Fatigue Risk Management Preferences for Consumer Sleep Technologies and Data Sharing in Aviation

Jaime K. Devine; Jake Choynowski; Steven R. Hursh

INTRODUCTION: Employees from any type of aviation services industry were asked to give their opinions about the usefulness of consumer sleep technologies (CSTs) during operations and their willingness to share data from CSTs with their organizations for fatigue risk management purposes under a variety of circumstances.

METHODS: Respondents provided information about position in aviation and use of CST devices. Respondents ranked sleep issues and feedback metrics by perceived level of importance to operational performance. Respondents rated their likelihood to share data with their organization under a series of hypothetical situations.

RESULTS: Between January-July 2023, 149 ($N = 149$) aviation professionals responded. Pilots comprised 72% ($N = 108$) of respondents; 84% ($N = 125$) of all respondents worked short- or medium-haul operations. "Nighttime operations" and "inconsistent sleep routines" ranked as the most important issues affecting sleep. "Sleep quality history" and "projected alertness levels" ranked as most important feedback metrics for personal management of fatigue. Respondents were split between CST users ($N = 64$) and nonusers ($N = 68$). CST users did not indicate a strong preference for a specific device brand. The most-reported reason for not using a CST was due to not owning one or no perceived need. Respondents indicated greater likelihood of data sharing under conditions where the device was provided to them by their organization.

DISCUSSION: These results suggest that aviation professionals are more concerned about schedule-related disturbances to sleep than they are about endogenous sleep problems. Organizations may be able to increase compliance to data collection for fatigue risk management by providing employees with company-owned CSTs of any brand.

KEYWORDS: fatigue risk management, consumer sleep technologies, preferences.

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Aviation is one of the most highly regulated industries when it comes to fatigue. The Federal Aviation Administration (FAA), the International Air Transport Association (IATA), the Civil Aviation Safety Authority (CASA), and similar regulatory organizations across the world require commercial airlines and other aviation services organizations to have a fatigue risk management system (FRMS) framework in place to limit exposure to risk in their employees who operate in safety-sensitive positions, such as pilots.[1–3] Regulatory requirements differ by region and sector of aviation. Not all types of aviation industries require an FRMS; many organizations choose to operate under an FRMS framework voluntarily as a safeguard against fatigue risk. Research has shown that aircrew are susceptible to fatigue due to sleep loss, shift work, jet lag, long working hours, high workload, early start times, or stress.[4–6] Apart from the growing body of academic literature that investigates fatigue across all types of flight operations,[5,7,8] many aviation service organizations collect their own objective sleep and performance data during operations to comply with regulatory guidance surrounding fatigue risk,[1–3] or to proactively protect their workforce and/or passengers.

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Historically, research-grade actigraphs have been the device of choice to collect sleep data from crewmembers during flight operations for both the fatigue research community as well as aviation safety departments.[8,9] Recently, many consumer sleep technologies (CSTs) like smart watches, fitness trackers, and mobile software applications (apps) have become popular on the consumer market. While not all CSTs have completed the necessary evaluation to determine accuracy for sleep-wake determination, many CSTs have been tested and shown to track sleep as accurately as traditional actigraphs for the purposes of FRMS.[10,11]

CSTs offer advantages over traditional actigraphy with regards to fatigue risk management on an individual level. CSTs deliver immediate feedback about sleep duration and quality directly to the wearer. CSTs also extract data remotely, meaning that researchers can access information about crewmembers' sleep without needing to be in the same region. The efficacy of CST feedback on sleep hygiene still needs to be rigorously tested to establish scientific accuracy, but is a promising lure to FRMS—a field that focuses on improving real world safety rather than understanding the biological phenomenon of fatigue. CSTs are, therefore, poised to revolutionize fatigue management by facilitating the ease of remote data collection, reducing the burden of data collection on the subject, increasing the window of time during which data can be collected, and providing personalized feedback about fatigue risk management to the wearer.

Aviation professionals have anecdotally expressed a desire to replace traditional actigraphs with their preferred CSTs to collect sleep data for FRMS purposes. However, crewmember preferences for data collection using CSTs, or their willingness to share data from CSTs, has not been investigated beyond anecdotal reports. The fatigue science team at the Institutes for Behavior Resources (IBR) has been conducting a series of surveys about the desirability of CSTs as scientifically relevant sleep tracking tools.[12,13] Previous surveys in this project have focused on the opinions of sleep researchers or general consumers. The goal of the current survey is to establish an estimate of aviation professionals' CST brand preferences, desirability of sleep-tracking features, and willingness to share sleep and activity data with their organizations for the purposes of fatigue risk management. To our knowledge, this is the first report of CST device and data-sharing preferences within a pilot or crewmember population.

