability to maintain social routines. Pilots operating short range tend to experience intense working days – potentially, involving three to four takeoffs and landings. This type of operation, despite accruing relatively low Block Hours, involves high workload. In medium and long range, the Block Hours may be higher, with longer periods of rest/down time while on duty (i.e. cruise periods), and typically longer duty periods.

Pilots experience much disruption to their sleeping and eating patterns. Specific patterns may also vary according to the operations flown. For example, if flying short range, duty might involve a week of 'earlies' (i.e. starting at 5am), followed by a week of 'lates' (finishing at 2am) – resulting in disruption of the circadian rhythm associated

with sleeping and eating patterns. As reported by Wright et al [27], mental fatigue and sleepiness may rise to unacceptably high levels during civil air operations given relatively long duty periods that may coincide with disruption of the circadian rhythm due to time zone shifts.

2.3 Mental Workload, Performance & Wellbeing

Mental workload refers to the amount of information processing capacity necessary for a person to complete a task during a specified time-period [28]. The relationship between mental workload and fatigue is well documented. Research indicates that high levels of mental workload can lead to mental fatigue [29]. Equally, mental fatigue can impact on workload/task management, along with other cognitive dimensions of the pilot performance – such as attention and decision making [14].

High workload is also associated with stress [30] – which in turn has an impact on wellbeing. However, the specific relationship between wellbeing and mental workload is under-researched.

2.4 Fatigue, Performance & Mental Health

The relationship between fatigue and performance is well documented. As reported by Caldwell (1997), shift work and long hours of duty exacerbate jet lag among aircrew [31]. This can lead to pilots becoming more tired and drowsy, and it may impair their focus and attention, thereby increasing the risk of errors [31]. According to Dinges and Kribbs (1991), specific impairments associated with drowsiness include slow reaction times, reduced vigilance, and deficits in information processing [32].

Moreover, the relationship between fatigue and aspects of mental health is receiving increased attention. A recent cross-sectional survey of >700 pilots investigating self-reported anxiety and depression, reported that 54.4% suffered from feelings of being depressed and/or anxious in the previous 12 months [33]. Respondents who typically spent longer hours on duty per week (>40 hours vs. <25 hours) were three times more likely to report feeling anxious or depressed [33].

Further, in a 2016 Harvard study, >1,800 pilots responded to the Patient Health Questionnaire 9 (PHQ-9). 12.6% of participants, and 13.5% of those who reported having flown an aircraft in the previous seven days, met the threshold for clinical depression, and 4.1% reported having suicidal thoughts within the past two weeks [34]. The authors recommended that “airline organizations increase support for preventative mental health treatment”, and called for further research to evaluate additional risk factors of depression such as sleep and circadian rhythm disturbances [34].

2.5 Coping Methods of Airline Pilots

It has been demonstrated that overall mental ill health has a very close association with lack of autonomy at work, fatigue, the inability to relax, and the lack of sufficient social support [21]. In an airline marriage, the spouse can function as a very helpful social support system, thus aiding the pilot in dealing effectively with psychosocial stressors

[35]. Pilots suffering marital distress are less able to concentrate effectively on their piloting duties and responsibilities [36]. On the other hand, the positive social support provided by romantic/spousal relationships can be undermined by antisocial work practices. The effect of life disruptions on pilots who frequently leave home to perform their flying duties is not fully appreciated. Bennett (2006) highlights the importance of social support obtained from fellow pilots, reporting that team members' mutual support, camaraderie and cohesion enhance their resilience to internal pressures (for example, busy rosters), and external pressures (for example, adverse weather, technical faults, delays and unruly passengers)" [37].

3 Research Design & Methodology

3.1 Introduction to Research & Research Question

Overall, this research seeks to investigate the relationship between work related stress (WRS), pilot wellbeing, pilot performance and flight safety. To this end, this research poses several related questions:

1. How do pilots currently perceive wellbeing and mental health issues?
2. Does the job impact on wellbeing?
3. Are pilots suffering because of the job (sources of WRS)?
4. What are the sources of WRS?
5. Do wellbeing issues have an impact on performance/safety?

3.2 Introduction to Workshops & Associated Workshop Objectives

Drawing on prior research relating to the biopsychological model of pilot lived experience [15], [16], [17], three workshops were undertaken with thirty-three commercial pilots (workshop 1: N=12, workshop 2: N=10, workshop 3: N=11). Specifically, the workshops had three objectives:

- To validate prior research relating to the impact of the job/WRS on pilot wellbeing.
- To map the relationship between WRS, pilot wellbeing, pilot performance and flight safety.
- To validate preliminary workshop findings related to the relationship between WRS, pilot wellbeing, pilot performance and flight safety.

Overall, the workshop methodology integrated participatory evaluation [38] and stakeholder evaluation approaches [39].

3.3 Procedure

In each case, participants were provided with briefing information seven days in advance of the workshop. The briefing included information about the biopsychosocial model of pilot lived experience (see Appendix 2), sources of work related stress (WRS)

and a preliminary safety case outlining the potential relationship between WRS, pilot wellbeing, pilot performance and flight safety (see Appendix 3). This briefing information reflected a summation of prior research undertaken by the authors with commercial pilots [8]. Prior to commencing each workshop, participants were briefed about confidentiality issues. All participants then provided written consent - agreeing to maintain confidentiality in relation to anything disclosed by workshop attendees. Participants were then provided with a short presentation pertaining to the biopsychosocial model of pilot lived experience, the preliminary safety case and associated worked examples.

