

Using Emerging Technologies to Support Wellbeing and Resilience for pilots & Enabling the Assessment of Wellbeing Risk in Airline Safety Management Systems

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Abstract. This paper reports on the findings of two anonymous online surveys undertaken with pilots (n=170) pertaining to pilot self-care behaviors, the use of technology to support wellbeing management, and the acceptability of sharing wellbeing information captured using mobile phone apps with aviation employers, to support the analysis of wellbeing risk in safety management systems (SMSs). New mobile phone-based apps might be implemented to support self-care for pilots as part of a phased approach to the promotion of an integrated health and safety culture, and the management of wellbeing risk in aviation safety management systems (SMS). In the short term, there is insufficient trust on behalf of pilots to support such information sharing practices. Accordingly, it is proposed that pending consent, pilots share deidentified wellbeing information using mobile phone apps (and/or a web interface), in a global repository. This repository or ‘wellbeing monitor’ would be accessible to the industry - providing airlines with general trends data and reports, supporting wellbeing management and risk assessment. This will help mitigate existing employee information sharing barriers, build trust, and foster an integrated health and wellbeing culture, which is the prerequisite for the future assessment of wellbeing risk within a company SMS.

Keywords: Pilots, Wellbeing, Self-care, Mobile Apps, Safety.

1 Introduction

The workplace is an important setting for health protection, health promotion and disease prevention programs [1]. New perspectives on stress coping illustrate the role of both individual and organisational factors in stress coping. Individual factors (i.e., age, experience, personality) and resources (i.e., social supports, coping mechanisms), along with the physical and social resources available in the workplace (i.e., equipment, social support, leadership, safety climate) impact on the individual’s ability to cope with Work Related Stress (WRS) and wellbeing challenges.

In the OECD countries, mental health conditions are the second largest cause for work disability [2] and their proportion is still increasing. At the 2021 World Economic Forum [3], it was reported two out of three employers now have mental health (MH) as their number one priority [4]. However, it was also noted that only one in six employees

feel supported by their company during the COVID 19 pandemic. The Forum's 'mental health in the workplace initiative' outlines a vision 'where all workplace leaders recognize and commit – with the right tools in place – to taking tangible and evidence-based action on mental health and wellbeing, enabling their workforces to thrive' [4].

The 2008 European Pact for Mental Health and Well-being recognizes the changing demands and increasing pressures in the workplace and encourages employers to implement additional, voluntary measures to promote mental well-being [5]. These voluntary measures highlight the need for employers to go beyond a 'compliance' based approach. However, the appetite for implementing voluntary measures to support well-being varies across different industries and sectors.

Aviation is subject to seasonal fluctuations in terms of ticket demands/passenger traffic. Many aviation workers (both on the ground and in the air) work antisocial and irregular working hours and have commuting lifestyles. This creates many psychosocial pressures for workers attempting to balance the demands of work life and home-based responsibilities. In 2006, Hubbard and Bor provided an informative account of the mental health issues affecting pilots and the consequences of these [6]. The last decade has seen an increase in studies focusing on Work Related Stress (WRS) and mental health issues for pilots. Prior to the COVID pandemic, there was ample evidence of work stress issues impacting on pilot wellbeing. This includes disengagement and burnout [7] and depression amongst pilots – including studies at Harvard [8] and Trinity College Dublin [9-12]. Notably, in the Trinity College Dublin study involving 2,000 commercial pilots, 92% of respondents stated that the environment in which pilots work can contribute to the onset of and/or worsen an existing a mental health issue [11, 12]. Further, the study highlights the benefits of self-care practices adopted by commercial pilots, to manage wellbeing (including mental health) and foster resilience [12]. Practices such as sleep management, managing social wellness and taking physical exercise were demonstrated to have a positive effect on pilot wellbeing, and in particular, depression severity levels [12]. However, the study highlights that at an organisational level, the culture of supporting and maintaining wellbeing for pilots falls short. Currently, there is no definitive data directly linking wellbeing risk (including mental wellbeing) to safety outcomes in aviation [9, 11]. Further, there is a dearth of evidence around wellbeing risk. Airlines are not required to collect wellbeing data on a routine basis. Wellbeing data is however being gathered in relation to pilot peer support programs. As defined by the European regulator, any wellbeing trends or insights must be anonymized/de-identified when fed back into safety systems [13].

Some argue that airlines need to think differently about (a) supporting pilot wellbeing, (b) capturing data about wellbeing (including the link between wellbeing issues and performance/safety events), and (c) using wellbeing information to assess wellbeing risk in airline safety management systems [14]. The use of apps Potentially, mobile technologies might be used to support pilot self-monitoring of wellbeing, whilst on and off duty, along with enabling wellbeing and WRS reporting, supporting an integrated health and safety risk assessment process.