METHODS

Subjects

Professional opinions from pilots and crewmembers who routinely travel for work were elicited from across the global aviation community through social media, email, and word of mouth. Any crewmember who works in an aircraft while it is in transit (e.g., pilots or cabin crew) was considered eligible for inclusion; aviation professionals who do not work in an aircraft while it is in transit were not eligible for this survey (e.g., air traffic controllers or ground crew). Efforts were taken to recruit respondents from across the world and across aviation industries by directly contacting regional, national, and international airlines, pilot and crewmember associations, aviation societies, advocacy groups, and unions, as well as the use of social media tags. **Fig. 1** shows a flow chart of subject inclusion based on response criteria. Respondents needed to indicate that they held a position in aviation and needed to respond to at least one survey question related to sleep or CST use to be included in the final analysis. Respondents did not need to complete the entire survey to be included in subsequent analysis but did need to provide at least one viable response to be included. A substantial proportion of respondents indicated a role in aeromedical transport via write-in response. Aeromedical transport,

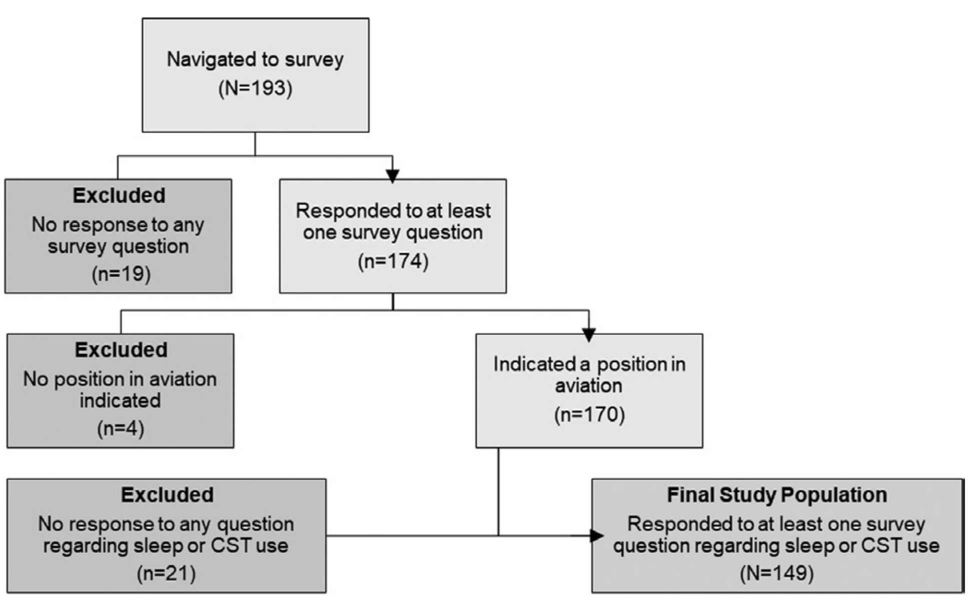

Fig. 1. Flow chart of inclusion and exclusion criteria for survey respondents. High importance is in dark grey; medium importance is in medium grey.

sometimes called air ambulance, medical evacuation (medevac), or helicopter emergency medical services (HEMS), is an emergency medical service that involves the use of an aircraft to move patients from one location to another. An aeromedical transport category was added and examined in subsequent analyses. This study was approved with exempt status by the Salus Institutional Review Board (Protocol Number IBR2023P) and these analyses were conducted in accordance with the Declaration of Helsinki.

Procedure

The survey was hosted on the online tool Qualtrics (www.qualtrics.com). Survey results included in this manuscript were collected between January and July 2023. The voluntary anonymous survey was composed of 11 questions grouped into 3 sections. The first section contained three questions focusing on the respondent's professional demographics (current job position, industry, and length of normal flight operations, in hours).

The second section contained seven questions asking about fatigue, sleep tracking, and device preferences. The last section contained one question asking respondents to rate the likelihood that they would share deidentified data with their organization under the conditions of four separate hypothetical scenarios. Scenarios were developed following discussion with multiple aviation industry fatigue risk managers. Scenarios were based on two of the most common data collection options for FRMS— up to 6 wk of data collection with a sleep diary or a noninteractive sleep tracker (actigraph or CST) and two potential alternative methods of data collection—providing employees with a sleep tracker to keep, or having employees share data from their personally owned sleep tracker. Respondents were able to provide comments in a text box up to a 20k character limit at the end of the survey.

