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Perceptions of Flight Crew Resilience Among Commercial Pilots: Evaluation of Pilots' Acceptance of CBTA Across China, America, Europe, and the Asia Pacific

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***Abstract*—Airline pilots play a critical role in ensuring safety in aviation. This study investigates commercial pilots' perceptions of flight crew resilience, and their acceptance of Competency-Based Training and Assessment (CBTA) utilizing revised questionnaires from the Flight Management Attitude and Safety Survey (FMASS). The research included pilots from China, America, Europe, and the Asia Pacific, aiming to assess their understanding, acceptance, and application of resilience concepts and CBTA methods in daily operations.**

The study uses a survey that includes open questions for pilots to share their suggestions for CBTA training. This advantage allows the study to apply both quantitative and qualitative approaches. The mixed methods of SPSS v.26 and NVivo provide valuable insights. The findings indicate that pilots possess a better understanding of, and more positive attitudes toward, Crew Resource Management (CRM) and Threat and Error Management (TEM). The study advocates for fostering a supportive cockpit environment, emphasizing the importance of airline culture and cockpit climate in building resilience. It also highlights the necessity of incorporating resilience training into initial pilot education and during CBTA programs.

Recognizing that humans are critical to the aviation system, the study concludes that resilience training for flight crews should begin with the very first lesson in pilot training. Additionally, successful pilot training outcomes will benefit from collaboration between researchers and industry practitioners.

Keywords—training, resilience, flight crew, monitoring, communication, practice

I. INTRODUCTION

The aviation industry has long recognized the critical importance of resilience among flight crews, particularly in the face of unexpected challenges. Resilience, in this context, refers to the ability of pilots and crew members to effectively manage and respond to adverse situations, ensuring safety and operational efficiency. This concept gained renewed attention following notable incidents such as the Air France Flight 447 disaster and the successful emergency landing of US Airways Flight 1549.

The tragic case of Air France Flight 447, which crashed into the Atlantic Ocean in 2009, serves as a stark reminder of the potential consequences of inadequate crew response to unexpected events. The aircraft experienced a degradation in airspeed indications due to high-level pitot icing, leading to confusion and a "startle effect" among the cockpit crew. This incident resulted in the loss of all 228 passengers and crew members on board. It raises a critical question: How can pilots enhance their resilience to prevent similar tragedies?

In contrast, the successful emergency landing of US Airways Flight 1549 in 2009, after both engines failed due to a bird strike, exemplifies effective crew resilience. The flight crew, led by Captain Chesley "Sully" Sullenberger, demonstrated exceptional airmanship, teamwork, and communication skills. Their ability to remain calm under pressure and make quick, informed decisions ultimately saved the lives of all 155 individuals on board. This incident highlights the importance of strong leadership and cohesive teamwork in fostering resilience within flight crews.

Resilience can be categorized into two types: strategic and tactical. Strategic resilience involves the ability to anticipate and prepare for potential challenges, while tactical resilience refers to the immediate management of emotional responses and cognitive skills during a crisis. Individual pilots may exhibit technical competence and knowledge of aircraft procedures; however, the overall resilience of a flight crew is significantly enhanced through effective teamwork and leadership. As noted by Martin (2019), practicing non-technical skills, such as communication and collaboration, is essential for developing crew resilience.

The European Union Aviation Safety Agency (EASA) has outlined four key abilities that contribute to resilience development: anticipating, monitoring, responding, and learning. These abilities are crucial for flight crews to navigate the complexities of aviation operations. However, Leveson (2020) argues that resilience should not solely be viewed as a function of individual behavior; rather, it must be integrated into the entire aviation system. This perspective emphasizes the need for a holistic approach to resilience that encompasses both human factors and systemic design.

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Research has shown that these four resilience abilities are applicable to various populations of pilots, including those in the United States. Studies conducted by Kiernan et al. (2020) and Cross & Kiernan (2022) have examined pilots' resilient behaviors, suggesting that a broader investigation across different airlines and cultural contexts is warranted. This raises an important question: Do these resilience abilities effectively apply to Chinese pilots in their day-to-day operations?

In response to the evolving landscape of pilot training, airlines are increasingly adopting CBTA approaches, which focus on developing a wide range of competencies that prepare flight crews for unexpected events rather than Task-Based Training (TBD), which merely trains pilots to respond to specific scenarios. The CBTA framework emphasizes the importance of knowledge, skills, and attitudes, which are assessed through behavior markers (Flin & O'Connor, 2001). The International Civil Aviation Organization (ICAO) is actively promoting the implementation of Evidence-Based Training (EBT) programs, which align with the principles of CBTA to enhance pilot resilience and performance.

The COVID-19 pandemic has further complicated the landscape of aviation, impacting pilots' job satisfaction and operational readiness. Through the pandemic years, it has resulted in significant disruptions to the aviation industry, leading to personnel layoffs, furloughs, and altered work schedules. Many pilots have faced extended periods without flying, resulting in skill decay and heightened concerns about their ability to respond effectively in emergencies (Kioulepoglou & Blundell, 2022; Whitley & Kotoky, 2021). This context underscores the need for ongoing resilience training and support for pilots as they navigate the challenges posed by the pandemic.