This paper reports on the findings of two anonymous online surveys (referred hereafter to as Survey 1 and Survey 2) undertaken with pilots. The surveys address pilot health and self-care behaviors, the use of technology to support wellbeing management,

and the acceptability of sharing wellbeing information captured using mobile phone apps, with aviation employers, to support the analysis of wellbeing risk in safety management systems (SMSs). Survey 1 was undertaken with pilots, but not specific to any organization. Survey 2 was undertaken with pilots working for a European aviation organization and elicited some additional feedback on the company's wellbeing culture and respondent attitudes to reporting MH issues and seeking support. First, a background to this research is presented. Following this, the methodological approach is outlined. Survey results are then outlined. The results are then discussed. A preliminary approach to implementing the proposed mobile phone apps is then reviewed, along with a plan for how this might link to the future analysis of wellbeing information in airline safety management systems. As part of this, a proposed industry wide 'wellbeing monitor' is suggested. Areas for further research are then examined and some conclusions drawn.

2 Background

2.1 Wellbeing, Mental Health, Quality of Life and Work Life Balance

Physical, psychological factors and social factors (including family relationships, social support, working conditions and working environment) are some of the determinants affecting a person's health and wellbeing [15]. As emphasized in the constitution of the World Health Organisation (WHO), health is more than the absence of disease [16]. Accordingly, the WHO highlight the importance of fostering and maintaining positive wellbeing and reaching one's potential, as opposed to simply preventing and managing illness. This aligns with positive psychology frameworks which are directed at human 'flourishing' [17]. The concept of 'quality of life' (QOL) is also related to that of wellbeing and 'flourishing'. Multiple factors play a role in QOL including financial security, job satisfaction, family life, health, and safety. Work life balance is a key part of QOL. Where good work life balance exists, workers can easily combine work, family commitments, and leisure. Importantly, the 'Better Life Index' includes work life balance as one of the eleven factors contributing to QOL [18]. Research indicates that occupations involving shiftwork and/or the requirement to work antisocial working hours can create imbalances in the home/work interface, leading to work family conflict [19]. Work family conflict (or work-family interference) refers to 'a form of inter-role conflict in which role pressures from the work and family domains are mutually incompatible in some respect' [19].

2.2 Occupational Health and Safety & Mental Wellbeing in the Workplace

The International Labour Organization (ILO) and the World Health Organization (WHO) define occupational health in relation to three objectives. "These are (1) the maintenance and promotion of workers' health and working capacity; (2) the improvement of working environment and work to become conducive to safety and health and (3) development of work organizations and working cultures in a direction which supports health and safety at work and in doing so also promotes a positive social climate and smooth operation and may enhance productivity of the undertakings" [20]. Tamers

(2019) proposes the ‘Total Worker Health’ (TWH) framework, which is defined in relation to policies, programs, and practices that integrate protection from work-related safety and health hazards, with promotion of injury and illness prevention efforts to advance worker well-being [21].

2.3 Aviation Worker Wellbeing & Wellbeing Reporting

The issue of aviation worker wellbeing/mental health has received increased attention since the 2015 Germanwings Flight 9525 accident. In particular, the tragedy raised issues pertaining to the aeromedical assessment of pilots, medical confidentiality, and issues around disclosure of (MH) issues to employers. In 2018, following the Germanwings tragedy, EASA introduced new rules in relation to the management of pilot mental fitness. These rules pertain to three key areas - psychological testing of aircrew pre-employment in line flight, access to a psychological support/peer support resource, and substance abuse testing on a random basis. Many in the industry argue that these guidelines do not go far enough – pointing to the fact that the rules overlook prevention [22, 23]. Further, it is argued that the new rules do not address positive wellbeing [24]. The Trinity College Study highlights the continued stigma associated with MH issues and reporting unfit for work [11, 12]. This was corroborated in a further anonymous survey undertaken in 2020, with a broad range of aviation workers [25]. In this study approximately 1 in 4 respondents stated that they would willingly report MH issues to their employer [25].

2.4 Safety Management Systems & Safety II Approach

Over the last 15 years, airlines have been introducing safety management systems (SMS). This follows a focus on prevention as opposed to reaction, and the advancement of a proactive safety culture, in which everybody in the company is responsible for safety. The objective of a SMS is to provide a structured management approach to control safety risks in operations [26]. Safety management systems include four components – safety policy, safety assurance, safety risk management and safety promotion. Currently, the assessment of wellbeing risk primarily relates to fatigue. Critically, it does not include other aspects of the pilot’s physical wellbeing (i.e., diet and physical activity), and/or other dimensions of their social and psychological wellbeing.

The Safety-I approach focuses on improving safety by examining and learning from system failures (for example, near misses, safety events and serious accidents). The Safety-II approach investigates all possible outcomes: involving normal performance (everyday routine performance), excellent performance, near-misses, accidents, and disasters [28]. As such, Safety-II focuses on all events (the full distribution profile of safety – both good and bad). In so doing, it seeks to enhance effectiveness while also addressing failure. Importantly, Safety-I and Safety-II are complementary [28].

