INFLUENTIAL FACTORS OF FLIGHT ATTENDANTS' FATIGUE – EVIDENCE FROM AIRLINE COMPANIES IN TAIWAN

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ABSTRACT

Fatigue poses an important safety risk to aviation, while it has been suggested as a key human factor which influences crew's working ability and flight safety. Flight attendants are in the first line to serve customers and also play an important role in flight safety. Thus, the modified Delphi method and grey correlation analysis are used to find the influential factors of the fatigue. Furthermore, the weight analysis and ranking of the fatigue factors of the flight attendants are discussed in the study context of the analytic hierarchy process. The results show that the company's planning and scheduling have the highest weight of fatigue. Furthermore, a load factor of 80% appears tiring for the crew, despite the fact that the number of flight attendants meets the legal requirements. In fact, this has the highest weight of fatigue in short-haul flights, unlike long-haul flights where the weight differs. Research findings may have managerial implications to airlines and relevant government agencies towards fatigue's reduction and improvement of flight attendants' working life.

KEY WORDS: Flight attendants; Fatigue; Short-haul flights; Long-haul flights

1. INTRODUCTION

Unlike other industries, flights are across the meridian and cabin crew often experience jet lags. When cabin crew worked in high altitude, some of the more common signs and symptoms of hypoxia are dizziness, fatigue, difficulty in processing visual information, and impaired judgment due to the lack of adequate oxygen supply (Federal Aviation Administration, 2008). The physical and mental load of the cabin crew is greater than that of the ground worker. Furthermore, as the aviation industry makes changes, such as longer flight times, shorter turnaround times, polar routes, increased passenger capacity, greater passenger numbers, and new safety procedures, the workload of cabin crew is also increased (McNeely et al., 2014).

According to the International Air Transport Association (IATA), the International Civil Aviation Organization (ICAO), and the International Federation of Air Line Pilots' Associations (IFALPA), fatigue is a major risk in terms of human factors. As it affects the work ability of cabin crew in various aspects, it poses risks to aircraft safety. Cabin crew's fatigue is a potential risk factor for flight safety (IATA, ICAO and IFALPA, 2011).

Over the years, international organizations have paid attention to and improved the research on fatigue management in the aviation industry. Fatigue is a type of body defense mechanism but extra accumulation of fatigue can change into a harmful and damaging event (Mahdavi et al., 2020). Research by the Civil Aeronautics Medical Institute, part of the Federal Aviation Administration (FAA), has found that disrupted sleep among cabin crew when they are on duty leads to common chronic sleep deprivation, fatigue, and declined performance in cognitive performance tests (FAA, 2013). Predictably, fatigue can lead to a decline in all types of human performance and a rise in aviation accidents or other accidents (ICAO, 2016). Therefore, it is necessary to identify the causes of fatigue among cabin crew, and implement effective fatigue management measures. It is the fact that no single strategy will fully eliminate fatigue and the aim must to promote and optimize alertness (Flower, 2001). That's the reason why need to find the factors which cause the fatigue.

Based on the above, this study invited experts from the civil aviation authority and flight attendants with management and training qualifications in the survey, in order to discuss the causes and degree of fatigue from the aspects of company planning, passengers, and individuals. The purposes of the study are: (1) a literature review and interviews with managers and also senior flight attendants to summarize the possible causes of flight attendant fatigue; (2) to acquire the influential factors of the fatigue by flight attendants using the Modified Delphi Method (MDM) and Grey Relational Analysis (GRA); and (3) to estimate the degree of influence of each factor on fatigue based on the Analytic Hierarchy Process (AHP). In addition, fatigue caused by several scheduling methods is also discussed in this study. Finally, based on the analysis results, conclusions and suggestions are proposed for reference to airlines or relevant government agencies in attempts to control or relieve flight attendants' fatigue.

2. LITERATURE REVIEW

2.1 Definition and Measurement of Fatigue

FAA (2007) defined fatigue as a kind of fuzzy multi-dimensional structure that can be explained in various ways, mostly used to reflect drowsiness/fatigue caused by a

prolonged waking state, lack of sleep, and desynchrony of day and night. The cause of fatigue is deprivation of two factors, which are the circadian rhythm (circadian clock) and a stable sleep process (sleep and wakefulness). ICAO (2011) defines fatigue as a physiological condition in which mental or physical performance is impaired by loss of sleep or prolonged waking state, circadian effect, or workload (mental and/or physical activity), which result in decreased alertness of crew members, and the impairment of the ability to safely operate the aircraft. Phillips (2015) pointed that a few broad definitions of fatigue which are included the aspects of experiential, physiological and performance. Moreover, fatigue is also a dynamic multidimensional concept. The traditional approach to managing crew fatigue is to limit the maximum number of flight days and duty hours per day, month, or year, and forest the minimum rest time while on duty (IATA, ICAO and IFALPA, 2011).

Moreover, fatigue is estimated in different measurements at different fields. Maslach Burnout Inventory (MBI) conceptualizes pointed "fatigue" into three aspects: emotional exhaustion, depersonalization, and reduced personal accomplishment (Maslach and Jackson, 1980). Copenhagen burnout Inventory (CBI) was developed by Kristensen, Borritz, Villadsen and Christensen (2005), and included three sub-scales: personal or generic burnout scale, work-related burnout scale and client-related burnout scale (Kristensen et al., 2005). Brief Fatigue Inventory (BFI) is also used to measure the severity and impact of fatigue (Mendoza et al., 1999). Fatigue Severity Scale (FSS) is a unidimensional scale on the physical focus and the Modified Fatigue Impact Scale (MFIS) is a multidimensional scale including physical, psychological and cognitive aspects of fatigue (Learmonth et al., 2013). The domain of the CBI assesses the exhaustion originating from people centered professions and can link the fatigue with their work (Kristensen et al., 2005; Kováč and Halamová, 2022).