This study aims to evaluate the perceptions of flight crew resilience among pilots across various regions, including China, America, Europe, and the Asia Pacific, particularly in the context of COVID-19. It seeks to address two key questions: What are airline pilots' attitudes toward CRM during the pandemic, and how have they responded to changes in CBTA training? Understanding these perceptions will provide valuable insights into the effectiveness of resilience and CBTA training and the cultural factors that influence pilot behavior.

In conclusion, the importance of resilience in aviation cannot be overstated. The lessons learned from past incidents, along with the ongoing challenges posed by the COVID-19 pandemic, highlight the necessity for a comprehensive approach to pilot training and support. By fostering resilience through effective teamwork, communication, and training methodologies, the aviation industry can enhance safety and operational performance, ultimately ensuring the well-being of both crew members and passengers.

II. Literature Review

In the aviation industry, the effectiveness of flight crews is paramount for ensuring safety and operational efficiency. CRM has emerged as a critical framework for enhancing non-technical skills among pilots and crew members. As a supporting measurement tool, the Cockpit Management Attitudes Questionnaire (CMAQ) was introduced (Helmreich, 1984). It helps airlines assess the effectiveness of their training programs and how well they meet their knowledge and attitudinal objectives. On one hand, CRM helps flight crews prevent errors; on the other hand, it enhances their capability to contain mistakes resiliently (Cowley et al., 2021). This literature reviews CRM implementation, the significance of resilience training, and the roles of individual and team competencies in the cockpit.

A. CRM in the flight deck

Historically, pilot training focused primarily on technical skills, often neglecting the importance of interpersonal and cognitive skills. CRM was introduced to address the shortcomings of traditional training methods, which often led to communication failures and coordination issues among crew members. Research indicates that many aviation accidents can be attributed to human factors, including poor communication and decision-making (Palmer et al., 1998). For instance, the Teneriffe air disaster turned the importance of teamwork onto the surface because of the downside of human involvement (Weick, 1990). In response, CRM training has been integrated into pilot education to foster better teamwork, enhance situational awareness, and improve decision-making processes.

CRM training programs have evolved to include resilience development as a core component. While traditional CRM training focused on communication and coordination, recent advancements have recognized the need to cultivate resilience as an expert attribute that requires time and effort to develop (Flin, 2019). Resilience training interweaves with other elements of CRM, emphasizing the importance of adaptability and flexibility in the face of challenges.

Training programs should incorporate scenarios that simulate unexpected events, allowing pilots to practice their responses in a controlled environment. This experiential learning approach helps build adaptive expertise, enabling crews to perform effectively under pressure. Additionally, training should address the psychological aspects of resilience, equipping pilots with strategies to manage stress and maintain focus during critical situations.

In conclusion, the evolution of Crew Resource Management has significantly impacted the training and performance of flight crews in the aviation industry. By emphasizing the importance of resilience, teamwork, and nontechnical skills, CRM training programs have become essential for enhancing safety and operational efficiency. As the industry continues to evolve, ongoing research and regulatory support will be crucial in developing effective training strategies that prepare pilots for the challenges of modern aviation.

B. CBTA approach

The aviation industry has shifted from TBD trainging to CBTA approach. This approach emphasizes the development of a broad range of competencies rather than merely teaching pilots to react to specific situations. CBTA focuses on both technical

skills, such as manual flying and automation management, and non-technical skills, including communication and teamwork (Alavosius et al., 2017).

A well-structured training program should consider the limitations of human performance and ensure that pilots operate within their capabilities. The ICAO has identified nine key competencies that contribute to pilot resilience, encompassing knowledge, skills, and attitudes that integrate CRM elements into the training framework. This holistic approach aims to enhance both individual and team performance in the cockpit.

C. The Role of Resilience in Flight Crew Performance

Resilience is a crucial attribute for flight crews, enabling them to adapt to unexpected challenges and maintain performance under pressure. The term "resilience" originates from the Latin verb *salire*, meaning to jump or recoil, and has been widely applied in various fields, including ecology and psychology (Zolli, 2012). In aviation, resilient crews are defined as those capable of recognizing, adapting to, and absorbing threats that exceed their training (Dekker & Lundstrom, 2007).

Recent studies emphasize the need for training programs to focus on developing resilience among pilots. Regulatory bodies, such as EASA and ICAO, have highlighted the importance of resilience training in their guidelines (EASA, 2012; ICAO, 2014). This training should prepare pilots to handle surprising situations and challenge rigid patterns during routine operations, ultimately enhancing their ability to respond to unforeseen events, often referred to as "Black Swan" or "Gray Rhino" events. Table 1 shows that resilience development has been included in the CRM training course topics.

TABLE I. KEY TOPICS FOR CRM TRAINING COURSES.

