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Occupational health in aviation: a cross-sectional study of barodontalgia among Malaysian air force pilots

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Abstract

Background Barodontalgia, or pressure-induced dental pain, poses a significant occupational risk to pilots, potentially impairing flight performance and safety. The present study aimed to determine the prevalence of barodontalgia among Malaysian military pilots, identify the associated risk factors, and examine its relationship with flight performance.

Methods A cross-sectional study employing a census approach was conducted among active Malaysian military pilots between 2021 and 2022 using a modified questionnaire. The questionnaire underwent content validation by five experts and was pre-tested on 10 pilots. Data collection was performed through an online survey. Statistical analyses included descriptive and inferential statistics (Chi-square, t-tests, ANOVA, logistic regression, and ANCOVA), with results considered significant at $p < 0.05$.

Results The questionnaire demonstrated excellent content validity. Among the 190 pilots surveyed (63% response rate), 12.1% experienced barodontalgia, most commonly at altitudes of 6,000–10,000 feet, with worsening symptoms at 0–5,000 and 11,000–15,000 feet. Transport pilots reported the highest prevalence (43.5%), and the most common symptoms were headaches (43.5%) and loss of concentration (34.8%). Age was negatively associated with barodontalgia (β=-0.1505, $p = 0.023$), with younger pilots more likely to be affected. Meanwhile, years of service, aircraft type, smoking, dental awareness, and brushing frequency showed no statistically significant associations ($p > 0.05$). Gender was a significant predictor when controlling for service years ($p = 0.048$) but not when controlling for age ($p = 0.067$).

Conclusion Barodontalgia is an occupational concern for Malaysian military pilots, particularly among younger pilots. Preventive dental care, targeted treatment, and regular check-ups are essential to mitigate risks and maintain operational readiness.

Keywords Altitude sickness, Dental care, Military personnel, Occupational health, Pilots

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Background

Pilots may occasionally experience tooth pain during flights, a condition historically termed aerodontalgia during World War II [1]. However, similar symptoms have also been reported among divers during deep-sea descents, leading to the broader term barodontalgia [2], which encompasses pressure-induced dental pain in various environments. Barodontalgia is defined as dental pain or damage triggered by changes in atmospheric pressure, whether at high or low altitudes [3]. It is not a disease but rather a symptom of an underlying dental condition exacerbated by changes in atmospheric pressure. In dentistry, this phenomenon occurs when the internal pressure within the pulp chamber fails to equalise with the external ambient pressure experienced during rapid altitude changes, such as those encountered during flights [2, 4]. Military and aerobatic pilots, who frequently endure abrupt pressure variations, are particularly susceptible to this condition. Barodontalgia is commonly associated with pre-existing dental issues, such as defective restorations or untreated caries, and can significantly impair a pilot's focus and performance, potentially jeopardising flight safety [5]. Therefore, preventive measures are critical to mitigate risks and ensure operational readiness.

Previous studies on barodontalgia have shown varying prevalence rates across different countries and military aviation settings [2, 4, 5]. In Jordan, Al Khawalde et al.. reported a relatively low prevalence of 10.49% among Jordanian military pilots who experienced barodontalgia at least once during their military activities. By contrast, studies from other countries, including India, Turkey, Saudi Arabia, Kuwait, Brazil, and Israel, have demonstrated substantial variation in prevalence rates, ranging from 20.6% to 81% [5–9]. These discrepancies highlight the need for region-specific investigations, particularly given the varying operational and environmental conditions that pilots face. Notably, barodontalgia typically occurs at altitudes between 1,970 and 5,000 feet, further highlighting the role of altitude in its onset [9].

The underlying causes of barodontalgia have been systematically classified by Ferjentsik and Aker [10], based on the timing of symptoms and associated clinical conditions. Pain during ascent is commonly linked to vital pulp tissue or pulpitis, while pain during descent often indicates pulp necrosis or facial barotrauma [3]. Pilots presenting with barodontalgia often have a history of dental conditions such as faulty restorations, untreated caries, pulp necrosis with periapical inflammation, or barosinusitis [9, 11]. In such cases, symptoms may include dental pain, oedema, or vascular gas embolism caused by pressure changes. Barosinusitis, a related condition, is particularly prevalent among pilots with a history of maxillary sinusitis and may manifest as headaches, numbness, or dental pain in the upper arch [12]. However, distinguishing between barodontalgia and barosinusitis can be challenging [13], with some cases remaining undiagnosed despite thorough evaluation.

In Malaysia, no official data has been published regarding the prevalence or impact of barodontalgia among military pilots, leaving a critical gap in understanding this occupational health issue in the local aviation context. Furthermore, the findings from other countries may not be directly generalisable to the Malaysian context, as differences in aircraft types, mission profiles, training schedules, and healthcare systems can significantly influence both the prevalence and associated risk factors of barodontalgia. This lack of region-specific data hinders the development of targeted preventive measures and management strategies tailored to the unique operational conditions of Malaysian pilots. Military pilots, such as those in the Royal Malaysian Air Force (RMAF), are routinely exposed to extreme altitude variations, making them particularly susceptible to this condition. However, without empirical data, the extent of the problem remains unknown, and its impact on pilot safety and mission readiness is underappreciated. Hence, the present study aims to address these gaps by determining the prevalence of barodontalgia among Malaysian military pilots, identifying the associated risk factors, and examining its relationship with flight performance.