2.2 Influence Factors of Flight Attendants' Fatigue

In the past, studies on fatigues are contributed to multi-dimensional factors, and the nature of work usually is shift work and/or long working hours. Most studies on crew fatigue of airline companies were based on pilots' fatigue. The influencing factors of flight attendants' fatigue were rarely discussed in literatures. Therefore, it is going to collect factors related to flight attendants' fatigue in this study.

Among the causes of fatigue, the most common factors are scheduling, sleeping, and working conditions, which were match the three aspects of CBI. Therefore, literature reviews were stated according these three facets, i.e., company planning, work-related and personal factors as follow, respectively.

2.2.1 Factors in company planning

Arrangements of airline operations play an important role in fatigue management. IATA, ICAO and IFALPA (2015) mentioned that proactive fatigue monitoring processes such as to obtain experience of fatigue and the effectiveness of different mitigation strategies from scheduling, in-flight rest facilities, layover hotels, etc. The increase in the number of duty shifts would lead to fatigue. Moreover, FAA (2007) pointed that aircraft factors also caused fatigue, such as airlines, aircraft factors.

Circadian rhythm was also the great impact on flight to cause fatigue, including number of trips across time zones, illumination (seasonality), direction of flight, departure and return and duration of stay (FAA, 2007; Flower, 2001). As to flight length, long-haul operations (i.e. flights ≥ 8h in length) and short-haul operations (i.e. flights <8h in length) has differences from a fatigue perspective (Roach et al.,2012). The causes of fatigue risk of short-haul flights include scheduling early in the morning or late at night, early duty reporting time, frequent taking off and landing, multiple flight routes in a day, high-density airspace, consecutive shifts over several days, and many days on duty (IATA, ICAO, IFALPA, 2011; Roach et al., 2012). Widyanti and Firdaus (2019) collected the complained factors of flight attendants were included duration of rest period, jet lag, scheduling, duration of work and management such as management support which related with company planning.

2.2.2 Factors in work-related

Related studies of fatigue are found that fatigue is highly exist among workers (Mahdavi et al., 2020). Influential factors of fatigue might come from communication overload (Lee et al., 2016), workload (IATA, ICAO, IFALPA, 2011; Van Den Berg et al., 2019; Yilmaz et al., 2022) and working environment (University of Illinois at Chicago, 2014; Mahdavi et al., 2020) which would impact the fatigue significantly. It is the fact that flight attendants need to deal directly with passengers, answer questions about flights, take care of passengers with special needs, help others in need, and assist all passengers accordingly and usually worked at multiple high workloads which might cause fatigue.

When flight attendants had long contact with passengers, the emotional labor required will increase (Anderson, 1993). Working conditions, emotional exhaustion, and intense interpersonal relationships with customers would increase the fatigue of flight attendants' (Yilmaz et al., 2022). FAA (2007) also classified the factors to cause fatigue of crew including length of service hours, heavy workload, duty time (short or long route), amount of walking demand, service class (economy class or first class and business class)

2.2.3 Factors in personal

The International Federation of Airworthiness (IFA) has stated that responsibility for control fatigue does not solely rest with the company and individuals have to use the opportunities and facilities for rest periods provided (SKYbrary, 2019). Li et al (2018) also pointed that fatigue caused by a prolonged period of exposure to task-related stimuli and the effects would be aggregated or mediated by individual resilience. The flight attendants tend to suffer from work fatigue after enduring high work pressure and emotional load for a long time and those are psychological factors which caused by the external effect. Thus, fatigue may be induced by physical, physiological and psychological causes (Kennedy, 1988) and it can be used for various conditions including lack of sleep, tiredness, mental fatigue/exhaustion and so on (Mahdavi et al., 2020).

FAA (2007) classified the sleep factors, such as sleep quality and sleep length; and medical, physical, or psychological conditions related to fatigue or insomnia: various physical problems (sinus problems, dehydration, headaches, and muscle cramps), personal problems, local conditions, emotional stress, sick leave and absenteeism, and post-traumatic stress syndrome. Insufficient or disrupted sleep will cause fatigue (Caldwell et al., 2019; Van Den Berg et al., 2019; Bendak and Rashid, 2020). Especially for shift work, it would interrupt workers sleep-wake cycle and degrades sleep conditions resulting in a high potential of human fatigue (Jones et al., 2005). As for personal factors caused fatigue, such as age, gender, morning-night type, personality (extrovert-introvert personality), degree of fatigue before execution, and eating habits (FAA, 2007).

Finally, it was summarized as three facets which to cause fatigue of flight attendants in the studies. Frist is the factor of company planning, which refers to the fatigue caused by the resources provided by the company due to scheduling. Second is the factor of work-related, which refers to cause by resulting from interactions between flight attendants and passengers. Third is personal factor, which refers to the physical and psychological factors of the flight attendants in response to their duties.

This study summarized the fatigue factors mentioned in previous literature into the above three aspects for subsequent research and evaluation. The aspects and factors related to fatigue factors are listed in Table 1.