• Application of the principles of CRM and threat and error management (TEM)
• Situation awareness
• Problem-solving and decision-making
• Workload management/task sharing
• Communication/assertiveness
• Leadership and teamwork
• Stress and Stress Management
• Fatigue and vigilance
• *Automation*
• *Monitoring and intervention*
• *Resilience development*
• *Surprise and startle effects*
• Operator's safety *culture* and company *culture*

Resilience is essential for the cockpit crew, as it enables pilots to recover from in-flight challenges and uphold operational safety under stress. Resilience is seen not just as an inherent trait but as a collection of skills and behaviors cultivated through training. CRM training is crucial in developing these skills as it emphasizes teamwork, communication, and decision-making, which are vital in complex and dynamic environments.

The pandemic has presented unique challenges for pilots, affecting their operational environment and possibly their attitudes toward CRM. As pilots adapt to new norms and operational procedures, their perceptions of CRM's importance may evolve. There may be a shift in their approach to teamwork and communication due to heightened stressors and changing dynamics in the cockpit. However, these responses are not thoroughly documented in current literature, highlighting an academic gap in understanding the nuanced effects of the pandemic on CRM attitudes and practices among pilots.

While the training shift from task-based to competency-based, there is a need for further investigation into how pilots perceive these changes amid the pressures of the pandemic. CBTA approach aims to develop a broader range of competencies, emphasizing resilience and adaptability. However, the effectiveness of such training in real-world scenarios—especially during periods of heightened operational stress like the pandemic—remains underexplored. Academic research thus has an opportunity to examine how pilots believe these changes in training impact their performance and resilience in both routine and unexpected situations.

The interplay between pilot resilience and effective CRM training has direct implications for aviation safety. Enhanced resilience facilitates better responses to emergencies, while effective CRM fosters a safety culture that can mitigate risks arising from human factors. While CRM and CBTA approach are intrinsically linked to operational safety, the precise attitudes of pilots towards CRM and their acceptance levels of CBTA necessitate further empirical investigation. Addressing this gap could provide insights into developing more robust training programs and improving overall safety in the aviation sector.

In summary, the relationship between pilot resilience, CRM training effectiveness, and aviation safety is complex and affected by external factors such as the pandemic. The research questions focus on understanding pilots' evolving attitudes towards CRM and adaptations to CBTA, which highlight significant gaps in the literature that, if addressed, could lead to more effective training methodologies and improved safety protocols within the aviation industry.

III. METHODOLOGY

This research employs quantitative measures to assess the perceptions of flight crew resilience within the airline pilot population, focusing on the relationship between attitudes and performance. Utilizing a questionnaire, the study aims to explore two primary questions: first, whether the attitudes of Chinese pilots toward CRM align with those of pilots globally; and second,

whether pilots exhibit positive attitudes toward the recent changes in CBTA. While the correlation between attitudes and performance is acknowledged to be imperfect (Helmreich & Foushee, 1993), the use of questionnaires is widely accepted as a valid method for gathering attitude-related data (Braun & Clarke, 2006). The final open-ended question in the survey invites pilots to share their comments on CBTA, providing additional qualitative insights into their perspectives.

A. Survey on Cockpit Crew Attitudes and Safety Perceptions

1) Introduction

This survey aims to assess the attitudes and safety perceptions of cockpit crew members, utilizing a modified version of the Flight Management Attitude & Safety Survey (FMASS) developed by Sexton et al. (2000). The FMASS has been validated for reliability and is commonly used in Line Oriented Safety Audits (LOSA). For this study, we focused on three specific scales from the FMASS: Safety Culture (SC), Job Attitudes (JA), and Stress Recognition (SR). Additionally, we included two new scales: Teamwork (TWK) and Pilots' Confidence, which were evaluated through selected questions.

The survey is designed to gather data that will serve as a baseline for future research on commercial pilots, particularly in the context of Asian cultures. To ensure inclusivity, we distributed the survey in English, along with a translated Chinese version to assist Chinese pilots in completing the questionnaire. The survey was disseminated via email to non-Chinese pilots and through a QR code shared on WeChat for Chinese pilots.

2) Methodology

a) Survey Design

The survey, developed using Jisc Online Surveys, consisted of three main parts:

TABLE II. DEMOGRAPHICS OF RESPONDENTS.

	Manager	**Check airman**	**Instructor**	**Captain**	**First officer**
Number of completed surveys	18	9	32	82	63
Age					
20-30	1			11	
31-40	6	1	16	29	26
41-50	6	5	8	25	4
51-60	5	2	6	14	
60 above		1	2	3	
Years at the airline					
Less than 1yr			2	5	1
1yr<3yrs	1		2	6	11
3yrs<10yrs	2		4	32	45
10yrs more	15	9	24	39	6
Location					
Northeast Asia	3			4	
Southeast Asia	2		2	2	1

China	11	5	26	52	54
America		4	2	6	3
Europe	2		1	12	3
Others			1	6	2
Gender					
Male	18	9	30	77	49
Female			2	5	14

- Collected demographic data, which includes age, gender, type of aircraft, and years of service at the airline.
- Focused on pilots' confidence, this section featured questions about self-evaluation of basic flying skills and the perceived support from the airline. Responses were measured on a 5-point Likert scale, ranging from (1) very low to (5) very high.
- Addressed cockpit management attitudes with a total of 41 questions, also using a 5-point Likert scale, ranging from (1) strongly disagree to (5) strongly agree, with a neutral midpoint. The final question was open-ended, requesting three recommendations for the CBTA program.

b) Participants

The survey was open from April 5th to May 24th, lasting seven weeks. A total of 585 individuals accessed the survey, with 213 completing it. Nine responses were excluded due to incompletion or missing essential information (e.g., gender). Among the remaining responses, 11 participants had one unanswered question; however, their data were retained as it did not affect the overall analysis. Ultimately, 204 valid responses were included, resulting in a response rate of 35%. Of these, 100 participants provided comments on the CBTA program, with 89 responses selected for qualitative analysis after excluding 11 meaningless replies.