In workshop 1, participants were invited to review both the model, the safety case and associated worked examples. This was followed by a group discussion concerning the relationship between WRS, pilot wellbeing, pilot performance and flight safety. In workshop 2 and 3, the findings of workshop 1 were presented to participants. This included six scenarios pertaining to the impact of WRS on wellbeing, performance and flight safety. Participants were invited to review/validate the six scenarios. Following this, there was a general discussion about the relationship between WRS, pilot wellbeing, pilot performance and flight safety.

All participants were invited to complete a homework exercise after the workshop. All participants were debriefed, at the end of each workshop. The debriefing included information about follow up supports and confidentiality. For more information about workshop procedures, please see Appendix 1.

3.4 Participants

Overall, thirty-three commercial pilots (spanning three airlines) attended the workshops. Workshop participants had on average 9,178 hours of flying experience, and included 20 Captains and 13 First Officers. Of the 33 participants, 7 were female and 26 were male. 8 participants had part time work contracts, while 25 were working full-time. In terms of flight operations, this included 4 short range, 7 long range, and 22 mid-range pilots.

3.5 Ethics

This research obtained ethics approval from the School of Psychology, Trinity College Dublin (TCD), Ireland.

4 Results

4.1 Pilot Wellbeing/Mental Health

It was agreed that pilots may be reluctant to stand down or disclose mental health problems, given real concerns over the potential impact of this on their job (i.e. fears of losing their license and/or possible impact on future career progression). Participants also stated that the prevailing culture (i.e. machoism and stigma associated with mental

health issues) presents significant challenges. As reported by participants, this contributes to a situation where there is a lack of awareness/openness about MH issues, MH issues are not being identified, and MH issues are not being addressed.

4.2 WRS & Unique Features of Pilot Job

In terms of the experience of WRS, pilots have much in common with other (a) shift workers, (b) remote workers, and (c) workers involved in safety critical/high stress operations (for example, Paramedics and Firefighters). This includes a high degree of responsibility, fatigue, limited breaks, working anti-social hours and shift work. Participants suggested that what is unique to pilots is (a) the combination of factors that exist and (b) the specific way in which these factors interact. Participants emphasized the 'unnatural' location of the work environment. It was stated that the remote and confined nature of the cockpit imposes certain physical, social and psychological constraints on pilots. As characterized by participants, *'ambulance drivers can step out of the vehicle, stretch their legs and talk to somebody'*. As stated by one participant, *'we are five miles up in the sky with an aircraft strapped to us'*. Unlike other occupations, *'there is no getting out of the aircraft'*.

4.3 Sources of Work Related Stress (WRS)

Overall, there was a consensus that *"year to year, the job is getting harder"*, that *"it is significantly harder than ten years ago"* and that *"pilots are working hard consistently through the year now, and there is no let up, or opportunity to recharge the batteries"*. It was agreed that both work and personal stressors either (1) acting on their own and/or (2) acting together, put pilots in a situation where they are at increased risk of developing a MH issue, and/or worsening a pre-existing MH issue. Participants highlighted the potential impact of personal stressors which can be intensified/made worse by certain features of the job (for example, time away from home and inability to contact family while in work).

Participants provided feedback as to sources of WRS and the potential impact on pilot wellbeing. Participants indicated that the key sources of WRS include the following:

1. Fatigue, potentially leading to burnout
2. Unnatural workspace (5 miles up in the sky)
3. Sleep disruption
4. Lack of breaks
5. Time away from home
6. Close confines of cockpit
7. Social isolation
8. Having different goals and values to management
9. Lack of management engagement with pilots
10. Lack of support from flight operations and management
11. Imposed sedentary nature of job

A full list of sources of WRS (aggregate of 3 workshops) is provided in Appendix 4.

Participants noted that certain challenges are associated with different types of operations (short, mid and long range). For example, multi-sector days can be very tiring, with little or no breaks. However, in such operations, “*pilots generally end up home at end of the day*”. In long range operations (Ireland to USA), pilots obtain breaks. However, much time is spent away from home and crew can feel quite isolated.

Specific feedback was provided in relation to all three pillars. For more information, please see Appendix 5, 6 and 7.

4.4 Impact of wellbeing on Pilot Performance and Flight Safety

Overall, participants agreed that pilot wellbeing is a significant factor in ensuring optimum performance and flight safety. Further, it was agreed that safety is compromised, if a wellbeing issue is not addressed.