Methodology

Ethical approval

Ethical approval was granted from the International Islamic University Malaysia (IIUM) Research and Ethics Committee (IREC 2020-112).

Sample size calculation

The sample size was calculated using Raosoft Sample Size Calculator, which is widely used for determining appropriate sample sizes in survey-based research. The calculation was based on a population size of 300 active military pilots. A 5% margin of error, a 95% confidence level, and a response distribution of 50% were applied to ensure statistical robustness and generalisability of the findings. Using these parameters, the minimum required sample size was determined to be 169 participants. To account for potential non-responses or incomplete questionnaires, an additional 10% was added to the calculated sample size, bringing the target to 186 participants.

Study design

This was a cross-sectional study that was conducted among active military pilots serving in the RMAF between 2021 and 2022. Retired pilots were excluded from the sample to ensure data represented the current operational environment. A census approach was

adopted, whereby all active RMAF pilots were invited to participate. This ensured that the entire target population was approached rather than selecting a subset. The questionnaire was adapted and modified from previous similar studies in English [2, 9], as it is the primary medium for communication within the RMAF and the aviation industry. The questionnaire items covered demographic details, dental care habits, episodes of dental pain, and awareness of dental health.

Questionnaire validation

The draft questionnaire was initially created, covering four key areas such as participant demographics (e.g., age, gender, smoking habits, years of service, flight hours, and types of aircraft handled), dental care (frequency of tooth brushing and dental check-ups), dental pain (experiences of tooth pain during flights, including onset, altitudes involved, and subsequent dental diagnoses and treatments), and dental awareness (importance of dental health and obstacles in accessing dental care). Most items were adapted from previous studies [2, 9], particularly those on tooth pain, aircraft type, dentist-provided diagnoses, frequency of pain episodes, and consequences of barodontalgia during flight. Minor modifications were introduced to improve contextual relevance for Malaysian military pilots. These included refining demographic questions and items related to dental care habits, such as smoking, brushing frequency, and dental check-ups.

To ensure content validity, the questionnaire was reviewed by a panel of five subject-matter experts, including specialists in aviation medicine, endodontics, and dental public health. Each item was evaluated for relevance, clarity, and appropriateness using a 4-point Likert scale (1 = not relevant, 2 = somewhat relevant, 3 = relevant, 4 = highly relevant). The Content Validity Index (CVI) was calculated at both the item level (I-CVI) and the scale level (S-CVI). An I-CVI of 0.78 or higher was considered acceptable for individual items, while an S-CVI of 0.90 or higher was deemed satisfactory for the overall scale [14]. Items with low CVI scores were revised or removed based on expert feedback. The refined questionnaire was pre-tested among a sample of 10 active military pilots to assess its clarity, comprehensiveness, and practicality. Feedback from this pilot testing phase was used to make final adjustments.

Distribution and data collection

Permission to distribute the questionnaire to all active military pilots was obtained from the Chief of the Royal Malaysian Air Force Office (Reference Number: MTU. PTU100-2/4-(81)). The questionnaires were distributed through the Institute of Aviation Medicine (IAM) using an online Google Form. Participation was voluntary, and informed consent was obtained from all participants. Data privacy and confidentiality were strictly maintained throughout the study, and responses were anonymised to ensure participant privacy. All data were securely stored and accessible only to authorised researchers.

Data analysis

Data were analysed using the Statistical Package for Social Sciences (SPSS), version 25 (IBM Corp., Armonk, N.Y., USA). Descriptive statistics were used to summarise the prevalence of dental pain and related factors. Relationships between the occurrence of dental pain and variables such as age, type of aircraft flown, and altitude were analysed.

Inferential statistical analyses were also performed to identify significant relationships and predictors, such as Chi-square tests to assess the association between categorical variables and the occurrence of dental pain, t-tests and ANOVA to compare age and years of service between pilots with and without dental pain, multivariable logistic regression to evaluate the predictive effects of multiple factors on the likelihood of experiencing dental pain, and analysis of covariance (ANCOVA) to investigate the effect of years of service or ages on dental pain while controlling for the potential confounding effect. All statistical tests were conducted at a significance level of 0.05.

Results

Content validation

The I-CVI of all items was at least 0.78, indicating strong individual item validity. The overall S-CVI for the questionnaire was determined to be 0.92, surpassing the commonly accepted threshold of 0.90 for excellent content validity. In addition, experts and the pre-tested pilot group provided additional qualitative feedback, suggesting improvements to the wording and clarity of certain items to enhance their comprehensibility for participants.