Respondents could select the best fitting option from a multiple-choice list for Q1–Q3 or provide a write-in response if no option described them. Respondents were next asked to rank a list of sleep issues that they felt affected their ability to perform in Q4 and information that helped them manage their own sleep in Q5 by order of importance (high importance, medium importance, or low importance). Respondents could additionally provide and rank a write-in response. Respondents indicated whether they used a sleep tracking device or app in Q6, followed by conditional logic questions asking the respondent to explain why they did or did not use a sleep tracker using a write-in response text box. Respondents next selected their preferred type of sleep tracker for personal use during duty periods in Q7 and ranked the likelihood of providing data (very likely, slightly likely, or not at all likely) under different circumstances in Q8.

Statistical Analysis

All data were exported from Qualtrics as an Excel file and subsequently analyzed using Excel 2013 and STATA MP 15 (StataCorp, College Station, TX, United States). Distribution of responses across job positions, industry, and operation length were tested using the Chi-squared test. The Excel Rank function was used to calculate weighted mean rank order for Q4, Q5, Q7, and Q8 items. Write-in responses for Q6.1a and Q6.1b and Q6.2 were thematically coded using summative content analysis.[14] Subgroup analyses were conducted for respondents within the same job position category or operation length category provided that the group consisted of at least 10% of the total respondent population ($\geq N = 15$) using subject counts, descriptive means and standard deviation, the rank function, and the Wilcoxon signed-rank test for paired samples to determine differences in overall ranking for Q4, Q5, Q7, and Q8 and differences in percentage of CST users and nonusers compared to overall results and between subgroups as appropriate.[15] Statistical significance was assumed at $P \leq 0.05$.

RESULTS

As shown in Fig. 1, the final study population consisted of $N = 149$ respondents. Distribution of respondents by job position, operation length, and organization type is summarized in **Table I**. All respondents completed between 38–100% of the survey, with $N = 72$ respondents completing 100% of the survey. Responses were unequally distributed across job positions ($\chi^2 = 99.86$, $P < 0.001$), industry ($\chi^2 = 158.36$, $P < 0.001$), and normal operation length, defined as short haul (SH), medium haul (MH), long haul (LH), ultra-long range (ULR), or on-call operations ($\chi^2 = 202.23$, $P < 0.001$). As shown in Table I, the greatest number of respondents indicated "pilot" as their job position. Commercial was the most common industry and SH operations were the most common normal operation length.

Rank order responses to Q4–Q5 are depicted in **Fig. 2**. Items are displayed in descending rank order and are numbered by rank. Fig. 2A shows respondents' ranking of important sleep issues that impact their ability to perform work activities. "Nighttime operations" and "inconsistent sleep routine" ranked as the most important. "Jet lag", "snoring/sleep apnea", and "inability to sleep/insomnia" were ranked as the least important sleep factors affecting ability to perform work activities. Fig. 2B depicts perceived importance about information about sleep. Information about "sleep quality history" followed by "projected alertness levels" were ranked as most important for personal sleep management. "Tips for improving sleep hygiene" or "advice on when to exercise or consume caffeine" were ranked as the least important information. Respondents did have the option of entering additional write-in responses for each question but did not name any other sleep issues or information about sleep.

Responses about current CST use, reasons for using or not using a CST, and brand preferences are depicted in **Fig. 3**. As shown in Fig. 3A, 43% of respondents indicated that they currently use a CST. Fig. 3B depicts these respondents' main reasons for using a CST. Sleep and fatigue tracking was the most reported reason for wearing a CST in this group. Fig. 3C shows the main reasons for not using a CST by the 46% of respondents who responded negatively to Q6. No perceived need for a device and simply not owning a device were the most reported reasons in this group. Some respondents provided multiple

Table I. Respondents by Job Position and Operation Length.

JOB POSITION & INDUSTRY TYPE	ON CALL	SHORT HAUL	MEDIUM HAUL	LONG HAUL	ULTRA-LONG HAUL	TOTAL
Pilots						
Commercial	0	23	27	10	3	63
Cargo	0	1	3	1	1	6
Business	0	1	0	1	0	2
Aeromedical	3	27	3	0	0	33
Other	0	4	0	0	0	4
Flight medic						
Commercial	0	0	0	0	0	0
Cargo	0	0	0	0	0	0
Business	0	0	0	0	0	0
Aeromedical	2	27	2	2	1	34
Other	0	0	0	0	0	0
Cabin crew or Other						
Commercial	0	2	2	0	0	4
Cargo	0	0	0	0	0	0
Business	0	0	0	0	0	0
Aeromedical	0	0	0	0	0	0
Other	0	2	1	0	0	3
Totals						
Pilots	3	56	33	12	4	108
Flight medic	2	27	2	2	1	34
Cabin crew or Other	0	4	3	0	0	7
Grand Total	5	87	38	14	5	149

reasons for not using a CST; each reason was independently coded into an appropriate category.