Table 1 : Literature reviews of the criteria influence on fatigue

Criteria	Sub-Criteria	Relative Literature
Company Planning	duty time (short or long route) , circadian rhythm(time zones, jet lag), company's policy, schedule arrangement, flight day, work environment, onboard crew rest facilities, layover hotel, airlines, aircraft, rest time, number of trips across	Flower (2001); FAA (2007); IATA,ICAO and IFALPA(2011); Roach et al.(2012); IATA, ICAO and IFALPA (2015); Widyanti and Firdaus (2019); VAN DEN Berg et al. (2019); Mahdavi et al.(2020)
Work-related Factors	length of service hours , experience, amounts of walking demand, work environment/ service class, workload, physical workload, multiple high workloads, passenger services, passengers' requests, passenger interaction, work pressure	FAA(2007); Anderson(1993); Lee et al.(2006);IATA, ICAO, IFALPA(2011); Damos (2013); Phillips (2015) ;Lee et al. (2016) ; VAN DEN Berg et al. (2019); Yilmaz et al.(2022)
Personal Factors	sleep factors, fatigue before execution, related to fatigue or insomnia issues, condition of mental and/or physical, emotional stress, sickness absences, personal status / personality, age, gender, morning-night type, eating habits	Kennedy (1988); Jones et al. (2005); FAA (2007); ICAO (2011) ;Li et al (2018) ; Caldwell et al.(2019); VAN DEN Berg et al. (2019); SKYbrary (2019); Mahdavi et al.(2020); Bendak and Rashid(2020)

3. METHODS

3.1 Questionnaire design and survey

Two national airlines were mainly used in the study. An airline company has about 4,200 flight attendants with an average seniority of 6 to 7 years, while B airline company has about 3,700 flight attendants with an average seniority about 12 years. The seniority between two airlines has a great gap which also showed high flow rate of flight attendants.

In this study, it used CBI which consisted of three main criteria, namely fatigue caused by company planning, fatigue caused by work related factors, and fatigue caused by personal factors. Based on literature review and interviews, 14 sub-criteria of fatigue were summarized in Table 2.

The expert and professor questionnaire survey of MDM were included professors, officials of civil aeronautics administration and airline companies. Flight attendant managers are more than 15 years of experience or/and with management or educational training qualifications from two major airline companies in Taiwan as Table 3.

Each group was 3 experts and total 12 people were participated in the MDM survey. The effective questionnaire recovery rate was 100%. As to AHP survey, 48 questionnaires were distributed to flight attendants who has a management qualification or/and work experience at least 5 years. After eliminating 13 invalid questionnaires, the effective questionnaire recovery rate was 73% as Table 4.

Table 2: Main criteria and sub-criteria of factors affecting flight attendants' fatigue

Main criteria/code	Sub-criteria/code
Company Planning Factors (C)	scheduling arrangement (C1); complex meals, or meals need to be reprocessed (C2); with 80% of passengers on board, the crew is tired even with legal flight attendants (C3); poor aircraft layout, unfriendly working environment, such as high refrigerator, uncomfortable sleeping area(C4); distance between the hotel and airport (C5)
Work-related Factors (P)	continuous and excessive service requests (P1); passengers that need special care, such as physically handicapped or disabled people (P2); poor communication with passengers (P3); additional needs of passengers (e.g. taking care of elderly/infants, chatting, and taking care of passengers in case of illness) (P4)
Personal Factors (S)	insufficient rest before flight (S1); physiological factors (e.g. low physical strength) (S2); psychological factors (e.g. poor mood) (S3); sleep disorders, such as shallow sleep (S4); physical discomfort, but not taking leave (S5)

Table 3: Respondents Profile of MDM

Item	A Airline Company	B Airline Company	Civil Aeronautics Administration	Professor
Top managers	2	1	2	3
Instructors	1	2	1	

Table 4: Respondents Profile of AHP

	Item	Number		Item	Number
Age (years old)	25-29	9	**Gender**	Male	13
	30-34	7		Female	22
	35-39	6	**Education**	Collage	24
	40-44	8		Above Mater	11
	Above 45	5	**Job Title**	Flight Attendant J Class/Deputy Purser	16
Seniority (years)	A t least 5	9		Cabin Chief / Chief Purser/ Inflight Service Manager	19
	6-10	12	**Flight Route**	Regional Routes	15
	Above 11	14		International Routes	20

3.2 Research Process

First, the MDM was used to estimate three main criteria and 14 sub-criteria based on literature review and expert interviews with senior flight attendants. Next, GRA was applied to evaluate indicates correlation among the factor. Finally, AHP was used to conduct pairwise comparison on the importance and weight of each factor and discuss the degree of influence of each factor on fatigue. The research framework was shown in Figure 1, which divided into three stages, to describe as follows.

1. Stage 1: Selection of main criteria and sub-criteria. According to Hill and Fowles (1975), the MDM is a structured questionnaire developed based on literature review and expert interviews. Therefore, based on literature review and interviews with senior cabin crews, and 3 main criteria and 14 sub-criteria were proposed in the study.

In the first round of expert survey, experts anonymously reached consensus by combining the knowledge and opinions of experts. The seniority of experts, i.e. senior flight attendants had more than 15 years of work experience.

2. Stage 2: Selecting criteria. The steps are as follows.

(1) As for the verification of the MDM, this study took the average as the basis for selecting and evaluating sub-criteria. According to an inter-quartile-range (IQR), if the IQR is below or equal to 0.60, the expert opinions can be regarded as being highly

consistent. When IQR in the range from 0.60 to 1.00, it means medium level consistency. When the IQR greater than 1.00, it means that no consensus has been reached (Fahety, 1979; Hollden and Wedman, 1993).

(2) GRA was used to assess the independence of the criteria for the results of first round expert questionnaire. GRA can determine the degree of correlation between factors according to the similarity or difference in the development trend of each factor, and is measured by the Grey Relational Grade. The study used the Grey Relational Grade of 0.75 as the threshold to find the sub-criteria group of correlation, and extracted the representative criteria of this group with the consent of experts.