This survey offers a thorough assessment of cockpit crew attitudes and safety perceptions, providing valuable insights for future research in commercial aviation. By establishing a baseline for pilots, particularly regarding Asian cultures, the findings will guide safety practices and training programs within the industry.

B. Analysis

The questionnaire data were organized and analyzed using SPSS v.26. To ensure the results were based on solid and reliable foundations, various inferential statistical methods were employed. A parametric T-test was utilized for comparisons between two groups, while one-way ANOVAs were conducted to identify significant differences among three or more groups. In cases where the assumptions of homogeneity of variances were violated, the Brown-Forsythe and Welch tests were applied. Additionally, to enhance robustness, given the disparate group sizes, a nonparametric Kruskal-Wallis test was used when the normality of the population was in question (Keppel & Wickens, 2004; Weiss, 2011).

It is noteworthy that Welch's two-sample t-test, although less commonly used than the Student's t-test, is more reliable for samples with unequal variances and potentially unequal sample sizes.

The study primarily focused on Chinese pilots, including a total of 148 participants from China. In comparison, there were 56 pilots from other regions, such as the USA, Europe, Southeast Asia, and Northeast Asia. Pilots from Northeast Asia and Southeast Asia regularly participate in joint meetings as members of the Asia Airlines Pilots Association (AAPA).

For the analysis, all Chinese transcripts were translated into English using Google Translate. Despite concerns regarding the accuracy of machine translation, as noted by Hofstadter (2018), Google Translate offers a comprehensive vocabulary and generally provides acceptable translations. The author reviewed the translations and listened to the recordings to correct any omissions.

IV. RESULTS AND DISCUSSION

A. Quantitative measures

Of the participants, 183 were male pilots and 21 were female pilots, making up 10.3% of the population. Their ranks included manager (8.8%), check airman (4.4%), instructor (15.7%), captain (40.2%), and first officer (30.9%). Based on airline locations, pilots were from Northeast Asia (3.4%), Southeast Asia (3.4%), Europe (8.8%), China (72.5%), the USA (7.4%), and others (4.4%). As expected, most participants came from China. Table 1 shows the demographics of the respondents.

Table 3 summarises the Means (M) and Standard Deviations (SD) for questions related to SC, JA, and SR scales within FMASS. An effort was made to compare the present (PRES) data (Pang, 2022), shown upright, with historical (H) data (Sexton et al., 2001), represented in italics. The table reveals interesting differences over the last 20 years, despite the samples being from different regions with different populations.

TABLE III. COMPARISONS BETWEEN CURRENT (PANG, 2022) AND HISTORICAL DATA (SEXTON ET AL., 2001).

Statement	Mean/ Std Dev		Sig.
	H	PRES	
Safety Culture			
1. I feel comfortable going to the senior manager's office to discuss problems or operational issues.	*3.21/ 1.01*	3.24/ 1.21	**.009**
2. The managers in Flight Operations listen to us and care about our concerns.	*2.94/ 1.22*	3.58/ 1.07	.511
3. My suggestions about safety will be acted upon if I express them to management.	*2.96/ 1.15*	3.69/ 1.03	.992
4. I am encouraged by managers to report any unsafe conditions I may observe.	*3.62/ 1.10*	4.18/ 0.92	.283
5. I know the proper channels to report my safety concerns.	*3.72/ 1.09*	4.33/ 0.78	**.048**
6. Management will never compromise safety concerns for profitability.	*3.08/ 1.23*	3.56/ 1.17	.053
Job Attitude			
7. Pilots trust senior management at this airline.	*2.52/ 1.24*	3.36/ 1.11	.121
8. Pilot morale is high.	*2.96/ 1.12*	3.33/ 1.13	.402
9. Senior management (VP and above) is doing a good job at this airline.	*3.79/ 1.05*	3.53/ 1.03	**.041**
10. Working here is like being part of a large family.	*2.56/ 1.26*	3.45/ 1.05	.093
11. I am proud to work for this company.	*3.50/ 1.19*	3.97/ 0.88	**.020**
12. I like my job.	*4.50/ 0.84*	4.24/ 0.93	**.045**
Stress Recognition (Rank/Location)			
13. I am more likely to make judgment errors in abnormal or emergency situations.	*3.41/ 1.23*	2.96/ 1.05	.735/ **.021**
14. I am less effective when I am stressed or fatigued.	*1.85/ 1.00*	1.96/ 0.95	**.002/ .000**
15. Personal problems can adversely affect my performance.	*2.16/ 1.05*	2.33/ 1.04	**.016/ .006**
16. My decision-making ability is as good in emergencies as in routine flying conditions.	*3.80/ 1.12*	3.81/ 0.86	**.003/** .999
17. My performance is not adversely affected by working with an inexperienced or less capable crew member.	*2.98/ 1.28*	3.47/ 0.97	.377/ .730
18. A truly professional crewmember can leave personal problems behind when flying.	*3.19/ 1.28*	3.72/ 1.12	**.019/** .094