CST users were additionally asked if they had a preferred brand. Largely, respondents did not have a brand preference (30%, $N = 19$). The most frequently named device brand was Garmin (21%; $N = 13$), followed by Apple (17%, $N = 11$), then Fitbit (10%, $N = 6$), Oura ring (6%, $N = 4$), Sleep Cycle (5%, $N = 3$), Samsung (5%, $N = 3$), Whoop (5%, $N = 3$), Google Fit (1%, $N = 1$), and CrewAlert (1%, $N = 1$).

For Q7, $N = 65$ respondents (43%) indicated a preference for a wrist-worn smart watch CST device, followed by a wrist-worn device with no smartwatch capabilities (16%, $N = 24$) or a device worn on the finger (14%, $N = 20$). Less than 10% of respondents preferred a sleep-tracking mobile app like Sleep

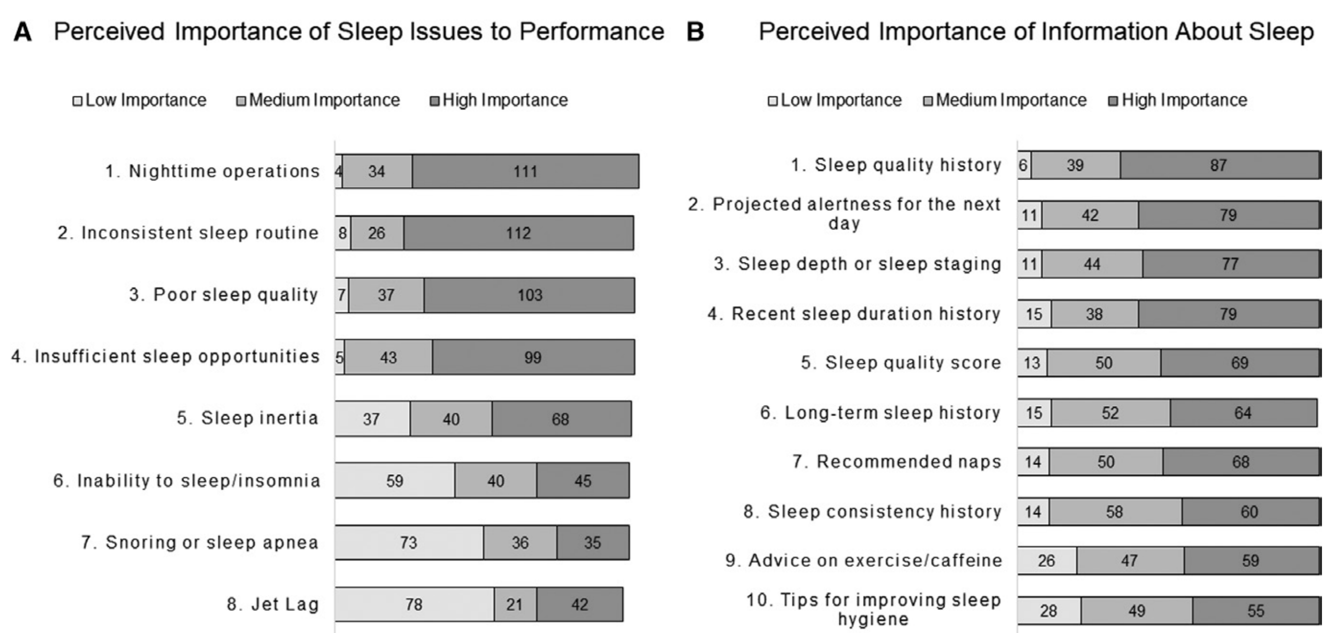

Fig. 2. Perceived importance of sleep issues and information about sleep. Mean rank order of responses regarding A) the level of importance of sleep issues to their ability to perform work tasks and B) the level of importance of information about sleep for personal sleep management. Items are listed on the y-axis by weighted rank, with number 1 corresponding to higher importance ranking. Bars depict the number of responses by level of importance (high importance is in dark grey; medium importance is in medium grey; and low importance is in light grey) for each item.