(3) In the second round of expert survey, using the results from the GRA, namely, correlation among factors that could be replaced, were provided to 12 experts, before obtaining the written consents from the experts to confirm these criteria. And the results of the second round, all of the criteria have high degree of consistency was considered to be the final criterion with a high degree of consensus.

3. Stage 3: AHP construction. Based on the results of the second round of expert survey, AHP was used to explore the weights of the criteria, and then the weights and ranking of factors affecting fatigue were obtained. The findings on the factors causing fatigue of flight attendants and the degree of fatigue could serve as a reference for future fatigue review and improvement.

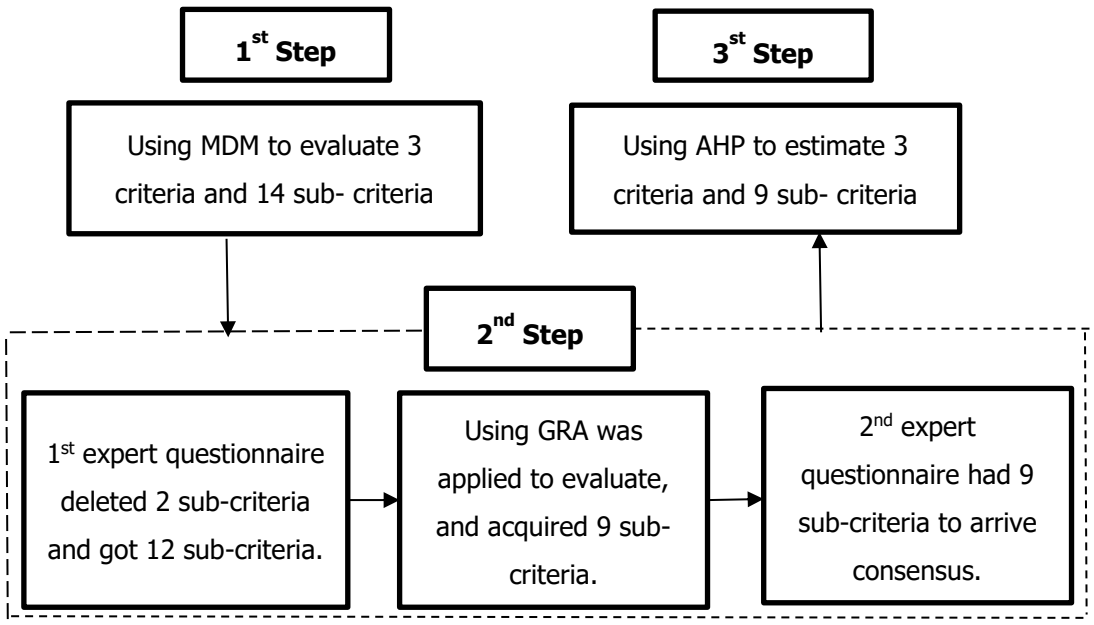

Figure 1**:** Research process

4. EMPIRICAL ANALYSIS

4.1 Results of the Modified Delphi Method

In Table 6, the results of the first round of expert survey showed that among the 14 sub-criteria, 12 of item reached the consensus level of above 86% (the average was higher than 4.24) and passed the consistency test. Because the expert opinions on items C4 and S5 varied, and the average score was below the threshold and without passing the consistency test, were removed from the questionnaire. After the GRA evaluated, there are 9 criteria used in second round of expert survey. The results showed that all criteria reached consensus of 100% (the average is higher than 4.92), indicating a high degree of consistency. The final criteria were thus regarded to have reached a high degree of consensus, and two rounds of expert questionnaires were concluded.

4.2 Results of the Grey Relational Analysis

GRA was performed based on the results of the first round of expert survey, and revealed that the Grey Relational Grade was higher than 0.75, and there were 6 sub-criteria in 3 groups in total. This indicates that the development trends among the criteria were similar, and it can use one of the indices to evaluate. The representative sub-criteria of each group selected in this study were scheduling arrangement (C1), passengers that need special care, such as physically handicapped or disabled people (P2), and insufficient rest before flight (S1) in Table 5.

Table 5: Results of Grey Relation Analysis

Criteria within each group	Grey relational grade	Representative Index of group
scheduling arrangement (C1), distance between the hotel and airport (C5)	0.76	scheduling arrangement (C1)
passengers that need special care, such as physically handicapped or disabled people (P2), additional needs of passengers (e.g. taking care of elderly/infants, chatting, and taking care of passengers in case of illness) (P4)	0.78	passengers that need special care, such as physically handicapped or disabled people (P2)
insufficient rest before flight (S1), physiological factors (e.g. low physical strength) (S2)	0.78	insufficient rest before flight (S1)

After the GRA results were respectively presented to the experts, they agree to replace distance between the hotel and airport (C5) with scheduling arrangement (C1) fully. As the Labor Standards Act and Aircraft Flight Operation Regulations on working hours, flying time, and rest time, airline companies tend to choose rest places for air crews near the airports despite cost considerations. As for the second group, since both sub-criteria are related to the additional requests of passengers, passengers that need special care, such as physically handicapped or disabled people (P2) was chosen to be the representative sub-criterion of this group. For the third group, the experts agree to choose insufficient rest before flight (S1) as the representative sub-criterion of this group. Thus, the remaining 9 indicators were used for the second round of expert survey. Finally, the results of selecting sub-criteria by using MDM and GRA are evaluated in Table 6. Hierarchy of the study is showed in Figure 2.