Participants agreed that aspects of the job cause stress, which in turn impacts on performance and by implication, flight safety. Further, life events (i.e. personal stressors) occurring outside of work can influence performance at work. In addition, the intensity/complexity of operational situation on the day can cause stress (i.e. bad weather, difficult interactions with management, operational & ground staff, complex routing and so forth). If prior stress exists, such operational complexity can worsen any pre-existing stress. Critically, in mapping the impact of WRS on pilot performance and flight safety, three distinct strands/sources of WRS must be considered

- General features of the job that cause stress/increase risk of MH Issue (i.e. what is in the model of lived experience)
- Current personal stressors (i.e. sick parent or child, unpaid mortgage, relationship problems)
- Current operational situation

In relation to conceptualizing the impact of wellbeing on performance and flight safety, participants noted that there are many factors to consider, and the specific impact of these factors on performance and flight safety is hard to quantify. Participants remarked that both (a) the specific constellation of factors occurring at any one time (i.e. general features of job/WRS, personal stressors, the operational situation), (b) how these factors might interact and (c) how these factors might potentially impinge on wellbeing and by implication performance and flight safety, is hard to predict. This is complicated by the fact that individual differences in relation to pilot coping ability must be considered. As reported by participants, Pilots are coping all the time. As stated by one participant, ‘*pilots are managing stress, adapting to the job and its challenges, and not having safety events/accidents*’. As stated by participants, ‘*some pilots cope better than others*’. Specifically, ‘*they have developed strategies to cope with the challenges they face*’. It was noted that the general estimation amongst pilots is that ‘*70% cope well, while 30% find adapting more difficult*’. However, participants agreed that ‘*pilots show up to work and tick all the boxes*’. Further, ‘*things don’t give until the very*

end'. As observed by participants, the fact that pilots are coping, presents its own risk. Critically, this masks the suffering that is experienced by pilots, and gives the impression that safety risks are being managed.

In terms of specific impacts on performance, participants highlighted issues around impact on cognition, workload management, teamwork and communication. Specifically, participants referred to the following:

1. Potential reduction in situation awareness
2. Impaired decision making
3. Inability to focus on the current task
4. Difficulties managing multiple tasks/workload
5. Task omissions
6. Reduction in quality of error identification and management behavior
7. Poor quality communications with fellow pilot
8. Withdrawal of pilot (not communicating)

4.5 Estimating Impact & Preliminary Safety Case/Worked Examples

In relation to workshop 1, the initial safety cases/worked examples were presented to the group. For an example of this (psychological pillar), please see Appendix 3. It was noted that the initial safety case seemed contrived. Participants suggested that the worked examples should (a) involve WRS issues which span the three pillars of wellbeing, (b) consider the specific operational circumstances on the day, (c) consider pilot coping ability (and variance), and (d) consider the risk mitigating role of the other pilot.

4.6 Estimating Impact & Example Scenarios

In workshop 1, participants proposed six scenarios that might be considered in relation to conceptualizing the potential impact of WRS on wellbeing, performance and flight safety (see Table 1). As pointed out by participants, not all scenarios have direct implications in relation to performance/flight safety. For example, see scenarios (4) and (5). In terms of modelling impact of WRS on wellbeing, pilot performance and flight safety, participants noted that the more typical situation is scenario (1). As reported by participants, this scenario reflects the typical situation of most pilots. It was stated that scenario (3) is the most likely scenario in relation to specific impact on safety and this is where attention should be focused.

Table 1. Wellbeing Scenarios

#	High Level Scenario	Frequency
1	Pilots mostly coping well – pilots may make the odd mistake but will identify this and correct actions/behavior – no safety impact/negligible	Frequent

2	Pilots mostly coping well, but impacts on physical health (i.e. GI issues and musculoskeletal problems) - - no safety impact/negligible	Frequent	
3	Pilots experiencing difficulties but mostly coping – however, something gives on the day – potential for safety event – but managed by other pilot, who acts as barrier to safety event	Infrequent, does happen	but
4	Pilots mostly coping well, but long-term impacts on health (evidence when on annual leave, or when retire) – sudden illnesses, early death	Frequent	
5	Pilots not coping – impact on wellbeing – stop working, develop MH issues, worst case is self-harm and suicide – no safety impact	Infrequent, does happen	but
6	Extreme cases – murder-suicide (Germanwings) – implication for safety /fatal accident	Exceptionally rare	

In relation to scenario (1), participants noted that this reflects day to day operations. Pilots are suffering, but they are also adapting and coping. Periodically, this suffering has an impact on performance – but this impact is typically managed (i.e. the pilot recognizes/identifies mistake/omission, and there is minimal safety impact).

Participants agreed that many pilots experience scenario (2). The specific impacts on wellbeing (i.e. GI issues and musculoskeletal problems) are quite common, but do not impact on performance and flight safety.

Overall, it was suggested that research focus on scenario (3), where there is a potential for something more serious/safety event. Typically, in such a scenario, a chain of events ensues. At a certain point, the pilot stops coping and ‘*goes over the edge*’. Importantly, this does not always lead to a ‘crisis situation’ and/or ‘safety event’. Performance issues are managed by the other pilot. As such, the other pilot acts as a barrier in mitigating the potential safety impact. In relation to their own direct experience, workshop participants provided several examples of such cases.

Scenarios (4) and (5) primarily focus on the impact of WRS on wellbeing. In relation to scenario (5), participants noted that this situation is very real and is not discussed. In relation to workshop 1, all twelve participants were familiar with such cases (i.e. aware of other pilots who are suffering or who have committed suicide). All participants noted that there should be a stronger focus on preventing suffering/harm to pilots. In relation to workshop 2, five of the participants had direct personal knowledge of such cases. In relation to workshop 3, several participants had direct personal knowledge of such cases.