2.5 Organisational Approaches to Addressing Wellbeing within SMS

Some airlines are adopting more innovative approaches to addressing wellbeing [27] and linking to predictive safety management concepts and the Safety II approach [28]. This involves capturing routine information about staff wellbeing levels using a combination of methods which protect employee identity and speak to concepts of ‘just culture’ and ‘trust’. This includes the use of pulse surveys (which elicit anonymous information about crew wellbeing levels and coping methods), operational learning reviews (which capture information about the presence of safety, via confidential interviews) and making use of de-identified data from Peer Assistance Network (PAN) reports and conversations with aeromedical/psychology professionals at the airline. As argued by McCarthy [27] ‘trust works both ways, as does accountability’. The objective is to channel learning via these alternative reporting methods into the airline’s safety management system, so that risks relating to staff wellbeing are identified and managed. In addition, other airlines are making use of deidentified information from the analysis of peer support referrals, to gather evidence about staff wellbeing and the contributory factors to wellbeing and mental health issues [29].

2.6 Safety Reporting, Managing Privacy & Industry Co-operation

Voluntary and confidential reporting systems have been established, enabling pilots and other aviation professionals to confidentially report near misses and safety events, with the goal of improving flight safety, while protecting operational personnel. Established in the 1982, the UK Confidential Human Factors Incident Reporting Programme for aviation (CHIRP), invites safety-related reports from flight crew, air traffic control officers, licensed aircraft maintenance engineers, cabin crew and the general aviation community along with workers in the international maritime sector, including the shipping industry, fishing industry and leisure users [30]. In addition, the Air Safety Reporting System (ASRS) system developed by the Federal Aviation Authority, and operated by NASA, enables safety reporting [31]. NASA operate as a neutral third party (i.e., no enforcement authority and no relationship with airlines). Protections are in place, to ensure that reporters can come forward, without fear of a punitive outcome. The benefit of this system is that it enables the reporting of systemic safety issues – and specifically, the identification of latent system hazards, necessary to predictive risk management approaches. However, no such database exists in relation to wellbeing, and more broadly the occupational health and safety (OSH) space within aviation.

2.7 Existing Wellbeing Self-Assessment Tools

Several checklists have been advanced to support pilot self-assessment of fitness to fly at an operational level. This includes two checklists developed by the Federal Aviation Authority (FAA) in the USA. That is, the I’m Safe Checklist, which supports pilot evaluation of the ‘pilot’ section of the 5Ps (i.e., plan, plane, pilot, passengers, and programming [32], and the Personal Minimums Checklist, which addresses four evaluation areas - the pilot, the aircraft, the environment, and external pressures [33]. The FAA’s

'I'm Safe Checklist' supports pilots in relation to self-assessment of their overall readiness for flight in relation to illness, medication, stress, alcohol, fatigue, and emotion. Many in the industry highlight the need for aviation workers to help themselves (i.e., address self-care) as opposed to waiting for regulation to mandate better supports for pilots [34]. It has been suggested that this checklist might be extended to address positive wellbeing (not simply illness) and to draw attention to mental health (i.e., mood, stress levels, attitude) and the use of coping strategies [34].

3 Methodology

3.1 Data gathering

An anonymous online survey using the Qualtrics survey platform, was administered at two different time periods to assess the acceptability of introducing novel mobile phone apps, to support a pilot to assess and manage their wellbeing in two contexts – namely, while off duty, and on duty.

The survey design drew upon prior research undertaken by the authors pertaining to a biopsychosocial model of wellbeing, the factors that can positively and negatively influence a pilot's physical, mental, and social health, and the case for introducing new tools to enable pilots to manage their wellbeing [9-12]. Survey 1 was administered between November 2020 and January 2021 (n=82), and targeted commercial pilots only. Respondents were recruited using social media platforms such as LinkedIn and Twitter. Survey 2 was administered between February 2021 and April 2022, and targeted staff working at a European based aviation organization, (n=88). In this case, staff received an email from management, advertising the survey and the research objectives. The second survey included some additional questions on mental health reporting and seeking help within the organization.

This research was conducted in accordance with the Declaration of Helsinki, and the survey protocol was approved by the Ethics Committee of the School of Psychology, Trinity College Dublin (TCD) Ireland. The data protection impact assessment was approved by the Data Protection Officer at TCD.

3.2 Data analysis

Survey questions involved categorical data only. Descriptive statistics were computed for all questions. Text analysis was undertaken for those questions eliciting additional text feedback. This involved undertaking counts in excel and the production of word clouds.

4 Results

4.1 Respondent Profiles

Survey 1 respondents were mostly male (77.63%), aged between 36-45 years (38.16%), most working between 11-15 years (20.83%), working for full-service carrier (51%), employed - permanent - full time (36%), captain rank (44%), and flying short range (43%). Survey 2 respondents were mostly male (95.24%), aged between 25 and 35 years (42.37%) and working full time (100%). The largest portion were Junior First Officers (31.33%).