Table 6: Results of using MDM and GRA

Main criteria	Sub-criteria	1st Expert questionnaire				Expert Suggestion after GRA Results	2nd Expert questionnaire				The Final Results
		Average Score	Quartile Deviation	Consistence Test	Selection Results		Average Score	Quartile Deviation	Consistence Test	Selection Results	
Company Planning Factors (C)	scheduling arrangement (C1)	4.75	0.25	highly consistent	Adopt	--	4.92	0	highly consistent	Adopt	Adopt
	complex meals, or meals need to be reprocessed (C2)	4.75	0.25	highly consistent	Adopt	--	4.92	0	highly consistent	Adopt	Adopt
	with 80% of passengers on board, the crew is tired even with legal flight attendants (C3)	4.75	0.25	highly consistent	Adopt	--	4.92	0	highly consistent	Adopt	Adopt
	poor aircraft layout, unfriendly working environment, such as high refrigerator, uncomfortable sleeping area(C4)	2.17	2	no consensus	Not Adopt	--	--	--	--	--	--
	distance between the hotel and airport (C5)	4.25	0.25	highly consistent	Adopt	Replaced by C1	--	--	--	All experts agree replaced	--
Work Related Factors (P)	Continuous and excessive service requests (P1)	4.75	0.25	highly consistent	Adopt	--	4.92	0	highly consistent	Adopt	Adopt
	passengers that need special care, such as physically handicapped or disabled people (P2)	4.25	0.25	highly consistent	Adopt	--	4.92	0	highly consistent	Adopt	Adopt
	poor communication with passengers (P3)	4.83	0	highly consistent	Adopt	--	4.92	0	highly consistent	Adopt	Adopt
	additional needs of passengers (e.g. taking care of elderly/infants, chatting, and taking care of passengers in case of illness) (P4)	4.25	0.25	highly consistent	Adopt	Replaced by P2	--	--	--	All experts agree replaced	--
Personal Factors (S)	Insufficient rest before flight (S1)	4.75	0.25	highly consistent	Adopt	--	4.92	0	highly consistent	Adopt	Adopt
	physiological factors (e.g. low physical strength) (S2)	4.25	0.25	medium consistency	Adopt	Replaced by S1	--	--	--	All experts agree replaced	--
	psychological factors (e.g. poor mood) (S3)	4.67	0.25	highly consistent	Adopt	--	4.92	0	highly consistent	Adopt	Adopt
	sleep disorders, such as shallow sleep (S4)	4.83	0	highly consistent	Adopt	--	4.92	0	highly consistent	Adopt	Adopt
	physical discomfort, but not taking leave (S5)	2.17	1	no consensus	Not Adopt	--	--	--	--	--	--

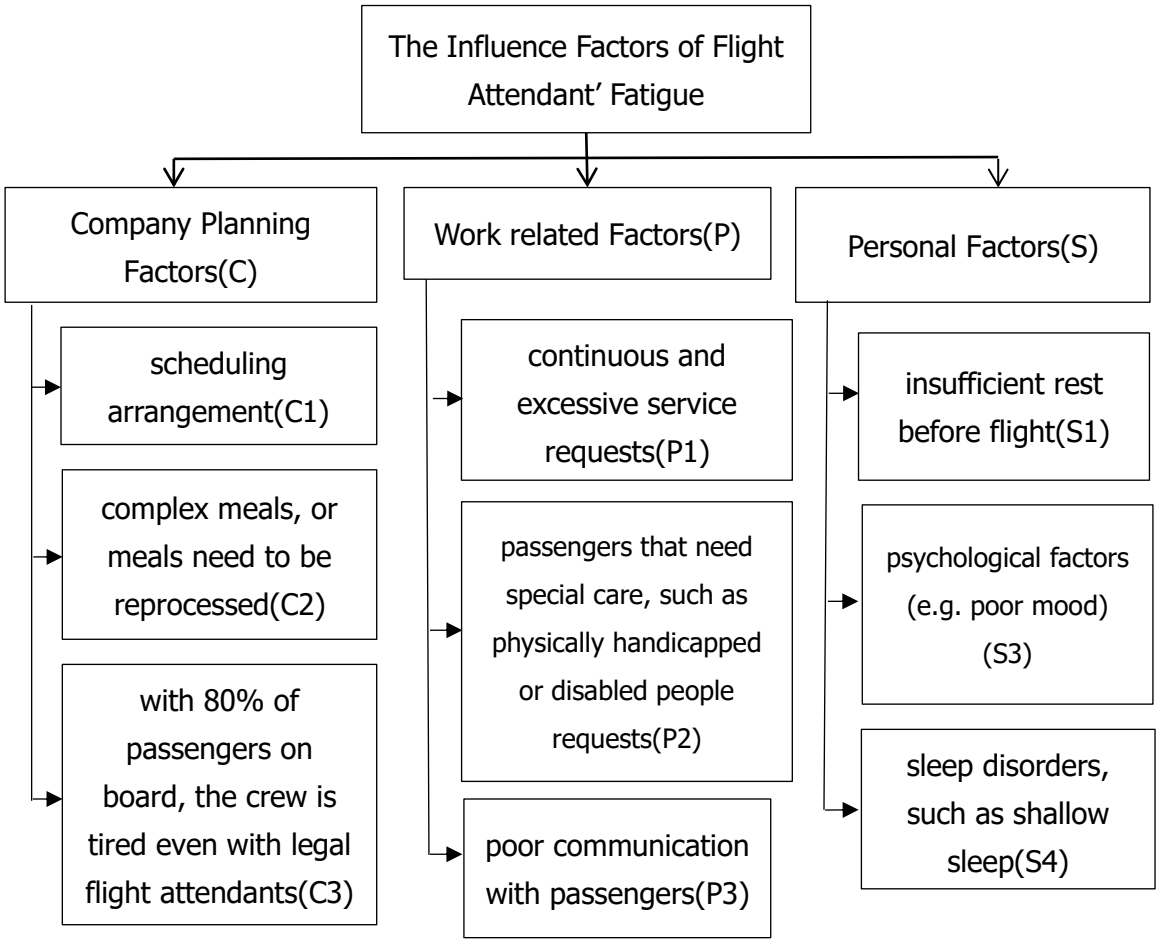

Figure 2: Hierarchy of the influence factors of flight attendant' fatigue

4.3 Results of the Analytic Hierarchy Process

Previous literature has suggested that gender, age, seniority, and long- or short-haul flights have different effects on fatigue. Therefore, this study analyzed and compared expert questionnaires based on various groups and overall results. The results show that the C.I. value is less than 0.1, indicating that although the judgments are not completely consistent, they are within the permissible error range. The value of C.R. is also less than 0.1, indicating that the consistency of the matrix is satisfactory. The results of the study are showed in Table 7.