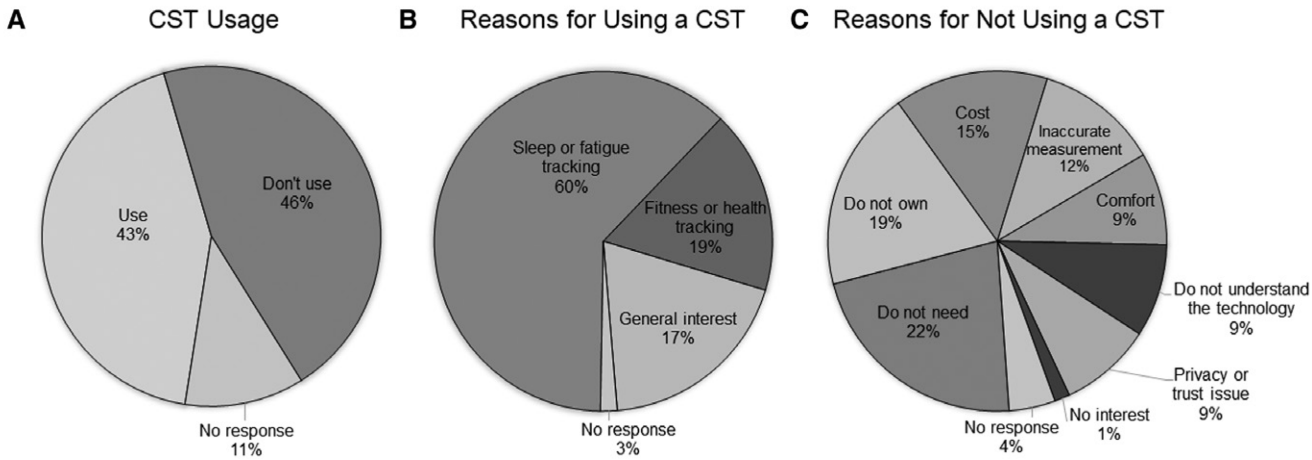

Fig. 3. Consumer sleep technology (CST) usage among aviation professionals. A) Pie chart depicting the percentage of respondents who use a CST, individuals who do not use a CST, and no response. B) Pie chart depicting CST users' reasons for using a CST by theme and percentage. C) Pie chart depicting CST nonusers' reasons for not using a CST by theme and percentage.

Cycle or CrewAlert (6%, $N = 9$), provided a write-in response for continuous positive airway pressure (CPAP) monitoring (1%, $N = 1$), or preferred no device at all (5%, $N = 8$). No respondents indicated a preference for a digital sleep diary or head-worn device. Of the respondents, 14% ($N = 21$) did not provide a response.

Respondents were evenly split between those who reported using a CST ($N = 64$) and those who reported not using a CST ($N = 68$), with no answer at all from $N = 17$ respondents. There were no significant differences between users and nonusers concerning sleep issues that affect performance (Q4; z = 0.00, $P = 1.00$), information about sleep (Q5; z = 0.49, $P = 0.62$), preferences in CST type (Q7; z = 0.00, $P = 1.00$), or data sharing (Q8; z = 0.00, $P = 1.00$). There were no differences in ranking on any question between either CST users or nonusers compared to the overall results (all $P > 0.52$).

Respondents' likelihood to share data with their organizations under different scenarios is summarized in **Fig. 4**. The scenario under which respondents were most likely to provide data was if they were given a sleep tracker to keep indefinitely by their organization. Respondents were least likely to provide data if they were required to complete an electronic sleep diary for up to 6 wk.

Four subgroups met the population threshold ($\geq N = 15$) for subgroup analysis. The pilot subgroup consisted of $N = 108$ respondents while the flight medic subgroup consisted of $N = 34$ individuals. A total of $N = 87$ respondents flew SH operations and $N = 38$ flew MH operations. There was considerable overlap between job positions and normal operation length, such that 52% of pilots ($N = 56$) and 78% ($N = 27$) of flight medics flew SH; 31% of pilots ($N = 33$) and 6% of flight medics ($N = 2$) flew MH. Regarding CST use, 44% ($N = 47$) of pilots and 38% of flight medics ($N = 13$) used a CST; 36% of respondents who flew SH ($N = 31$) and 58% of respondents who flew MH ($N = 22$) used a CST. There were no significant differences in subgroup responses for Q4, Q5, Q7, and Q8 for MH, SH, pilots, or medics compared to overall results between SH and MH, or between pilots and medics (all $P > 0.31$). Due to the overlap in job positions, industries, and operation lengths, no further statistical tests between subgroups were appropriate.