4.2 Health, Wellbeing & Self-care

Respondents reported higher levels of physical wellbeing than mental and emotional wellbeing. 66% of Survey 1 respondents and 68% of Survey 2 respondents rated their physical health as either very good or excellent. 54% of Survey 1 respondents, and 62% of Survey 2 respondents rated their mental/emotional health as very good or excellent. 66.20% of Survey 1 respondents and 74% of Survey 2 respondents reported that they used self-care strategies to deal with stress and WRS. Respondents in both surveys provided examples of the top five coping strategies which they found most beneficial from a stress coping perspective. Taking exercise was the most frequently selected strategy in both surveys. Table 1 below details the five top selfcare strategies reported by survey respondents.

Table 1. Selfcare Strategies.

#	Survey 1	Survey 2
1	Take exercise/sport (13.66%)	Exercise, sport (15.56%)
2	Socialize/spending time with family & friends (12.68%)	Spend time outdoors/nature (12.59%)
3	Focus on sleep & rest (10.24%)	Socialize/spending time with family & friends (10.74%)
4	Spend time outdoors/in nature (10.24%)	Focus on sleep & rest (9.63%)
5	Try to do things I enjoy (eating out, watch TV, play video games, hobbies etc.) (9.76%)	Try to do things I enjoy (eating out, watch TV, play video games, hobbies etc.) (8.15%)

Participants were also asked about their use of alternative/maladaptive strategies to cope with stress and WRS. A large proportion in both surveys reported using 'avoidance' as a strategy. Table 2 below details the five top maladaptive strategies, as reported by survey respondents.

Table 2. Maladaptive Strategies.

#	Survey 1	Survey 2
1	Avoidance/ignore (38.10%)	Avoidance/Ignore (31.47%)
2	Self-harm (17.46%)	Alcohol (21.68%)
3	Substance misuse - alcohol (7.94%)	Withdraw from people (16.08%)
4	Screaming/throwing things/tantrums (7.94%)	Temper/lash out/aggressive behavior (10.49%)
5	Smoking (4.76%)	Disordered eating (6.29%)

4.3 Self-Care & Technologies

Many respondents reported using a mobile phone app to manage their health and wellbeing - 41% of survey 1 respondents and 31% of survey 2 respondents. In the case of respondents who currently do not use a mobile phone app to manage their wellbeing, nearly half noted that they would be open to doing this (44% of survey 1 respondents, and 48% of survey 2 respondents). 40% of Survey 1 respondents and 60% of survey 2 respondents reported using a wearable device (for example, Fitbit or Garmin) to track aspects of their health and wellbeing. The top three types of health data tracked was the same in both surveys. The top 3 were exercise/activity, sleep, and heart rate. In survey 1, over 50% of respondents referred to exercise/activity, while in Survey 2, 100% of respondents referred to this. Of those who are currently not using wearables, 34% of survey 1 respondents and 48% of survey 2 respondents stated that they would be open to using a wearable to manage their health. Respondents were invited to provide suggestions of the top three health factors/areas that they would like to monitor using a wearable. The same items were reported in both surveys, with exercise being rated the most important in both surveys. In relation to Survey 1, the top three were sleep, exercise/physical activity/steps, and heart rate. In Survey 2, the top three were exercise/physical activity/steps, sleep, and heart rate.

4.4 Self-Reporting Health Data

Respondents were asked whether they would be happy if the information collected using a wearable device might be integrated into an aviation worker health and wellbeing app, for the purpose of assessing wellbeing risk (pending their consent and appropriate security protections). 59% of Survey 1 respondents agreed or strongly agreed that they would be happy, while 47% of Survey 2 respondents agreed or strongly agreed that they would be happy.

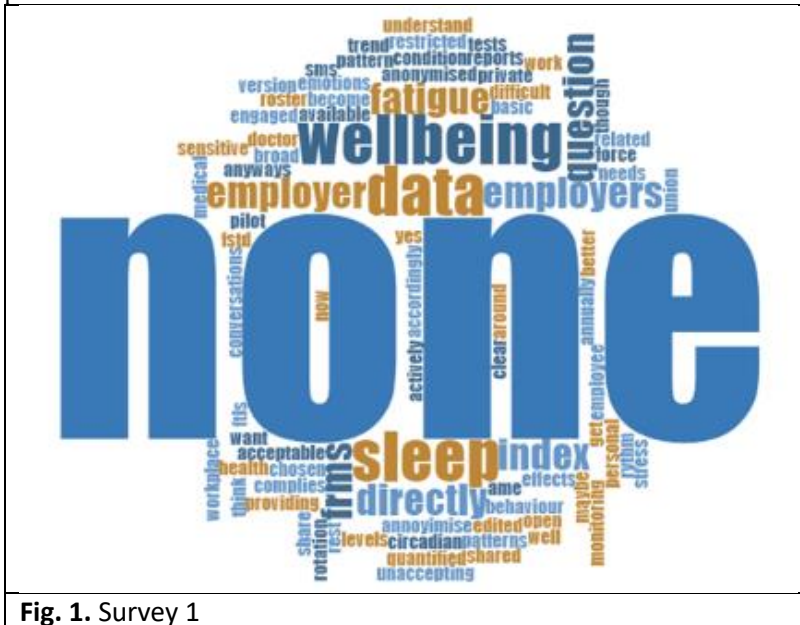
77% of survey 1 respondents and 64% of survey 2 respondents reported that they would be willing to self-report certain types of health data. In both surveys, the top ranked data type was data pertaining to stress levels. Table 3 below provides feedback as to the types of information they would be willing to self-report, using a mobile phone app.