Table 7: Weight of each group indicators influence on the fatigue of flight attendants

Groups		Main Criteria			Sub-Criteria								
		C	P	S	C1	C2	C3	P1	P2	P3	S1	S3	S4
Gender (Female)	Weight	0.568	0.272	0.159	0.434	0.272	0.294	0.493	0.191	0.316	0.48	0.308	0.212
	Rank	1	2	3	1	3	2	1	3	2	1	2	3
	Total Weight	--	--	--	0.247	0.155	0.167	0.134	0.052	0.086	0.076	0.049	0.034
	Rank	--	--	--	1	3	2	4	7	5	6	8	9
Gender (Male)	Weight	0.463	0.301	0.237	0.434	0.156	0.411	0.493	0.191	0.316	0.507	0.217	0.276
	Rank	1	2	3	1	2	3	1	3	2	1	3	2
	Total Weight	--	--	--	0.201	0.072	0.097	0.148	0.058	0.095	0.120	0.051	0.065
	Rank	--	--	--	1	6	4	2	8	5	3	9	7
Age (Below 35)	Weight	0.652	0.22	0.128	0.476	0.261	0.263	0.493	0.191	0.316	0.41	0.301	0.289
	Rank	1	2	3	1	3	2	1	3	2	1	2	3
	Total Weight	--	--	--	0.310	0.170	0.171	0.109	0.042	0.07	0.053	0.039	0.037
	Rank	--	--	--	1	3	2	4	7	5	6	8	9
Age (Under 36)	Weight	0.459	0.33	0.211	0.402	0.236	0.362	0.497	0.214	0.290	0.549	0.28	0.171
	Rank	1	2	3	1	3	2	1	3	2	1	2	3
	Total Weight	--	--	--	0.185	0.108	0.166	0.164	0.071	0.096	0.116	0.059	0.036
	Rank	--	--	--	1	5	2	3	7	6	4	8	9
Seniority (Below 10)	Weight	0.62	0.234	0.146	0.407	0.279	0.314	0.382	0.268	0.35	0.432	0.305	0.263
	Rank	1	2	3	1	3	2	1	3	2	1	2	3
	Total Weight	--	--	--	0.252	0.173	0.195	0.089	0.063	0.082	0.063	0.044	0.038
	Rank	--	--	--	1	3	2	4	6	5	6	8	9
Seniority (Under 11)	Weight	0.457	0.34	0.203	0.48	0.212	0.308	0.575	0.189	0.236	0.559	0.27	0.171
	Rank	1	2	3	1	3	2	1	3	2	1	2	3
	Total Weight	--	--	--	0.219	0.097	0.141	0.196	0.064	0.08	0.113	0.055	0.035
	Rank	--	--	--	1	5	3	2	7	6	4	8	9
Short-haul flight	Weight	0.482	0.299	0.219	0.327	0.231	0.442	0.493	0.191	0.316	0.453	0.291	0.256
	Rank	1	2	3	2	3	1	1	3	2	1	2	3
	Total Weight	--	--	--	0.158	0.111	0.213	0.132	0.08	0.087	0.099	0.064	0.056
	Rank	-	-	-	2	4	1	3	7	6	5	8	9
Long-haul flight	Weight	0.591	0.264	0.145	0.503	0.251	0.246	0.493	0.191	0.316	0.504	0.293	0.203
	Rank	1	2	3	1	2	3	1	3	2	1	2	3
	Total Weight	--	--	--	0.297	0.148	0.145	0.13	0.05	0.083	0.073	0.043	0.03
	Rank	-	-	-	1	2	3	4	7	5	6	8	9
Overall Results	Weight	0.554	0.277	0.169	0.439	0.249	0.313	0.463	0.236	0.301	0.486	0.292	0.221
	Rank	1	2	3	1	3	2	1	3	2	1	2	3
	Total Weight	--	--	--	0.243	0.138	0.173	0.128	0.065	0.083	0.082	0.049	0.037
	Rank	-	-	-	1	3	2	4	7	5	6	8	9

4.4 Discussion

Based on the above results, all demographic groups, as well as the overall analysis, indicate that company planning factors (C) is subject to the highest level of fatigue, followed by work related factors (P) and personal factors (S).

In terms of sub-criteria, "with 80% of passengers on board, the crew is tired even with legal flight attendants (C3)" in company planning factors (C) which is also the leading cause of fatigue in short-haul flights, and also the leading cause in the overall weight ranking. It shows significant difference from other groups. According to literature, fatigue occurs when pilots repeat short flights at the same take-off and landing site, or when they are on duty under heavy workloads (Roach et al., 2012; IATA, ICAO and IFALPA, 2015). In addition, Yilmaz et al. (2019) also stated excessive fatigue arises from tasks that should be fulfilled in a short time. Since the flight time of a short-haul flight is limited, even if the number of legal flight attendants meets the requirements, it is tiring for the flight attendants to complete all services, such as meal delivery, clean-up, selling duty-free goods and so on. Food and beverage services provided on a short-haul flight can lead to a significant increase in fatigue (FAA, 2007), which is consistent with the result of this study.