DISCUSSION

Fatigue risk management in aviation depends upon objectively collected sleep and fatigue data that can inform decisions about flight-duty limitations. Research-grade actigraphy has historically been used to collect sleep data for FRMS, but recent advancements in commercial sleep-tracking technology could open up more opportunities for aviation organizations to collect sleep data from crewmembers in a low burden manner. Developing a strategy to update data collection methods for FRMS begins with understanding crewmembers' preferences about CSTs and data sharing. The goal of this survey was to establish which sleep data collection methods would appeal to the greatest number of aviation professionals based on job roles, operation lengths, or specific industry. Importantly, this survey assessed demand for CSTs in aviation professionals in the context of work and FRMS data collection. Thus, findings may not generalize to aviation professionals' preferences about CSTs for personal use.

Overwhelmingly, respondents agreed that the most important sleep issues that impacted their work performance were nighttime operations and inconsistent sleep routine (see Fig. 1A). Circadian misalignment and sleep disruption are considered two major biological factors that contribute to fatigue in aviation.[4,6,7] Aviation FRMS commonly use biomathematical models of fatigue to evaluate the fatigue risk associated with a planned schedule or operation based on sleep loss and circadian misalignment. The aviation industry also takes a proactive approach in educating crewmembers about the causes of fatigue. The findings depicted in Fig. 2A suggest that crewmembers are in agreement with the scientific and risk management communities regarding causes of fatigue that impact performance.

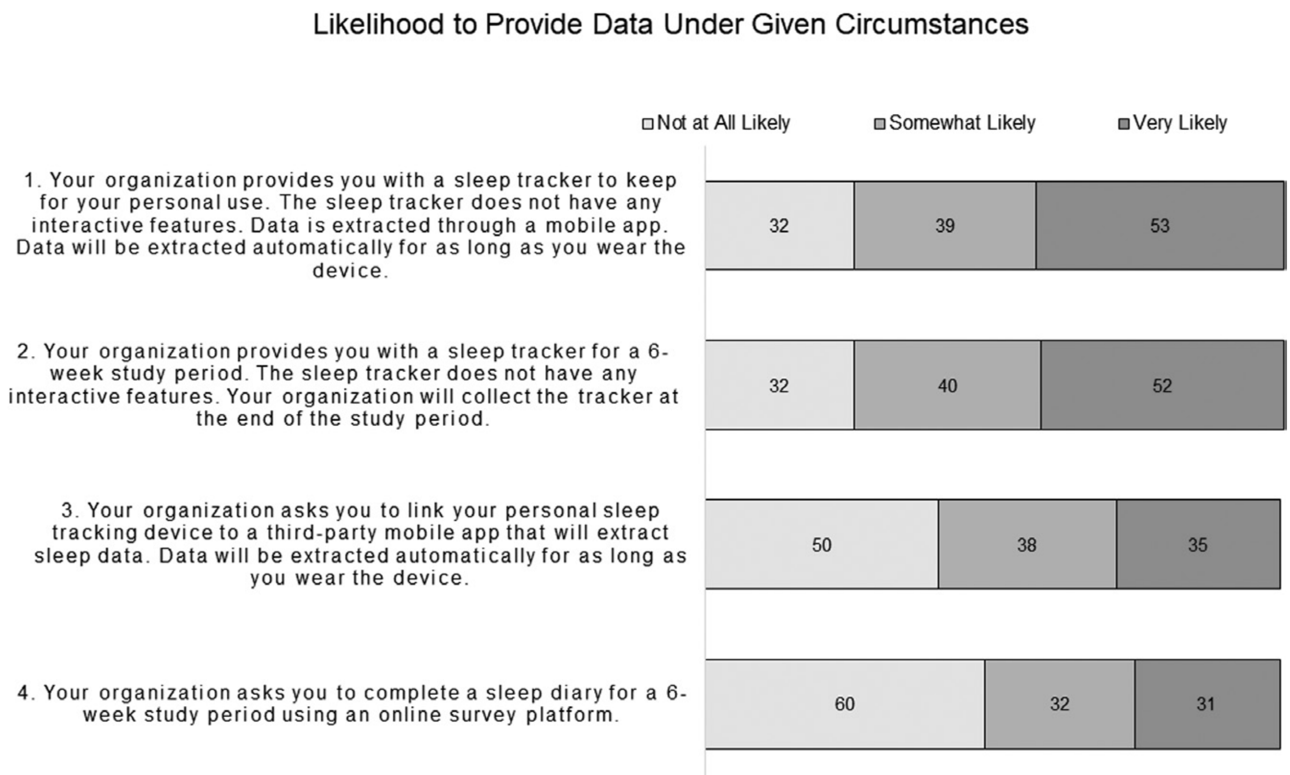

Fig. 4. Likelihood of providing data to organization across circumstances. Mean rank order of responses regarding respondents' likelihood of sharing data with their organization based on the circumstances of data collection. Items are listed on the y-axis by weighted rank, with number 1 corresponding to greater likelihood. Bars depict the number of responses by likelihood (Not at All Likely in light grey, Somewhat Likely in medium grey, Very Likely in dark grey) for each item.