As stated by participants, it was noted that scenario (6) specifically pertains to a person who might have a pre-existing MH issue. Currently, such a person is not obtaining adequate supports at an airline level. Participants noted that such a scenario is comparable to the Germanwings accident. Participants noted that pilots commuting/foreign First Officers based away from home are at risk (i.e. might be suffering from fatigue

and experiencing significant social isolation). Further, if there is a pre-existing MH issue, then this risk is amplified.

4.7 Scenarios & Further Elaboration of Impact

In workshops 2 and 3, participants provided feedback about the scenarios defined in workshop 1 – specifically in relation to impact on (1) wellbeing, (2) performance and (3) safety. In relation to (2), participants also provided an estimation of the frequency such a situation would arise. It should be noted that this estimation was subjective.

Table 2. Wellbeing Scenarios & Performance/Safety Impact

#	High Scenario	Level	WRS	Wellbeing Impact	Impact Performance	Frequency
1	Pilots coping well	mostly	Any pillar – include fatigue, social isolation	Minor impact	Minor impact Sometimes performance degraded – might miss something like ATC instruction, but will notice and correct action	Frequent
2	Pilots coping well, but impacts on physical health (GI, musculoskeletal problems)	mostly	Mostly biological pillar	Minor impact – suffering in daily life	Minor impact Sometimes performance degraded – might miss something like ATC instruction, but will notice and correct action	Frequent
3	Pilots experiencing difficulties but mostly coping – however, something gives on the day – potential for event but co-pilot acts as barrier –	experi-	Complex combination of personal factors, work factors and operational	Significant/considerable impact	Loss of attention Impact on situation awareness, decision making and teamwork Protection of co-pilot means	Infrequent

	compensate for the other pilot	situation on the day		avoid safety critical scenario	
4	Pilots mostly coping well, but long-term impacts	Any pillar – include fatigue, social isolation etc	Long term impact on health – develop illness when on annual leave or when retire	N/A	N/A
5	Pilots not coping – impact on wellbeing	Complex combination of personal factors and work factors	Significant impact - suffering in daily life – stop working – potential for serious MH issues including self-harm and suicide	N/A	N/A
6	Extreme cases – murder/suicide (Germanwings) – media attention - implication for safety – very rare –should not be the immediate focus	Potentially pre-existing MH issue	Major impact	Major impact	Exceptionally Rare
Impact – no impact/neutral, negligible impact, minor impact, significant/considerable impact, major impact					
Frequency: exceptionally rare, rare, infrequent, frequent, very frequent					

5 Discussion

5.1 Establishing Prevalence of MH Issues & Impact on Wellbeing

Workshop feedback highlights the need to establish the prevalence/incidence of MH issues amongst pilots and the overall impact of the job on pilot wellbeing. This might take the form of an anonymous survey (i.e. non-jeopardy). Without a measure of the extent of this problem and how it is impacting on pilots, it may be hard to convince

other stakeholders (for example, both pilots and airlines) of the need to address this issue.

5.2 Conceptualizing & Measuring Safety: Have we got it right?

Currently, we are measuring safety solely by the number of “aircraft crashes”. The application of this measure leads (1) to judgements that we are ultra-safe, (2) to risk/safety management approaches that focus on near misses, safety events and accidents and (3) the application of safety performance indicators that focus on the socio-cognitive dimensions of performance (i.e. situational awareness and teamwork) and associated ‘aircraft state’ outcomes (i.e. flight level busts, overspeed in approach, runway over-runs etc). Critically, this research indicates that we need to question the validity/appropriateness of such an approach. Specifically, we need to question the current avoidance/overlooking of using metrics and safety performance indicators that address certain fundamental dimensions of human performance, such as factors associated with pilot wellbeing and WRS.

Potentially, the current framework and associated metrics and KPI result in a false/incomplete picture in relation to (1) understanding routine performance (i.e. pilots adapting/safety being maintained), (2) understanding why accidents happen and (3) making flight safety estimates. Given this, it could be argued that there are vulnerabilities in the existing approach to risk/safety management (i.e. proactive techniques are not considering MH/wellbeing and dimensions linked to WRS). As indicated in this research, if we use a different evaluation metric (for example, consider metrics and KPI linked to wellbeing and WRS), we might conclude that we are far from “Ultra-Safe” and that a significant number of safety risks (i.e. wellbeing/MH) are not being managed. Moreover, we are missing important outcomes linked to pilot suffering and wellbeing (see scenario 2, 4 and 5).

Crucially, this research indicates that pilots are coping with significant challenges/sources of WRS (scenario 1). If WRS leads to a potential error (scenario 3), this is typically identified and managed by the co-pilot. The fact that pilots are adapting/coping and working effectively as part of a team is important. But it should not be used to underestimate or mask safety issues, or wellbeing impact (scenario 2, 4 and 5).

5.3 Addressing Routine Suffering

Recent attention on the potential safety impact of MH issues (for example, Germanwings/Scenario 6), does not serve the overall needs of pilots. More attention needs to be given to issues around routine suffering and its impact on both wellbeing (i.e. scenario 4 and 5) and safety (i.e. scenarios 1, 2 and 3).