B. Reliability & Validity

Table 4 presents the results of reliability and validity for the three original scales (SC, JA, and SR) derived from (Sexton et al., 2001) and the two scales (TWK and PC) examined by the author. As indicated by the Cronbach α value, the top three scales, PC, SC, and JA, demonstrate good reliability and validity, while the other two, SR and TWK, show poor reliability and validity.

TABLE IV. RELIABILITY & VALIDITY RESULTS FOR SCALES.

	Reliability		**Validity**
	Cronbach's Alpha	KMO	Bartlett's Test of Sphericity
Self confidence	0.861	0.853	χ^2=525.841 P=0.000
Safety Culture	0.818	0.828	χ^2=408.123 P=0.000
Job Attitude	0.875	0.816	χ^2=475.604 P=0.000
Stress Recognition	0.644	0.651	χ^2=205.452 P=0.000
Team Work	0.680	0.690	χ^2=227.567 P=0.000

1) Safety Culture

There were six questions regarding pilots' safety culture. For comparison purposes, the samples have been divided into three groups based on their cultural similarities: China, Northeast & Southeast Asia, and Europe & America. The aims were to examine the similarities and differences in pilots' attitudes from different countries and regions (participants treated as "Others"

were not compared). One-way ANOVA tests have been applied to the total samples and sub-groups of samples. Q41 utilised the Brown-Forsythe and Welch tests instead of the ANOVA tests since it failed the homogeneity of variances test (table 5).

TABLE V. MEANS (M), STANDARD DEVIATIONS (SD), AND MULTIPLE ANALYSES OF VARIANCE OF FLIGHT MANAGEMENT ATTITUDES.

		N	Mean	Std.Deviation	Sig.	Effect Size
Safety Culture	China	148	22.39	4.17		
	Northeast & Southeast Asia	14	23.79	4.96		
	Europe & America	33	23.30	5.11		
	Others	9	21.11	6.60		
	Total	204	22.57	4.51	.381	
Job Attitudes	Male	127	21.54	4.95		
	Female	21	24.00	3.55		
	Total	148	21.89	4.84	.030	0.515
Stress Recognition	Chinese Captain	94	18.73	3.50		
	Foreign Captain	47	17.17	4.13		
	First Officer	63	18.30	3.22		
	Total	204	18.24	3.61	.510	
Stress Recognition	China	148	18.73	3.28		
	Northeast & Southeast Asia	14	18.71	5.20		
	Europe & America	33	16.30	3.87		
	Others	9	16.56	2.46		
	Total	204	18.24	3.61	.002	0.071
Teamwork	Chinese Captain	94	24.59	3.40		
	Foreign Captain	47	26.17	2.35		
	First Officer	63	23.60	3.03		
	Total	204	24.65	3.20	.000	0.086
Pilots' confidence	Chinese Captain	92	26.28	4.86		
	Foreign Captain	47	26.66	4.87		
	First Officer	63	25.35	3.55		
	Total	202	26.08	4.50	.270	

The total M & SD for the six questions are (M = 22.57, SD = 4.51). The internal consistency (Cronbach α) averaged 0.818 across the scales/facets (Table 4), which was considered satisfactory.

Even though there were some differences among pilots, the total M & SD of Chinese pilots (M=22.39, SD=4.17) has slightly less than pilots from Europe & America (M = 23.30, SD = 5.11). The one-way ANOVA test indicated $p > .05$. Hence, there were no significant differences in the data. However, question 33 (I feel comfortable going to the senior manager's office to discuss problems or operational issues.) has a significant difference between Chinese pilots (M = 3.11, SD = 1.16) and pilots from Europe & America (M = 3.79, SD = 1.29). Test results indicated $P < .01$ and $\eta 2 = .056$. The effect size was small. This may be because pilots from Europe & America developed more confidence in going to the seniors' office to discuss and solve some issues, especially when working overseas. Question 49 (I know the proper channels to report my safety concerns.) has also presented the significant difference between Chinese pilots (M = 4.24, SD = .79) and pilots from Europe & America (M = 4.61, SD = .61). Results showed $P < .05$ and the $\eta 2 = .039$, the effect size was small. Pilots generally do well in making a pilot report in the aviation sector. However, pilots from America may have more channels to make their reports, such as Aviation Safety Action Program (ASAP).