Table 3. Data Willing to Report.

#	Survey 1	Survey 2
1	Stress level (28.97%)	Stress level (29.67%)
2	Levels of anxiety (19.63%)	Mood (25.27%)
5	Levels of depression (15.89%)	Levels of anxiety (17.58%)

In addition, 48% of survey 1 respondents and 44% of survey 2 respondents noted that they would be happy to self-report data about social activity.

Respondents were invited to report using free text what data (if any) they would you like to be shared with their employer. In Survey 1, the word 'none' was most frequently cited. In Survey 2, the words 'data' and 'health' were most frequently cited. See example word clouds below.

**Fig. 1.** Survey 1

that there are low levels of speaking out and/or reporting about mental health amongst their colleagues. Over half (58%) agreed or strongly agreed that they would look for help if they had a health issue (including mental health). The top three people they would look for help included (1) a partner/spouse (27.47%), a close friend (24.73%) and a family member (15.93%). A small number indicated they would use peer support (10.44%). Just under 4% indicated that they would approach a mental health professional at their company. A very low number (32%) indicated they would willingly approach their employer with a MH issue. 22% indicated that they had approached a MH professional outside their company to obtain help.

4.8 High Level Concepts for Mobile Phone Apps & Tool Requirements

Respondents were asked several questions pertaining to the high-level requirement for a potential mobile app, to support wellbeing management for pilots. A large majority either agreed or strongly agreed that staff must be educated about the boundaries between life inside and outside of work and managing conflicting demands (84% of Survey 1 respondents, and 93% of Survey 2 respondents). 73% of Survey 1 respondents, and 86% of survey 2 respondents either agreed or strongly agreed that staff require tools to nudge them towards healthy behaviors, and to prevent the onset of problems (i.e., to keep them well). 66% of Survey 1 respondents, and 71% of Survey 2 respondents either agreed or strongly agreed that future wellbeing tools (i.e., mobile apps) should provide staff with tools/checklists to enable them to evaluate their health and wellbeing, in advance of reporting for duty. 82% of Survey 1 respondents, and 85% of Survey 2 respondents either agreed or strongly agreed that any health and wellbeing assessment provided by the wellbeing tools should include the three pillars of wellbeing (i.e., physical, psychological/emotional, and social). 68% of Survey 1 respondents, and 75% of Survey 2 respondents either agreed or strongly agreed that any health and wellbeing assessment provided by the wellbeing tools should include what I am currently doing to manage stress/work related stress.

88% of both Survey 1 and Survey 2 respondents either agreed or strongly agreed that future wellbeing tools (i.e., mobile apps) should provide the user with feedback about the state of their health and wellbeing. 86% of Survey 1 respondents, and 90% of Survey 2 respondents either agreed or strongly agreed that mobile apps should provide the user with feedback about their stress levels 68% of Survey 1 respondents, and 73% of Survey 2 respondents either agreed or strongly agreed that supporting healthy behavior requires the development of a set of targets for oneself and monitoring of one's level of achievement of the targets. 59% of Survey 1 respondents, and 47% of Survey 2 respondents either agreed or strongly agreed that future wellbeing tools (i.e., mobile apps) should provide the user with feedback about their own health and wellbeing and how it compares with others. 66% of Survey 1 respondents, and 68% of Survey 2 respondents either agreed or strongly agreed that future wellbeing tools (i.e., mobile apps) should provide access to virtual coaching/support to maintain positive wellbeing. 59% of Survey 1 respondents, and 68% of Survey 2 respondents either agreed or strongly agreed that future wellbeing tools (i.e., mobile apps) should enable the user to report challenges to their health and wellbeing that may impact on their work. 63% of Survey 1

respondents, and 68% of Survey 2 respondents either agreed or strongly agreed future wellbeing tools (i.e., mobile apps) should enable them to report wellbeing issues that contribute to safety events.

4.9 App Concepts/Tools & Functions

Respondents were rate from 1 (low) to 10 (high) the most useful functions for a mobile phone app supporting wellbeing, while off duty. Respondents across both surveys highly rated the function ‘reporting of stress and wellbeing issues that impact on safety’. This feature was rated second most important by survey 1 respondents, and third most important by Survey 2 respondents. Table 4 and 5 below provide a summary of the top three selected functions, for both the off duty and on duty apps.