5.4 Managing Wellbeing issues

Pilot wellbeing/MH issues need to be treated as both an Occupational Safety & Health (OSH) issue and a Flight Safety issue, and roles need to be defined and funded, so that

appropriate supports for pilots can be provided. As highlighted by workshop participants, much work is required in relation to promoting awareness of wellbeing/MH problems amongst pilots and normalizing this issue. In relation to both pilot culture and airline/organizational culture, MH issues for pilots need to be destigmatized. Pilots need to be encouraged to put their hands up if they are experiencing difficulties. Critically, pilots will not do this if they believe the outcome will be punitive (i.e. loss of license, impact on career progression). The current perceived punitive culture presents a clear threat to the wellbeing of pilots, and to flight safety.

At an early stage (i.e. initial Human Factors training), pilots need to be trained in terms of (a) self-managing wellbeing issues and (b) risk identifying in relation to their own wellbeing/MH (i.e. detecting potential for problem/problem in self and managing this). In relation to (a), current training does not focus on the promotion of resilience and the development of coping skills (i.e. learning how to be resilient to challenges and practice self-management techniques). In relation to (b), checklists might be developed to support pilots to identify MH risks. This might build on prior research in relation to the application of TEM concepts to the specification of an intelligent flight plan, supporting pre-flight planning and briefing [40], [41].

5.5 Fatigue, Flight Time Limitations & Pilot Wellbeing

European Airline Pilots are exempt from the European Working Time Directive 2003 [42]. Instead, duty hours and rest periods are governed by Flight Time Limitations (FTLs), the purpose of which is to ensure air safety by protecting against the effects of fatigue [43, 44]. While intended to protect against the risks posed by tired pilots, FTLs do not protect against the other issues that pose a challenge to maintaining the different biopsychosocial dimensions of pilot wellbeing (for example, time away from home, working anti-social hours etc.).

5.6 Single Crew Concepts

Given the mitigating role of the ‘other pilot’ in terms of acting as a safety barrier (see Scenario 3), this raises issues in relation to the safety implications of single crew operations. As indicated in this research, the potential for a safety event might increase, without the supporting role of the second pilot. Further, as identified in the biopsychosocial model of pilot lived experience, social isolation and lack of peer support is a risk factor in relation to the development of MH issues.

5.7 Limitations of Research, Areas for Further Research & Next Steps

The findings presented reflect preliminary research involving a small number of participants (total of 33). Participant estimations of impact of sources of WRS on (1) wellbeing, (2) performance, and (3) flight safety are subjective. The specific estimations reflect the consensus view of participants attending Workshop 2 and 3. In relation to conceptualizing and measuring the impact on wellbeing and on performance/safety, further work is required. Critically, the six scenarios (and associated dimensions and measures

defined in Table 2) provide an initial explanation of the relationship between WRS, pilot wellbeing and flight safety. Evidently, these six scenarios require further validation with commercial pilots and other stakeholders. It is anticipated that such feedback (scenario definition, frequency, impact) will be elicited as part of an upcoming wellbeing survey.

6 Conclusions

There is evidence that pilots are under stress and experiencing wellbeing/mental health problems. Specific features of the job can result in wellbeing problems and increase a pilot's risk in relation to developing a MH issue. Further, personal stressors (i.e. factors outside the job), can be intensified/worsened given specific features of the job.

Pilot wellness is a significant performance shaping factor in terms of ensuring optimum performance. Overall, pilots are managing wellbeing issues. In general, pilots try to normalize/adapt to the job. However, there is much variation in relation to coping ability. This variation needs to be considered in relation to modelling performance/safety impact.

Six scenarios were identified. Of these, participants suggested that the primary focus should be on the prevention of Scenario 3 (i.e. something giving on the day, impacting on flight safety) and Scenario 5 (i.e. pilot suffering which ends in harm to the person). The relationship between positive mental health and pilot professionalism and flight safety needs to be understood and supported at different levels. The goal is not simply to prevent catastrophes. Rather it is to deal with wellbeing issues among pilots (routine suffering/adapting) and address safety implications (Scenario 3). Not all MH issues result in a fatal accident/catastrophe (Scenario 6).

Potentially, the current framework and associated metrics and KPI result in a false/incomplete picture in relation to (1) understanding routine performance (pilots adapting/safety being maintained), (2) understanding why accidents happen and (3) making flight safety estimates. Given this, it could be argued that there are vulnerabilities in the existing approach to risk/safety management (i.e. proactive techniques are not considering MH/wellbeing and dimensions linked to WRS).

Overall, pilots need to be trained in relation to (1) coping strategies and (2) risk identifying behavior. Safety is enhanced when a wellbeing issue is addressed and supported, as opposed to allowing it to go undiagnosed and untreated. Pilots with wellbeing/mental health difficulties for the most part are perfectly able to continue to do their jobs, especially with support. Mental health is a normal part of health and needs to be treated and/or managed accordingly.