Compare the current data (N 204, M = 22.57, SD = 4.51) from Pang (2022) and the historical data (N1489, M = 19.52, SD = 4.72) from Sexton et al.. Welch's two-sample t-test yields the test statistic 9.01 and p-value < .01. The current Means increased, and the SDs decreased. These significant changes may benefit from the efforts of CRM training and spreading CRM knowledge worldwide. Questions related to the safety culture increased the Mean significantly, except the question (I feel comfortable going to the senior manager's office to discuss problems or operational issues.), which has remained nearly the same, Current (M = 3.24, SD = 1.21) vs Historical (M = 3.21, SD = 1.01). Welch's two-sample t-test yields the test statistic of 0.28 and a p-value of 0.78. It presented that the communication gap remained between the management and the frontline pilots, and airlines should pay more attention to linking the two parties.

2) Job attitudes

There were six questions about pilots' job attitudes. Parametric T-tests were used to examine whether similarities and differences exist between Chinese male and female pilots. To avoid national bias, non-Chinese pilots were not included in the comparison. Parametric T-tests have been applied during the examinations (table 5).

The M & SD for Chinese male pilots (M = 21.54, SD = 4.95) and Chinese female pilots (M = 24.00, SD = 3.55) showed differences. The internal consistency (Cronbach α) averaged 0.875. across the scales/facets (see table 4), which was considered satisfactory.

There were significant differences between Chinese male and female pilots, with a p-value of $.03 < .05$. It has shown that the female pilots population has higher job satisfaction than the Chinese male pilots during the COVID-19.

Specifically, the Mean of question 31 (Pilot morale is high.) was relatively lower for both male pilots (M = 3.30, SD = 1.14) and female pilots (M = 3.52, SD = 1.08). This may be because of the COVID-19 effect for nearly three years. Pilots' emotion has been significantly influenced. Of the six questions about JA, Q26 (I am proud to work for this company.), Q28 (Senior management (VP and above) is doing a good job at this airline.) and Q38 (I like my job.) have shown significant differences. Accordingly, Q26 (p-value . 02 < .05, d = .552, the effect size was medium.), Q28 (p-value . 04 < .05, d = .479, the effect size was small.), and Q38 (p-value . 04 < .05, d = .478, the effect size was small.).

Furthermore, comparing the current and historical data has shown some exciting changes over the last 20 years.

Compare the existing data (N 204, M = 21.89, SD = 4.84) from Pang (2022) and the historical data (N 1489, M = 19.83, SD = 4.85) from Sexton et al. (2001). Welch's two-sample t-test yields a test statistic of 5.70 and a p-value < .01. The Mean of the current data increased, and the SD remained about the same. These significant changes may be benefited from the efforts of CRM training and the spread of CRM knowledge, also because of improved operation environments and advanced technologies. For questions about job attitudes, most questions increased the Mean significantly. However, question 28 (Senior management (VP and above) is doing an excellent job at this airline.) and question 38 (I like my job.) decreased, which were Q 28 Current (M = 3.53, SD = 1.03) vs Historical (M = 3.79, SD = 1.05) (Welch's two-sample t-test yields test statistic -3.37 and p-value < .01) and Q 38 Current (M = 4.24, SD = .93) vs Historical (M = 4.50, SD = .84) (Welch's two-sample t-test yields test-statistic -3.79 and p-value < .01). It may be represented that the pandemic and the required medical measurements during flights had significantly affected pilots. For example, the reduced flight hours, the decreased income due to lay-offs and pay cuts, and the tedious workload due to epidemic prevention methods have decreased pilots' satisfaction with their jobs.

3) Stress recognition

There were six questions related to pilots on how they recognise stress. The comparisons have been made separately based on pilots' ranks and locations.

Firstly, the author has compared the total M & SD for Chinese captains (M = 18.73, SD = 3.50), Chinese co-pilots (M = 18.30, SD = 3.22), and non-Chinese captains (M = 17.17, SD = 4.13). The results show a p-value of .051 > .05. The internal consistency (Cronbach α) averaged at 0.644 across the scales/facets (see table 4), which was considered lower.

Even though the data have shown that Chinese captains have a higher value than non-Chinese captains, there were no significant differences among Chinese captains, Chinese co-pilots, and non-Chinese captains when they faced stress. But for individual questions related to stress recognition, there are significant differences. These are Q39 ($p < 0.01$, $\eta 2 = 0.055$, the effect size was small.), Q42 ($p < .01$, $\eta 2 = 0.061$, effect size was medium.). This may be revealed that training can only slowly improve pilots' stress recognition ability. Hence, these ability criteria should be set up in the pilot selection process.

Secondly, the author made a comparison for pilots from different locations. The author has compared the total M & SD for pilots from Northeast+Southeast Asia (M = 18.71, SD = 5.20), China (M = 18.73, SD = 3.28), Europe +America (M = 16.30, SD = 3.87), and Others (M = 16.56, SD = 2.46). The results from ANOVA followed through Welch & Brown-Forsythe tests showed a $p < .01$. The significant differences in stress recognition levels are sequenced as Europe+America < Others < Northeast+Southeast Asia < China. The effect size is medium ($p < .05$, $\eta 2 = .071$, the effect size was medium). The results satisfied the concept of Resilience-to stress, which means that employees may be exposed to the same stressors (e.g., COVID-19) but are unequally affected due to personal stress resistance (Wilks, 2008).