Table 4. Off Duty Tool - Functions.

#	Survey 1	Survey 2
1	Integration with airline information systems (for example, roster, health promotion information, EAP services information) (54.5%)	Provision of general resources/information and relaxation exercises (45.76)
2	Reporting of stress and wellness issues that impact on safety (52.27%)	Self-assessment tools (37.28%)
3	Wellness tracking, assessment, and reporting (47.73%)	Wellness goal setting, plans and feedback (35.59%) Reporting of stress and wellness issues that impact on safety (35.59%)

Table 5. On Duty Tool - Functions

#	Survey 1	Survey 2
1	Enable crew self-assessment of wellbeing/state in advance of the flight (63.64%)	Provide supports in a crisis (55.87%)
2	Provide supports in a crisis (61.37).	Enable crew self-assessment of wellbeing/state in advance of the flight (43.97%)
3	Enable reporting concerning stress and wellbeing threats that impact on safety (56.82%)	Enable access to support services within the airline (38.77%)

5 Discussion

5.1 Pilot Self-Care & Stress Coping

Respondents reported higher levels of physical wellbeing than mental and emotional wellbeing. A large proportion of survey respondents (66.20% of survey 1 respondents and 74% of survey 2 respondents), reported that they are using coping strategies to manage stress and WRS. This should be both encouraged and supported by their employers. However, a significant number of respondents reported ‘avoidance’ as a strategy. This needs to be addressed in relation to crew training and safety promotion activities. Pilots should be encouraged to assess their own wellbeing and adopt healthy approaches to managing stress and WRS, to benefit their individual wellbeing perspective along with flight safety. In cases of mild suffering, it is likely that a self-management approach will prevent an escalation of symptoms, with consequences for the person’s wellbeing and operational performance.

5.2 Use of technologies & health promotion

This research indicates the overall acceptability of using mobile phone apps and wearable devices to manage pilot wellbeing. A large proportion of survey respondents reported using both mobile phone apps and wearable devices to manage their wellbeing. Survey feedback indicates that the evaluation of wellbeing requires capturing data across the three pillars of wellbeing (i.e., biological, psychological, and social). In addition, it highlights the importance of including information about a person stress coping activity. Further, the survey indicates that pilots might benefit from nudges in relation to both self-assessing their wellbeing and managing their wellbeing (i.e., engaging in health promoting activities, or activities that deliver therapeutic benefits).

There is an opportunity to address work stress and wellbeing from a positive managerial perspective. The use of mobile phone apps might be supported by employers, in terms of enabling self-awareness and self-assessment of wellbeing and MH, along with the adoption of healthy strategies to promote positive wellbeing/resilience and manage stress and WRS. Airlines might sponsor this technology for their pilots, as part of a preventative health management approaches. This would supplement existing secondary approaches to wellbeing management (for example, wellbeing awareness training), along with tertiary approaches (for example, peer support, access to company psychologist and or access to external counselling services).

5.3 Management of Wellbeing Risk in SMS

In keeping with the literature, this study highlights the existing poor wellbeing culture within aviation. In both surveys, respondents indicated that they would be willing to self-report data using a mobile phone app, to support self-assessment of their own health and wellbeing. However, respondents also indicated that they have concerns sharing this data with their employer. In both surveys, the term ‘none’ was the most

frequently reported term used by respondents in relation to the question of ‘would you be willing to share this data with your employer’. Further, survey 2 highlights significant issues pertaining to MH stigma and disclosing MH challenges to an employer. Very low numbers agreed that they would willingly disclose wellbeing/MH challenges to their employer. However, in both surveys, a large number agreed that existing safety management systems should be extended to consider the analysis of information pertaining to wellbeing risk. This presents a quandary. The capture and use of wellbeing information in an airline SMS is perceived as required and beneficial. However, pilots do not feel safe sharing this information with their employer. In the current climate, there seems to be insufficient trust between pilots and their management, to support such reporting practices. Thus, assessing wellbeing risk within a SMS is dependent on building trust between staff and management, and making progress in terms of fostering a wellness culture within aviation.

Further, in relation to the proposed tool concepts, we would expect additional barriers in relation to collecting wellbeing information while on duty (i.e., identification and privacy). Unsurprisingly, the top three features for an on-duty tool, did not include this. As indicated in this research, airlines will need to think differently about how wellbeing information is obtained and used, to support an integrated approach to health and safety risk assessment. A future strategy necessitates careful attention to issues of data protection, and a phased implementation approach. From an implementation perspective, trust is obtained via staff protections and safeguards. De-identifying information (i.e., protecting employees/staff) is a route to both obtaining wellbeing data (i.e., evidence), and to building a culture of wellbeing. This in turn, is a stepping-stone to the assessment of wellbeing risk in aviation SMSs.