In personal factors (S), the group analysis found that insufficient rest before flight (S1) has higher weight and is ranked first. The result is also consistent with of Van Den Berg et al (2019) which stated that a good rest before a flight is extremely important. FAA (2010) also found cabin crews rarely start their work with sufficient rest. When the cabin crews are tired at the start of the workday, there is "floor effect", meaning they do not have much room to deliver excellent performance during their shifts. Thus, it is important to disseminate the concept of sufficient rest time before flight to flight attendants.

In the overall weight, this study found that "male flight attendants" and flight attendants with "over 11 years of experience" not only indicate "scheduling arrangement (C1)" to be the main cause of fatigue, but also consider "continuous and excessive service requests (P1)" to be a cause. Anderson (1993) has pointed out that flight attendants are emotional labor workers and spend a long time with passengers, which leads to a high emotional labor workload.

Furthermore, the ranking between below 35 years old and less than ten years' seniority, and between older than 36 years old and more than eleven years' seniority, results are also showed similar between age and seniority in the study. Widyanti and Firdaus (2019) studied on the mental workload of flight attendants and results also indicated that age and work experience didn't have significant differences on the mental

workload of the flight attendants. Thus, it might be able to use one of age or seniority to be a variable in the future studies.

Additionally, the flight attendants considered the "scheduling arrangement", among all groups and overall analysis, as the most important factor causing fatigue. It collected eight scheduling methods and asked senior flight attendants to explore the severity of fatigue by using a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree) in the study. Results are in Table 8. Consecutive morning shifts, consecutive shifts and flying across time zones with heavy workload were the top three severity of fatigue in the company planning. Especially the continuous morning shift, duty periods with early-morning start times affect the amount of sleep obtained by shift workers, and the several consecutive early-morning starts should be avoided where possible (Roach et al, 2012).

Table 8: Severity of fatigue caused in the company planning

Item	Maximum	Minimum	Average	Rank
consecutive morning shifts	7	6	6.64	1
consecutive night shifts	7	1	4.95	8
cancellation of overnight flights and round trip flights on the same day	7	1	5.68	5
consecutive shifts	7	5	6.45	2
ultra-long distance flights	7	4	6.18	4
flying across time zones with heavy workload	7	5	6.41	3
mixed scheduling of morning and night shifts	7	2	5.59	6
scheduling under abnormal conditions	7	3	5.55	7

5. CONCLUSION AND SUGGESTIONS

5.1 Conclusions

1. Based on the literature review, three main criteria and nine sub-criteria were selected by MDM, and GRA to explore the influential factors of flight attendants' fatigue in the study. In terms of the criteria of fatigue, the demographic group and the overall analyses found that company planning factors (C) has the most influence on fatigue, followed by work related factors (P) and personal factors(S). As for the sub-criteria, scheduling arrangement

(C1) has the highest weight in the company planning factors (C). In the work related factors (P), the highest weight factor is continuous and excessive service requests (P1). In the personal factors (S), insufficient rest before flight (S1) has the highest weight.

2. In the short-haul flight, the results showed that with 80% of passengers on board, the crew is tired even with legal flight attendants (C3) is a highest factor influence on the fatigue of flight attendants. Due to the amount of services that they need to complete within a short amount of time.
3. As to the severity of fatigue caused in the company planning, the top three ranking were consecutive morning shifts, consecutive shifts and flying across time zones with heavy workload.
4. This study also found that age and seniority have almost the same results which may due to airlines in Asia prefer to hire young flight attendant. Therefore, it might use one of item to be a variable in the future studies.

5.2 Suggestions

1. As the issues of working hours and fatigue on flight safety in the aviation industry have gained much attention. Besides the governmental policies and airline regulations, it is suggested that airlines should understand the causes of fatigue in order to management the crew fatigue and offer training courses on fatigue management.
2. The overall results showed that the "problem of scheduling" is a main factor causes of fatigue. Therefore, it is recommended that not only to follow the standards but also to consider the workload and/or load of the flight to arrange the number of flight attendants.
3. To make it convenient for the flight attendants to serve meals quickly, airlines should minimize the number of food items that need to be processed or heated. For example, routes in Asia, soup bases and soup are heated separately, or one meal contains several items to be heated, while the number of ovens is not enough. This is among the top three factors causing fatigue. Therefore, airlines could improve the meal planning to reduce workload which also can reduce fatigue.
4. Finally, it is suggested that future studies can focus on the methods to reduce and alleviate fatigue or propose incentives to motivate flight attendants to reduce fatigue, so as to improve the effective and efficient of flight attendants and enhance the competitiveness of airlines in the study.