The current and historical data comparison explored some changes over the last 20 years. Compare the recent data (N 204, M = 18.24, SD = 3.61) from Pang (2022) and the historical data (N 1489, M = 17.38, SD= 4.18) from Sexton et al. (2001), Welch's two-sample t-test yields test statistic 3.13 and $p < .01$. The Mean of the current data increased, and the SD of the existing data decreased. The changes may have benefited from updating CRM training and spreading CRM knowledge (e.g., TEM). The changes are represented differently for each question related to stress recognition. Q58 (I am more likely to make judgment errors in abnormal or emergency situations.) showed a significant decrease from (N 1495, M = 3.41, SD = 1.23) to (N 204, M = 2.96/SD = 1.05). Welch's two-sample t-test yields test statistic -5.49 and $p < 0.01$). The difference may indicate that pilots have better confidence from their recent training and the developed technologies. Question 48 (My performance is not adversely affected by working with an inexperienced or less capable crew member.) and Question 55 (A truly professional crewmember can leave personal problems behind when flying.) have increased significantly. These changes may explain the value of why CRM was broadly implemented worldwide, and pilots have gained more human factors knowledge to know themselves well and built more vital CRM skills to recognise internal threats. The rest of the questions were related to pilots' physiological factors and have increased slightly. Overall, the stress recognition had no massive changes physically.

4) Teamwork

There were six questions about teamwork related to the cockpit crew. The samples have been divided into three groups based on their ranks & locations (Chinese captains, Chinese co-pilots, and non-Chinese captains) to examine the similarities and differences. The selected questions differ from those Sexton et al. (2001) applied in their survey. The Author did not compare the findings with historical data (table 5).

The total M & SD for Chinese captains were (M = 24.59, SD = 3.40), Chinese co-pilots (M = 23.60, SD = 3.03), and non-Chinese captains (M = 26.17, SD = 2.35). The internal consistency (Cronbach α) averaged 0.680 across the scales/facets (see table 4), which was considered lower.

Welch & Brown-Forsythe tests have been conducted, resulting in a p-value < .01. Furthermore, a Post Hoc test of DunnettT3 indicated a sequence level of non-Chinese captains, Chinese captains, and Chinese co-pilots. The results showed significant

differences between Chinese captains and non-Chinese captains, as well as the Chinese co-pilots and non-Chinese captains. The effect size is medium ($p < .01$, $\eta 2 = .086$). Four questions were conducted using one-way ANOVA tests, and two questions went through Welch & Brown-Forsythe tests. The results showed four questions as Q29 ($p = .011$), Q35 ($p = .015$), Q64 ($p = .001$), and Q65 ($p = .002$), and were less than the p-value of .05. Except Q29 is an original question from FMASS, other questions are derived from external resources which have concerned the Asia cultures. Below are the four questions:

Q29. Our training has prepared the crew to work as a well-coordinated team.

Q35. The captain should encourage crewmember questions during normal operations and in emergencies.

Q64. It is important for me to be aware of the different backgrounds of my crew members, in addition to their technical skills.

Q65. When appropriate, I take the initiative and time to share my knowledge and experience with others, even if this means that a task takes more time.

5) Pilots' confidence

Confidence has been considered one of the two pillars of flight crew resilience. Seven questions were selected to examine the confidence factors. Pilots have been divided into groups based on their ranks (Chinese captains, Chinese co-pilots, and non-Chinese captains).

The total M & SD were for Chinese captains ($M = 26.28$, $SD = 4.86$), Chinese co-pilots ($M = 25.35$, $SD = 3.55$), and non-Chinese captains ($M = 26.66$, $SD = 4.87$). The internal consistency (Cronbach α) averaged 0.863 across the scales/facets (see table 4), which was considered satisfactory.

Both one-way ANOVA and nonparametric tests have been conducted, with a p-value of $.27 > .05$. The results showed no significant differences between Chinese captains and non-Chinese captains, as well as the Chinese co-pilots and non-Chinese captains. But for a particular question, Q21. Annual Line check. Significant differences existed, and the effect size was medium ($p < .001$; $\eta 2 = .107$).

Overall, there were no significant differences in attitudes toward CRM among various groups of pilots. However, distinctions existed among multiple groups for different sub-scales. For example, one question about safety culture indicated that effective communication between pilots and management might be necessary. When comparing Chinese male and female pilots, the data showed that female pilots had more favourable job attitudes than their male counterparts. In recent years, the population of Chinese female pilots has increased significantly, and this new opportunity has enabled them to occupy their positions in a predominantly male working environment.

On the other hand, due to the impact of COVID-19, pilots' morale decreased, and their job satisfaction was negatively affected by layoffs, wage cuts, and other factors. The study findings on stress recognition align with the concept of Resilience-to stress from Wilks (2008), which suggests that different employees may be unequally affected when exposed to the same stressors, such as the effects of COVID-19. The data indicated that Chinese pilots possess broader resilience margins when facing adverse turbulence. Most non-Chinese respondents had overseas operational experience, and the foreign environment required a more open cooperation style when engaging with other nations' cultures. The resulting pilot evaluation questions revealed no significant differences in pilots' confidence, except for an "Annual Line check" question, which indicated that Chinese pilots might experience more pressure during their line check in the current aviation context.