5.4 Wellbeing Apps, Total Worker Health & Joint Responsibility

Safety management needs to be integrated with wellbeing management, as part of an integrated approach to occupational health and safety, and the adoption of a total worker health perspective [21]. Supporting pilots to manage their own wellbeing (i.e., self-assessment and self-care), while on and off duty, and enabling wellbeing reporting is the start of advancing a wellbeing culture. Moreover, it is key to advancing an integrated health and safety culture and associated process. As evidenced in this research, the design and conceptual approach to managing wellbeing underpinning the mobile phone apps follows from an integrated approach. In this respect, it is anticipated that pilots would use the apps to bolster positive wellbeing, to report on their wellbeing, along with reporting on specific wellbeing/WRS issues that impact on performance and operational safety, and to access supports where required. In the short term, wellbeing information might not be shared with employers directly. However, this might happen further down the line (see below). Importantly, if this information is shared with employers, employers have a responsibility to ensure that pilot are supported, and that safety levels are maintained. This requires aviation organizations to adopt a ‘joint responsibility’ approach to managing wellbeing.

6 Recommendations & Future Roadmap for Managing Wellbeing in Airline SMS

6.1 Augmenting I'm Safe Checklist & Wellbeing Assessment Using Mobile Apps

It is worth noting that pilots responded positively to the idea of using the mobile phone app to assess their own wellbeing in advance of the flight. Here, an individual pilot would assess their own wellbeing, using a mix of objective data (i.e., data gathered from wearable) and subjective data (i.e., self-reports) about their wellbeing. In the current concept (i.e., tool used on a personal basis, not integrated with work), it would be up to the individual pilot to decide how this self-assessment might be treated from a 'fitness to fly' perspective. Further, it would be up to the pilot to decide how they might share their own assessment of their wellbeing with their copilot. To note, the pilot using the app would not be required to share his/her data with anybody (the process would sit outside any organizational process). This could lead to difficult situations for different parties. For example, if a pilot showed the mobile phone app user interface to their copilot, and the interface indicated extreme fatigue, what would be expected of the copilot? Would this be different from what might be expected from a pilot verbalizing, 'I am exhausted today', without any app data? Does the availability of objective data change the requirement to ask the copilot to step down, and/or report the issue to flight operations? If there was a safety event, would the co-pilot be considered responsible? Evidently, pilots are already using apps and making such self-assessments – outside any formal process within the airline. Is this acceptable from a safety management perspective?

6.2 Assessing Wellbeing Risk in Airline SMS

As indicated in this research, a phased approach to the management of wellbeing risk in aviation SMS is required. Airlines might consider the implementation of mobile phone apps for staff as part of a broader wellbeing management roadmap.

The off-duty app might be used to promote positive wellbeing, to enable a preventative approach to wellbeing management (at an individual level), and to promote a wellbeing culture. This would foster trust and destigmatize wellbeing/MH – paving the way for an improved wellbeing reporting culture which is a prerequisite for the collection and analysis of data about wellbeing risk in an airline SMS.

Further, with the right protections in place and pilot consent, pilot wellbeing data (i.e., data harvested via the off duty mobile phone app) might be shared in a central repository. In addition, such information might be collected using web-based reporting interfaces. This might be more acceptable for pilots (i.e., protection afforded by online reporting as opposed to mobile phone app, where there are always fears of hacking). Specifically, pilots might be invited to share their deidentified wellbeing information in an industry wide 'wellbeing monitor'. Potentially, this system might collect anonymous information in five core topic areas. These are outlined in Table 5.

Table 5. Data to Gather from Pilots.

#	Description
1	Real time levels of wellbeing for aviation workers.
2	Sources of WRS linked to the job (span biopsychosocial - that is, beyond fatigue to include psychosocial hazards).
3	The relationship between wellbeing, performance, and safety (i.e., impact of wellbeing and sources of WRS on performance - including near misses and safety events).
4	Coping methods (i.e., what self-care practices using) and what are more/less useful.
5	Use of organizational supports (i.e., examples of supports) and what is most beneficial.

Such a system might produce trends reports based on aggregated deidentified data. This would enable the industry to (1) better understand wellbeing for aviation workers, (2) to normalize wellbeing and MH/addressing stigma and reporting barriers (i.e., enable a safe space for sharing of wellbeing information), and (3) to drive change in the industry in terms of wellbeing culture and making use of data about real time wellbeing and WRS within an organisation's SMS, in support of (a) a preventative approach to managing wellbeing risk and psychosocial hazards (i.e., primary interventions), and (b) joined up approach to health and safety (i.e., integrated health, wellbeing and safety). Further, such a system would (4) enable airlines to consider wellbeing risk in their SMS - albeit indirectly and (5) enable pilots sharing data, to compare their wellbeing with other groups.