Sleep quality history and projected alertness levels ranked as the most important information for managing sleep, shown in Fig. 2B. Sleep quality may have higher importance than sleep duration to aircrew because their time has schedule constraints. Maximizing sleep quality may be the only option to improve performance during a limited time window that does not allow for longer sleep duration. Inconsistent sleep routines and nighttime operations can both lead to diminished sleep quality that can accrue over time. Perhaps information about how well a crewmember slept combined with a prediction of their alertness for the upcoming day is more salient than information about the overall duration of sleep or advice that may not be applicable given their work constraints.

Sleep quality history outranked similar metrics like sleep depth/sleep scoring or sleep quality score. It therefore would seem that sleep quality is viewed separately from sleep depth or sleep scores by the aviation community. Sleep efficiency, or the ratio between the time a person spends asleep over the total time dedicated to sleep, is a common measure of objective sleep quality in the scientific community[16] and could represent what respondents want as feedback about objective sleep quality. Respondents could have been interested in a self-report measure of their own subjective sleep quality. An important follow-up survey would be to investigate the most salient measure of sleep quality over time to provide feedback to aviation professionals.

Another interesting point is that some information that is commonly provided by apps, such as sleep duration or recommendations to improve sleep hygiene, was ranked as having low importance in the current study while projected alertness, which is not a standard metric provided by apps, was ranked second overall. There seems to be a market gap between information that CST developers feel is important to report and information that aviation professionals feel is important to their ability to perform. There are a few mobile apps such as SleepTank,[17] 2BAlert,[18] or CrewAlert[19] that aim to predict alertness in relation to sleep history. These apps have been developed with military or aviation populations in mind, but are not available yet for all platforms or devices.

Interestingly, recommendations about napping, exercise, optimal caffeine consumption, or sleep hygiene tips ranked as the least important perceived information about sleep, as shown in Fig. 2B. This finding seems counterintuitive given the potential benefit that tactical napping, caffeine optimization, exercise, or sleep hygiene techniques may have for an occupational population in a safety-sensitive industry like aviation. It may be that the respondents in this study are unfamiliar with how these techniques may benefit them, have already adopted these techniques, feel that they cannot adequately apply them given the operational constraints of their jobs, or are disinterested in making additional behavioral changes to accommodate their work performance. An interesting follow-up study will be to investigate why aviation professionals viewed actionable advice from a wearable as low value.

Wrist-worn devices were the preferred type of sleep tracker for work purposes. Smart watch sleep trackers and wrist-worn fitness bands with no watch face were selected by a combined 60% of respondents, with devices worn on the finger as the third most popular choice. Aviation professionals frequently sleep in different locations for work, such as an onboard rest facility or a hotel, so a device that can continuously be worn on the body makes practical sense. A previous survey asked real-world sleep researchers their preferences about CSTs and also showed a majority preference for wrist-worn devices, despite the expert respondents reporting "brain activity in combination with motor activity and biometrics" as the most accurate method of measuring sleep.[13] Respondents in the current survey may not be familiar with portable technologies that can measure brain activity, but were provided with the option of a "headband" device on Q7. Respondents in the previous study were members of the sleep research community with experience collecting in the field[13] and, so, were familiar with fieldable CSTs beyond wrist-worn options and were also familiar with compliance problems when working outside the lab.

Wrist-worn devices may be preferrable to real-world sleep researchers because subjects are more likely to wear them consistently. The main goal of a sleep data collection for FRMS is to assess whether the working conditions allow sufficient opportunities for sleep rather than to investigate the biological underpinnings of sleep physiology. Device removal can result in periods of no data that can skew or render the dataset useless. Subject compliance becomes more important than the ability of the device to accurately measure sleep on an epoch-by-epoch basis. The best possible technology may not always be the most accurate technology, but perhaps may be the most convenient technology in some cases.