6) Open question about CBTA matters:

One hundred respondents answered the open question, and 11 responses were excluded due to incompleteness. A total of 89 responses were collected, resulting in a completion rate of 44%. The author analysed the collected responses using NVivo software. Two pilots were invited to review the themes, codes, and references to minimise the author's bias. Forty-nine participants were assessed as having positive attitudes toward the move to CBTA. Five negative views (such as "stop use it!") were noted, while the rest were considered neutral. Among proposers, the captain group is more active in voicing their opinions. Pilots suggested topics like "train the trainers, " "scenario-based training, " "applications of CRM & TEM, " and "briefing. " Moreover, pilots also emphasised the airline culture and the 4Ps (Philosophy, Policy, Procedures, Practices). They expressed concerns about how the CBTA would be conducted. These responses were consistent with the analysis results from the interview measures (Pang & Blundell, 2022).

TABLE VI. THE CODING DISTRIBUTIONS OF THE RECOMMENDATIONS FOR CBTA.

	Manager	Check airman	Instructor	Captain	First officer
4Ps-Philosophy, Policy, Procedures, Practices	1	1	4	9	2
Airline culture	2	0	3	8	2
Positive Attitudes	4	2	10	27	6
CRM&TEM	3	1	4	12	5
Educating CBTA	6	3	5	14	9
Scenario-based training	0	2	1	8	4
Technical skill training	1	0	0	11	6
Train the trainer	1	3	6	5	5

Recommendations indicate that additional education on a broad and explicit understanding of the CBTA is necessary. The analysis should not only apply to the trainees (frontline pilots) but also to trainers (instructors and managerial pilots). Until then, training can foster a collective and shared understanding of the CBTA, allowing quality' Training of Transfer" to occur. Table 6 above presents the number of themes and codes extracted from NVivo. The distribution of the codes reflects the demands and focus of the proposers.

V. Conclusion

The study on flight crew resilience among airline pilots produced several key findings and recommendations derived from data collected and analyzed in relation to the research objectives.

A. Awareness of Training Methods:

Most pilots are familiar with Competency-Based Training and Assessment (CBTA) as a new training approach. However, a notable gap exists in awareness of the concept of resilience among pilots.

B. Perception Gaps:

The findings indicate a disconnect between academic understanding and practical application of flight crew resilience, suggesting a need for enhanced education and awareness in this area.

C. Attitudes Towards Crew Resource Management (CRM):

The analysis revealed no significant differences in pilots' attitudes toward CRM. However, a comparison of current data with historical data (Pang and Blundell, 2022 vs. Sexton et al., 2001) demonstrates significant improvements in flight management attitudes over the past 20 years, affirming the effectiveness of CRM in enhancing aviation safety.

D. Communication Importance:

Consistent data indicates that maintaining open communication between pilots and management is essential for fostering a safe and effective working environment.

E. Concerns Regarding CBTA Implementation:

While there is generally a positive attitude towards CBTA, concerns were raised about the trainers' proficiency and the training's execution. This aligns with Flin's (2019) observations regarding the need for extensive training for instructors.

F. Impact of COVID-19:

The study found that pilots' morale and performance declined during the COVID-19 pandemic, exacerbated by various stressors. Regulators and airlines should monitor the well-being of flight crews and provide necessary support.

Recommendations

- Enhance education on resilience concepts and Competency-Based Training and Assessment (CBTA).
- Ensure that instructors receive effective training to address proficiency concerns.
- Foster open communication between pilots and management.
- Implement support systems for pilots to tackle mental health challenges, particularly during crisis situations such as the pandemic.

VI. Limitations

This study has several limitations that should be taken into account:

A. *Participant Representation:* The participants were volunteers, which may result in a sample that does not represent the entire pilot population. Most respondents had experience primarily in Asia or China, potentially influencing their perspectives.

B. *Geographical Distribution:* The pilots were unevenly distributed across various geographical regions, which made it difficult to draw fair comparisons between groups.

C. *Female Pilot Representation:* While some female pilots participated in the survey and interviews, they were primarily in their 20s and 30s. This age group may not accurately reflect the broader population of female pilots in China.

D. *Language Barriers:* The survey was conducted in English, which may have presented challenges for Chinese participants. Furthermore, translating from Chinese to English could have led to a loss of meaning.

E. *Impact of COVID-19:* The data collection took place during the COVID-19 pandemic, which may have influenced the responses and overall findings of the study.

VII. FUTURE RESEARCH

The study included both Chinese pilots and pilots from around the world, comprising male and female Chinese pilots. Future research is recommended with a larger sample size from more Chinese airlines to represent the entire Chinese pilot population. Additionally, it would be valuable to maintain diverse global samples to explore cultural differences. The survey should be carefully refined to evaluate pilots' attitudes and social skills and to assess cognitive skills (such as monitoring, crosschecking, problem-solving, and decision-making).

Furthermore, developing customised CRM content and a case study pool to suit Chinese culture is worthwhile.

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Perceptions of flight crew resilience among commercial pilots: evaluation of pilots' acceptance of CBTA across China, the United States, Europe, and the Asia Pacific

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