As indicated in Figure 3, an online platform might be developed enabling the capture of wellbeing information (reports in), and the analysis of trends information (reports out). In terms of 'reports in', this might include data gathered from mobile phone apps (i.e., linked to wearables), and data captured using web-based reporting methods (i.e., not linked to wearables, but potentially allowing pilot to report this data, if they choose). As such, different functions might be provided for data creators (pilots providing information) and data viewers (those viewing reports). 'Reports out' might be targeted at different stakeholders. For example, (1) pilots sharing information (2) pilots not sharing information (3) airline staff [safety managers, crew rostering, human resources, occupational health and safety, training, and flight operations], (4) aeromedical examiners, (5) aviation regulator and (6) health and safety regulator.

Wellbeing Monitor

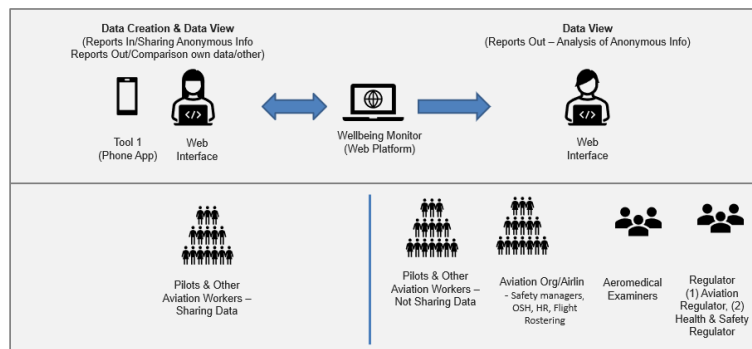


Fig. 3. Wellbeing Monitor

Once a more positive wellbeing culture has been advanced, and trust has improved, this approach might be extended. That is, in the longer term, airlines might develop their own ‘wellbeing monitors’. In this case, pilots providing consent might share deidentified information with their employer to assess wellbeing risk within the airline SMS. This would enable a preventative approach to wellbeing management at an organisational level. Deidentified and aggregated wellbeing data might be used within the context of the flight planning and crew scheduling/rostering processes. This aligns well with a commitment to ‘just culture’, to a ‘learning culture’ and a ‘people-centric’ approach. The aviation community understands the role of ‘just culture’ in relation to safety. Health/wellbeing and safety culture needs to be framed from this perspective (i.e., safe disclosure and psychological safety). Evidently, it is not enough to talk about ‘just culture’. This needs to be enshrined in laws that protects aviation workers, so that workers can disclose problem without this impacting on their license and career progression.

7 Next Steps & Areas for Further Research

Participatory based human factors action research is required to specify the design of mobile phone app, along with the proposed wellbeing monitor for use by the industry. This will require collaboration across different stakeholders in relation to both ‘reports in’ (i.e., pilots sharing deidentified information) and ‘reports out’ for different stakeholders. In relation to the design of the off-duty wellbeing app, the algorithm producing a wellbeing scoring requires consideration. This score will need to integrate a mix of subjective (pilot self-reports) and objective reporting data (i.e., data from wearable). Potentially scores might be provided for the individual pillars. In addition, attention needs to be paid to the design of nudges. This should consider the duty status of the pilot, and the expected role of the health promoting nudges. In this context, the purpose of the nudges is not to diagnose mental ill-health. However, nudges might be

used to signpost the pilot to available supports and/or specialist help if a consistent pattern of poor wellness is detected. This requires further research. Data protection issues must also be addressed. Pilots require assurances about how their data is protected and shared with the industry. Governance and oversight in relation to data protection is critical

8 Conclusion

Airlines need to go beyond a compliance-based approach to wellbeing management for pilots, to a human centered and ethical process. This involves treating pilot wellbeing as a shared responsibility. Further, the management of wellbeing should be an integral part of the safety culture (i.e., integrated health, wellbeing, and safety culture). This starts with gathering and making use of data regarding the wellbeing of their staff, while addressing issues pertaining to trust.

In addition, aviation organizations need to rethink their objectives and approach in terms of prioritizing wellbeing, and providing appropriate wellbeing supports for pilots. Technologies are part of addressing wellbeing management for pilots, and for addressing an integrated health and safety culture. New mobile phone apps might be implemented to support self-care for pilots as part of a phased approach to the management of wellbeing risk in aviation safety management systems (SMS), and the promotion of an integrated health and safety culture. Further, they might be considered as part of a preventative health strategy (i.e., primary intervention).

With the increasing use of operational intelligence and reporting systems involving machine learning and artificial intelligence, there is an opportunity to use technology to further enhance the Safety II approach. This depends on the ability to gather information about the wellbeing of operational personnel, both when on and off duty. However, this will only happen if there is a strong safety/reporting culture – underpinned by protections for staff, so that personal information is protected. In the short term, an industry wide wellbeing monitor enabling the collection of anonymous information pertaining to pilot WRS and wellbeing levels is required. Airlines might make use of this information, as a ‘stepping-stone’ to analyzing wellbeing risk in an airline SMS. The use of the proposed mobile phone apps is one of many interventions that might be considered by aviation organizations in relation to supporting employee wellbeing.

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