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Appendix 1: Workshop Procedures

Table 3. Workshop Procedures

#	Topic
1	Welcome
2	Introduce team and explain objectives
3	Participants provide written consent and complete profile form
4	Introduce model – background, research overview
5	General discussion (feedback on model)
6	Validate model with group
7	Introduce safety case
8	Validate safety case with group
9	Overview of homework/feedback (optional)
10	Debriefing, thanks & Wrap up

Appendix 2: High Level Biopsychosocial Model of Pilot Wellbeing – The Lived Experience

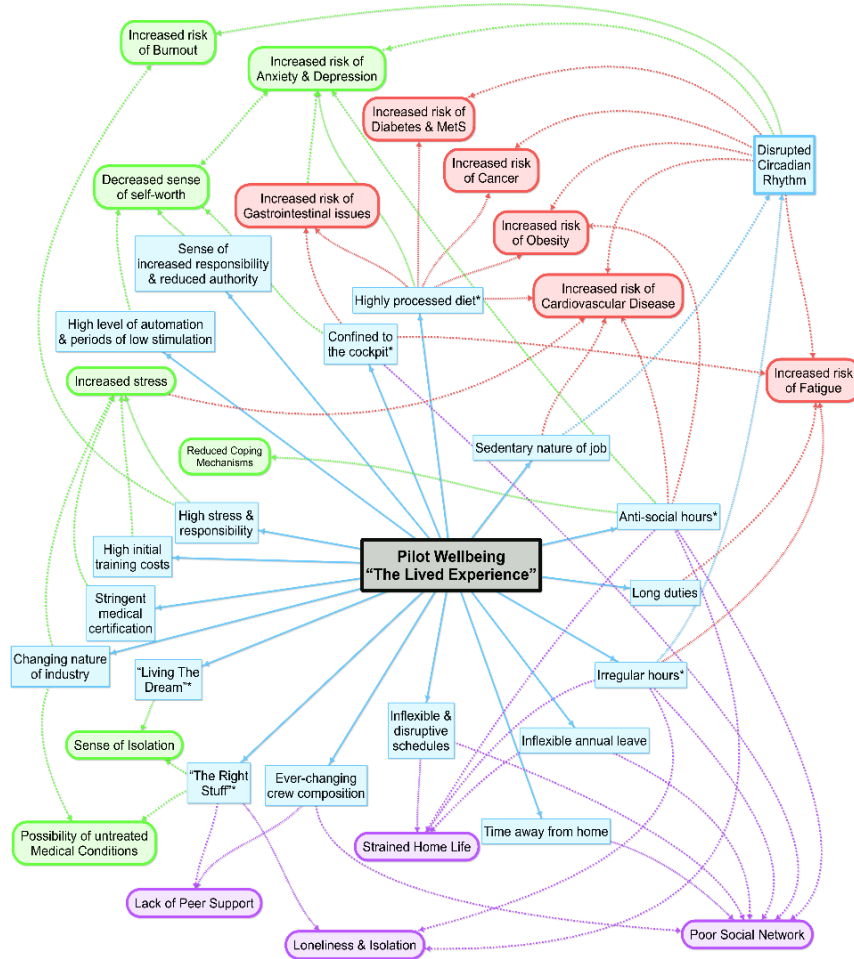


Fig. 1. Biopsychosocial Model of Pilot Wellbeing: The Lived Experience

Appendix 3: Preliminary Safety Case (Psychological Pillar)