REFERENCES

- Anderson, G. (1993) Emotions and Work in Lifestyle Occupation, Journal of European Industry Training, 17(5), pp.10-14.
- Bendak, S., and Rashid, H. S. (2020) Fatigue in aviation: A systematic review of the literature, International Journal of Industrial Ergonomics, 76, 102928.
- Caldwell, J. A., Caldwell, J. L., Thompson, L. A., and Lieberman, H. R. (2019) Fatigue and its management in the workplace. Neuroscience & Biobehavioral Reviews, 96, 272-289.
- FAA (2007) Flight Attendant Fatigue. Available from: https://tinyurl.com/yv3mfx7z (accessed on 20/12/2021)
- FAA (2008) Introduction to Aviation Physiology. Available from: https://tinyurl.com/4jtruasr (accessed on 20/12/2021)
- FAA (2010) Flight Attendant Fatigue Recommendation II: Flight Attendant Work/Rest Patterns, Alertness, and Performance Assessment. Available from: https://tinyurl.com/53jhz5xe (accessed on 20/12/2021)
- FAA (2013) An Evaluation of Aviation Maintenance Fatigue Countermeasures Training. Available from: https://tinyurl.com/2z52c28y (accessed on 20/12/2021)
- Fahety, V. (1979) Continuing Social Work Education: Results of a Delphi Survey. Journal of Education for Social Work, 15(1), 12-19.
- Flower, D.J.C. (2001) Alertness management in long-haul flying. Transportation Research Part F, 4, 39-48.
- Hill, K. O., & Fowles, J. (1975) The Method Ontological Worth of the Delphi Forecasting Technique. Technological Forecasting and Social Change, 7, 179-192.
- Holden M. C. and Wedman J. F. (1993) Future issues of computer-mediated communication: The results of a Delphi study. Educational technology research and development, 4(1), 5-24.
- IATA, ICAO and IFALPA (2015) Fatigue Management Guide for Airline Operators. Available from: https://tinyurl.com/2z2zbcby (accessed on 20/12/2021)

- IATA, ICAO and IFALPA (2011) Fatigue Risk Management Systems (FRMS)-Implementation Guide for Operators Available from: https://tinyurl.com/vcurmpss (accessed on 20/12/2021)
- ICAO (2011) Fatigue Risk Management System. Available from: (accessed on 20/12/2021)
- ICAO (2016) Manual for the Oversight of Fatigue Management Approaches. Available from: https://tinyurl.com/mry6fssx (accessed on 20/12/2021)
- Ji, M., Liu, B., Li, H., Yang, S., & Li, Y. (2019) The effects of safety attitude and safety climate on flight attendants' proactive personality with regard to safety behaviors. Journal of Air Transport Management, 78, 80-86.
- Jones, C. B., Dorrian, J., Rajaratnam, S. M., and Dawson, D. (2005) Working Hours Regulations and Fatigue in Transportation: A comparative analysis. Safety science, 43(4), 225-252.
- Kennedy, H. G. (1988) Fatigue and fatigability. The British Journal of Psychiatry,153,1, 1-5.
- Kováč, K., & Halamová, J. (2022) Psychometric Properties and Factor Structure of the Slovak Version of the Copenhagen Burnout Inventory. International Journal of Environmental Research and Public Health, 19, 12586.
- Kristensen, T.S., Borritz,M., Villadsen, E. and Christensen, K.B. (2005) The Copenhagen Burnout Inventory: A New Tool for the Assessment of Burnout. Work and Stress, 19(3), 192-207.
- Learmonth, Y., Dlugonski, D., Pilutti, L. A., Sandroff, B. M., Klaren, R., and Motl, R. W. (2013) Psychometric properties of the fatigue severity scale and the modified fatigue impact scale. Journal of the neurological sciences, 331(1-2), 102-107.
- Lee, A. R., Son, S. M., and Kim, K. K. (2016) Information and communication technology overload and social networking service fatigue: A stress perspective. Computers in Human Behavior, 55, 51-61.
- Li, F., Chen, C. H., Khoo, L. P., & Xu, G. (2018) Contextual information-based human fatigue prediction for integrated traffic control. In Proceedings of International Conference on Computers and Industrial Engineering, CIE.

- Mahdavi, N., Dianat, I., Heidarimoghadam, R., Khotanlou, H., & Faradmal, J. (2020) A review of work environment risk factors influencing muscle fatigue. International Journal of Industrial Ergonomics, 80, 103028.
- Maslach, C., and Jackson, S. (1980) The measurement of experienced burnout. Journal of Occupational Behavior, 2, 99-113.
- McNeely, E., Gale, S., Tager, I., Kincl, L., Bradley, J., Coull, B. and Hecker, S. (2014) The Self-Reported Health of U.S. Flight Attendants Compared to the General Population. Available from: https://tinyurl.com/3r352weh (accessed on 20/12/2021)
- Mendoza, T.R., Wang, X.S., Cleeland, C.S., Morrissey, M., Johnson, B.A., Wendt, J.K., Huber, S.L. (1999) The rapid assessment of fatigue severity in cancer patients: use of the Brief Fatigue Inventory. Cancer, 85(5), 1186–1196.
- Phillips, R.O. (2005) A review of definitions of fatigue – And a step towards a whole definition. Transportation Research Part F: Traffic Psychology and Behaviour, 29, 48-56.
- Roach, G. D., Sargent, C., Darwent, D. and Dawson, D. (2012) Duty periods with early start times restrict the amount of sleep obtained by short-haul airline pilots. Accident Analysis and Prevention, 45, 22-26.
- SkYbrary (2019) Fatigue Risk in Maintenance. Available from: https://tinyurl.com/wf2dh7vp (accessed on 20/12/2021)
- University of Illinois at Chicago (2014) International Hazard Datasheet on Occupation Flight Attendant. Available from: https://tinyurl.com/4cjwtsyn (accessed on 20/12/2021)
- VAN DEN Berg M.J., Signal T.L. and Gander P.H. (2019) Fatigue Risk Management for Cabin Crew: The Importance of Company Support and Sufficient Rest for Work-Life Balance-a Qualitative Study, Industrial Health.
- Widyanti A. and Firdaus M. (2019) Assessment of Mental Workload of Flight Attendants Based on Flight Duration: An Effort to Provide Safe Working Condition. Aviation, 23(3), 97-103.
- Yılmaz, M. K., Erbudak, G., & Gunduz, S. (2022) An exploration of the causes and effects of flight attendant fatigue in Turkish aviation. International Journal of Research in Business and Social Science, 11(5), 1-17.

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