Device brand loyalty was not strong among CST users, a finding which bodes well for organizations looking to purchase devices for FRMS. This also indicates that there is a market opportunity for CST manufacturers to create a device that can accurately measure sleep in aviation's unique sleeping environment. Only current CST users were asked if they have a preferred device, of whom 30% indicated that they did not have a preference. The most frequently reported devices were Garmin, which were preferred by 21% of CST users ($N = 13$). Five of the reported preferred brands can be categorized as wrist-worn smart watch trackers (Garmin, Apple, Fitbit, Samsung, WHOOP) and one was a ring-based device (Oura). This supports the finding that most aircrew prefer a wrist-worn smart watch CST. Reifman et al. recently showed in a meta-analysis of device validation studies that currently available Fitbit and Oura devices, but not current versions of Garmin or WHOOP, produced sleep measurements that are operationally acceptable for fatigue management.[11] Apple and Samsung devices were not included in that meta-analysis. Three of the preferred trackers were mobile apps (Sleep Cycle, CrewAlert, Google Health) that either require completing a sleep diary or linking the app to a CST. Nonusers' reported "no perceived need", "no device ownership", and "cost" as common reasons for not using a CST, as shown in Fig. 3B. While some nonusers reported concerns about privacy, comfort, the accuracy of the measurements, or unfamiliarity with the technology, these results suggest that nonusers could be convinced to wear a device if they were given one at no personal cost.

The majority of respondents reported high likelihood of providing data through the use of a sleep tracker that has been given to them by the organization. Interestingly, even respondents who were current CST users still preferred to wear a device purchased by the organization over linking their personal device to a third-party data extraction app. Respondents were least likely to provide data through a sleep diary, indicating that if an organization wants to use an app to collect sleep data for FRMS, the app should be able to link to a wearable device. Respondents were not asked if they had ever provided data for FRMS before. This limitation means that we cannot evaluate whether respondents' likelihood ratings were tempered by past experiences. Common methods for data collection in FRMS have been actigraphy or sleep diary for a limited time period (up to 6 wk). It may be that respondents' previous experience with data collection influenced their responses. For example, completing a sleep diary requires more effort on the part of the subject than does wearing an actigraph and can be frustrating. Someone with prior experience as a study subject may have stronger opinions about data collection methods than a respondent who has not done a data collection before.

This report is not without limitations. Responses are not evenly distributed across all sectors of aviation, restricting our ability to compare results with statistical robustness across groups. This is an ongoing study, so efforts will be taken to increase recruitment of survey respondents in meagerly represented categories, such as flight attendants/cabin crew ($N = 7$), LH ($N = 14$), or ULR ($N = 5$) crewmembers. Rank order tests are also qualitative in nature and are most likely not the best method to determine differences between subgroups. These reasons may be why there were no statistical differences in rank order between the overall sample population and subgroups. The results of this survey should be interpreted as preliminary and descriptive. Since the survey is ongoing, follow-up analyses can assess whether there are differences between groups based on position or operation length once a larger number of subjects have responded for each category of interest. Reasons for fatigue are known to differ by operation length,[5,20] so it is important to evaluate fatigue independently across different operational parameters.

Secondly, respondents were not asked to provide information about their region of operation, gender, ethnicity, or level of experience—information that could intersect with issues of fatigue and performance. The recruitment material was also only provided in English and posted on North American-based social media platforms, such as LinkedIn, Instagram, and Twitter/X or live presentation in North America and Europe, which may skew recruitment toward aviation professionals from those regions. Efforts were taken to increase exposure of the recruitment materials to crewmembers globally as well as crewmembers who may identify as an ethnic or gender minority, but these demographic data were not measured by the survey. Therefore, it is impossible to determine between-group differences or gauge the possibility of biased results.

Thirdly, this survey assesses demand in a population that may not fully appreciate the current shortcomings of consumer sleep trackers. Previous surveys in this series have assessed CST demand within a sleep researcher population,[13] as well as demand for scientific accuracy in a CST in a general consumer population,[12] but respondents in this study were not asked about scientific evaluation of CSTs. This was done because any device used for FRMS would need to meet regulatory requirements for validity, so the onus of determining the appropriateness of a device falls on the regulator or operator rather than the individual crewmember. Finally, this survey is tightly focused on sleep-tracking and data sharing, thus it does not encompass the breadth of fatigue issues in aviation. Sleep is a major component of readiness however, so it is our hope that maximizing compliance to data collection within the sleep domain will lead to a better understanding of the impact of fatigue on performance in general.

In conclusion, pilots, flight medics, and cabin crew from commercial aviation, aeromedical transport, cargo aviation, business aviation, and other aviation industries would be more likely to provide sleep data to their organization through a third-party mobile app if they are given a wrist-worn CST to wear by the organization than if they need to link their personal device or complete a sleep diary. Respondents did not indicate strong preferences overall regarding brand loyalty or adopting the use of a CST for FRMS purposes. Crewmembers are most concerned about the impact of nighttime operations and inconsistent sleep routines on their ability to perform and would most appreciate feedback about sleep quality history or predictions about next day alertness. Providing crewmembers with CSTs that simultaneously collect data and provide feedback to improve sleep may doubly benefit FRMS efforts by increasing the flow of information between the organization and the individual worker.

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