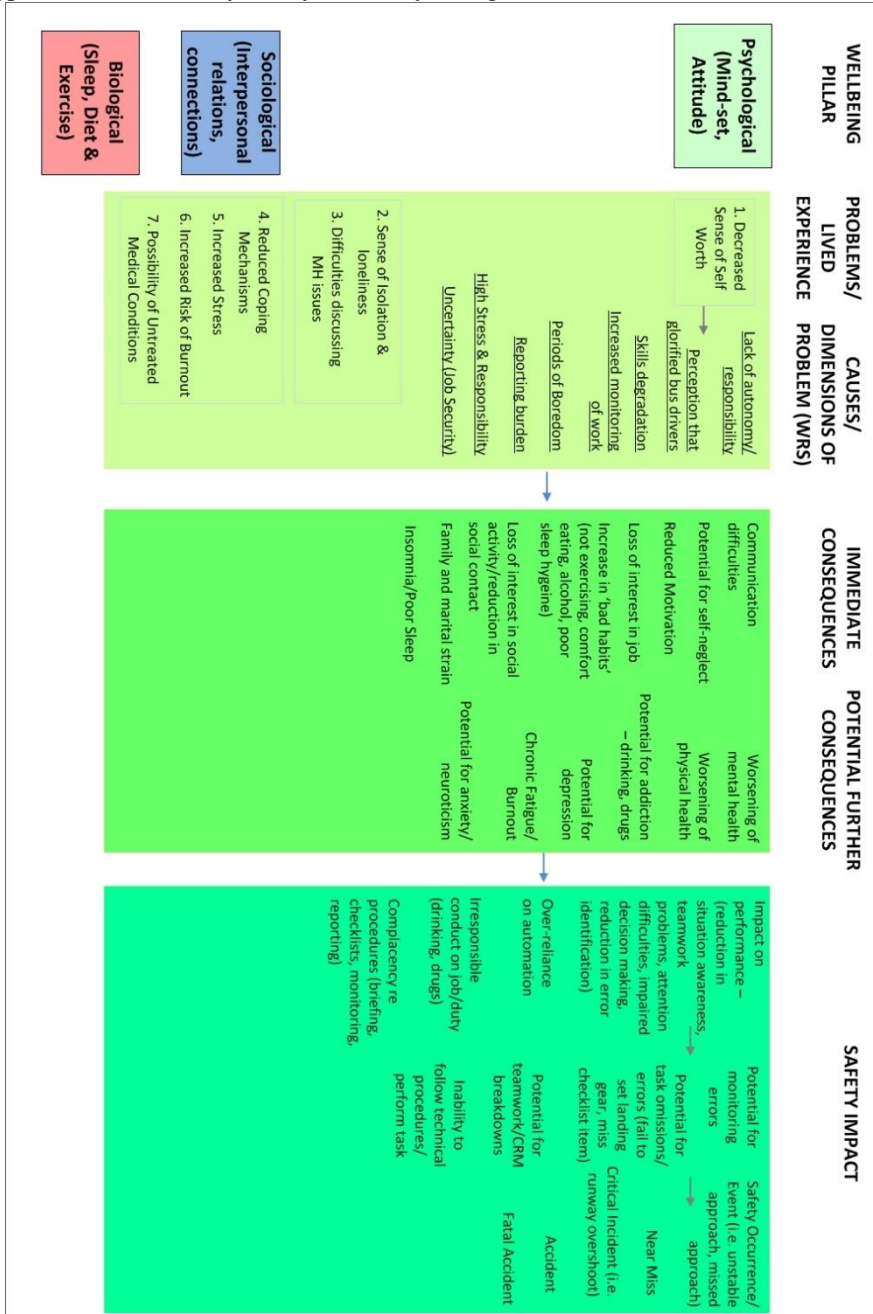


Fig. 2. Worked Example: Psychological Pillar

Appendix 4: Workshop Findings: Sources of Work Related Stress



Fig. 3. Sources of WRS

Appendix 5: Updated Model: Pilot Wellbeing, The Lived Experience: Biological Pillar

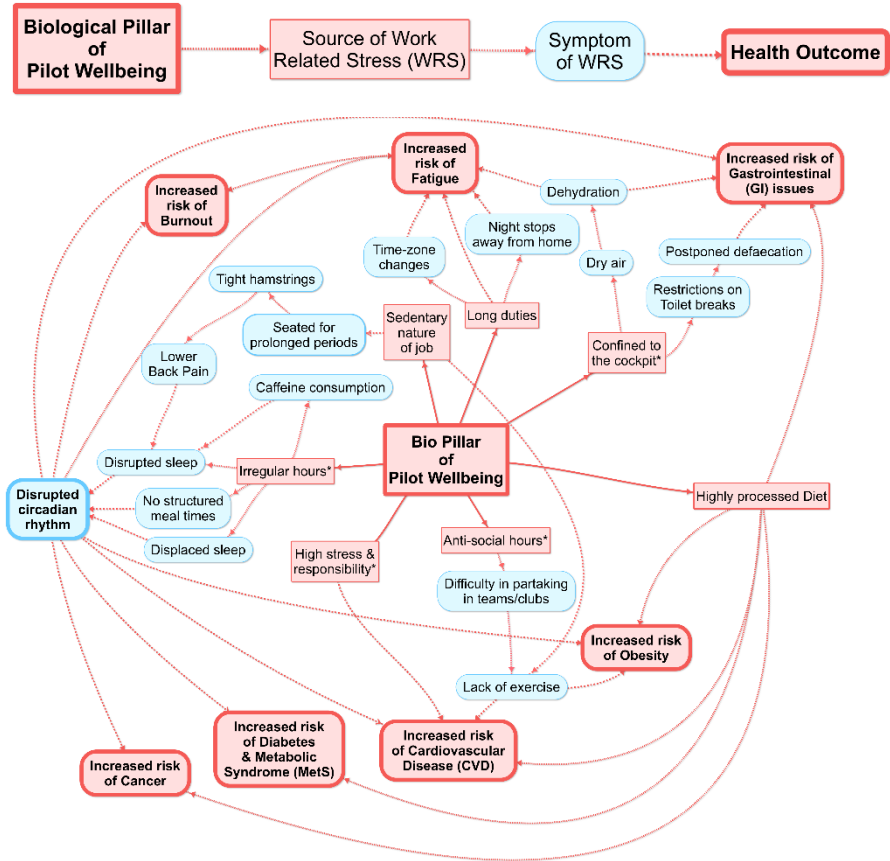


Fig. 4. Updated Model: Biological Pillar

Appendix 6: Updated Model: Pilot Wellbeing, The Lived Experience: Psychological Pillar

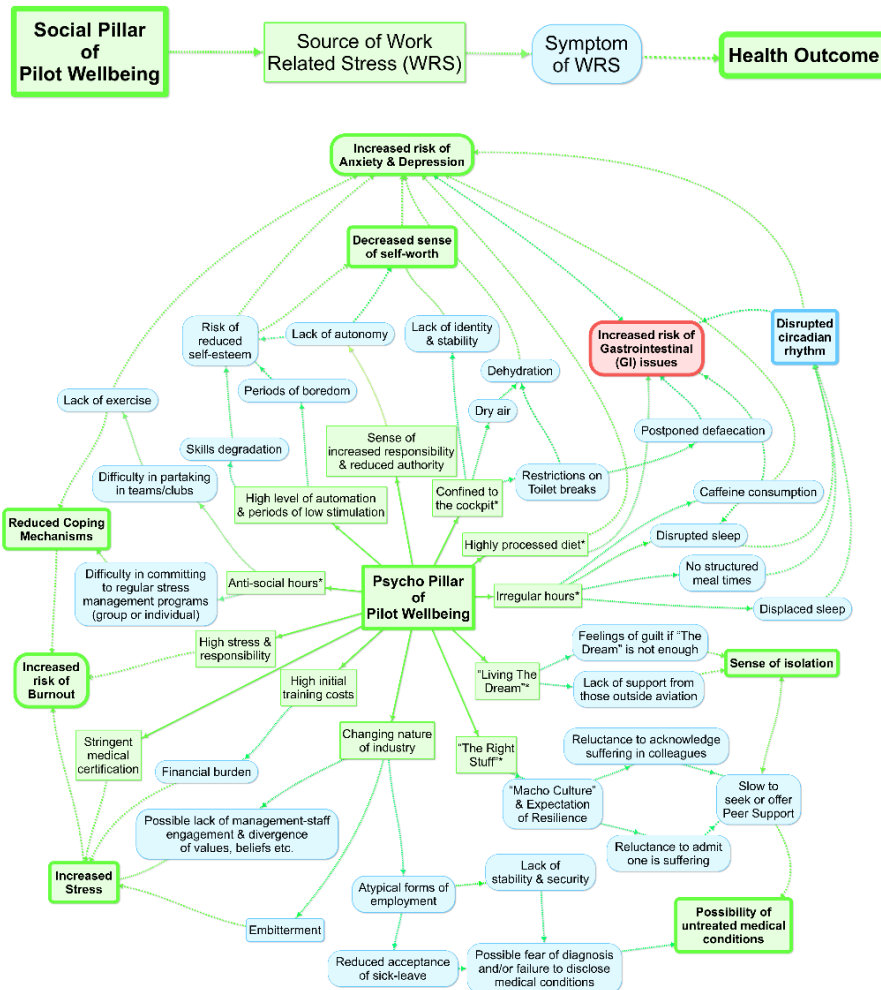


Fig. 5. Updated Model: Pilot Wellbeing, The Lived Experience: Psychological Pillar

Appendix 7: Updated Model: Pilot Wellbeing, The Lived Experience: Updated Social Pillar

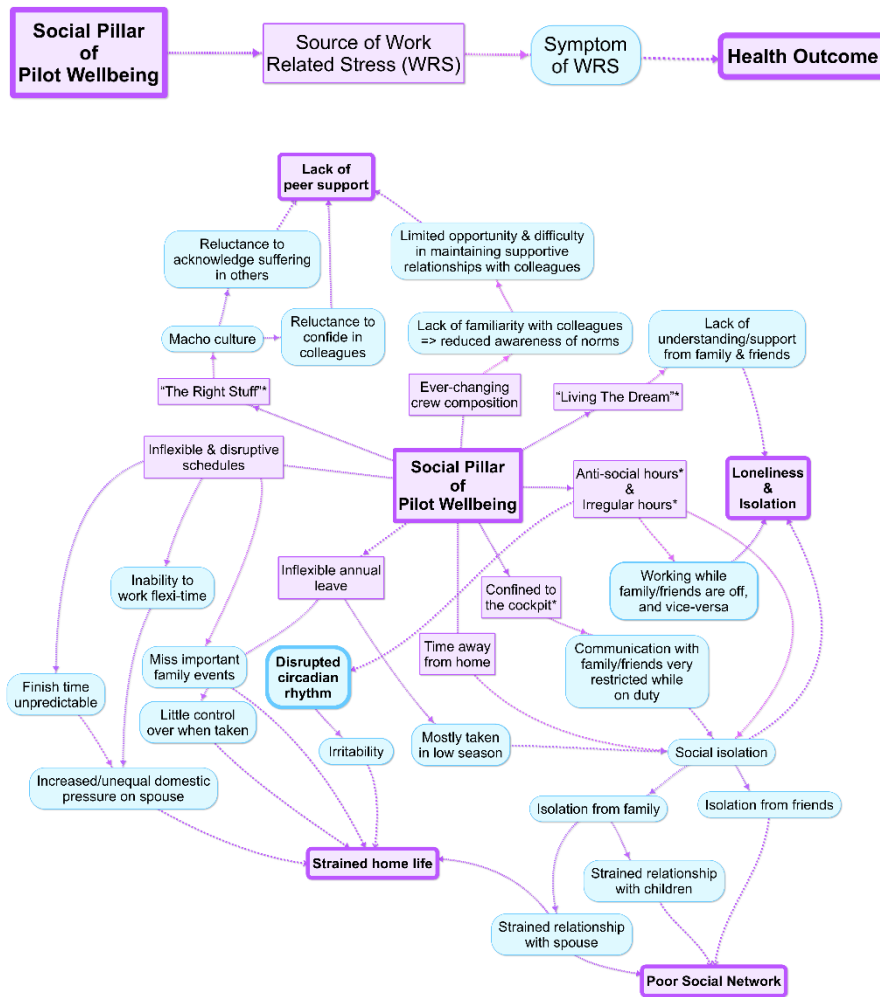


Fig. 6. Updated Model: Pilot Wellbeing, The Lived Experience: Social Pillar