Study outcomes

A total of 190 responses were obtained from 300 active military pilots, yielding a response rate of 63%. The respondents' ages ranged from 22 to 49 years, with a mean age of 31 ± 5.7 years, providing a representative sample of active military pilots. The study revealed that 12.1% ($n = 23$) of respondents experienced tooth pain during flight (Table 1). Of these pilots, 39% ($n = 9$) reported having at least one episode of barodontalgia during their activities. Notably, the age group most affected by barodontalgia was between 25 and 30 years, with 9 out of 23 pilots (39.1%) in this category reporting symptoms (Fig. 1). Barodontalgia episodes were most frequently reported to occur at altitudes between 6,000 and 10,000 feet, accounting for 34.8% of cases. Meanwhile, the symptoms were reported to worsen most significantly

Table 1 Prevalence of barodontalgia, aircraft type, diagnosis, and frequency of pain episodes among military pilots ($n = 190$)

	Frequency/ count (*n*)	Percentage (%)
Tooth Pain (Barodontalgia)		
No	167	87.9
Yes	23	12.1
Total	190	100.0
Aircraft Types Operated by Military Pilots Experiencing Barodontalgia		
Fighter	7	30.4
Helicopter	3	13.0
Transport	11	47.8
Training aircraft	2	8.7
Total	23	100.0
Diagnosis		
No (Didn't seek dental treatment)	6	26.1
Cavity/Decayed tooth	7	30.4
Fractured or faulty restoration	4	17.4
Infection involving nerve of the tooth	2	8.7
Infection involving wisdom tooth	1	4.3
Infection of the gum	2	8.7
Wisdom tooth pain	1	4.3
Total	23	100.0
Frequency of Pain Episode		
1	9	39.1
2	9	39.1
3	4	17.4
4	1	4.3
Total	23	100

at two altitude ranges: 0–5,000 feet and 11,000–15,000 feet, each accounting for 30.4% of cases (Fig. 2).

The prevalence of barodontalgia varied across the five categories of aircraft operated by military pilots. The highest number of cases was reported among transport pilots (47.8%), followed by fighter pilots (30.4%), helicopter pilots (13.0%), and training pilots (8.7%). Moreover, the most common symptoms experienced during episodes of barodontalgia were headaches (43.5%), followed by loss of concentration (34.8%). A smaller proportion of affected pilots (8.7%) were grounded from flying until they received treatment and were symptom-free. Furthermore, 4.3% of pilots reported feeling general discomfort during flights due to dental pain (Fig. 3). Among the pilots who experienced barodontalgia, 73.9% sought dental treatment. The most common diagnoses provided by dentists were cavities or decayed teeth (30.4%), followed by fractured or faulty restorations (17.4%), infections involving the nerve of the tooth or gums (8.7%), and wisdom tooth-related issues (4.3%).

Based on the Chi-square test, there was no statistically significant association between smoking habits ($p = 0.195$) or aircraft types ($p = 0.528$) and dental pain prevalence. Furthermore, there was no statistically significant association between brushing frequency and the occurrence of dental pain ($p = 0.308$), as well as between dental awareness and the occurrence of dental pain ($p = 0.884$). Meanwhile, the difference in mean age between pilots with and without dental pain was statistically significant ($p = 0.023$), with younger pilots (25–30 years) showing a higher prevalence of barodontalgia. The years of service among pilots with different dental pain experiences were found to show no statistically significant difference ($p = 0.553$). According to the multivariable logistic regression findings in predicting dental pain, it can be observed that increasing age was negatively associated with barodontalgia (β=-0.1505, $p = 0.023$), indicating that younger pilots were more likely to be affected (Table 2). The other predictors, such as years of service (β=-0.0140) and flight times (β=-0.0003), had minimal influence. In addition, age had a statistically significant association with the occurrence of dental pain when controlling for years of service ($p = 0.022$), while years of service did not have a statistically significant association with dental pain when controlling for age ($p = 0.884$). Similarly, the effect of gender on dental pain was not statistically significant ($p = 0.067$) while controlling for age, but was found to be significant ($p = 0.048$) when controlling for years of service.

Discussion

The present study highlights critical insights into the prevalence and factors associated with barodontalgia among military pilots, uncovering patterns that warrant further exploration. Overall, 12.1% of the pilots experienced barodontalgia, with younger age emerging as the strongest predictor. The strong content validity of the questionnaire reflects its robustness in capturing the relevant variables associated with barodontalgia. The high I-CVI and S-CVI values suggest that the questionnaire effectively addressed the complexities of this occupational health issue. Our findings revealed a slightly higher prevalence of barodontalgia than that reported among Jordanian and Israeli military pilots [2, 11]. However, the prevalence in our study is notably lower than that reported in Saudi-Kuwaiti and Indian studies [6, 9] while being comparable to the prevalence observed in Turkish and Brazilian military pilots [5, 15]. These variations in prevalence may be attributed to differences in study populations, aircraft types, operational altitudes, and dental care practices across regions [15]. Moreover, it can be postulated that countries with comprehensive pre-flight dental screenings and preventive care may report lower prevalence rates [16].

The present study found that 39% reported having at least one episode of barodontalgia during their activities, which is higher than those reported in India, Jordan,

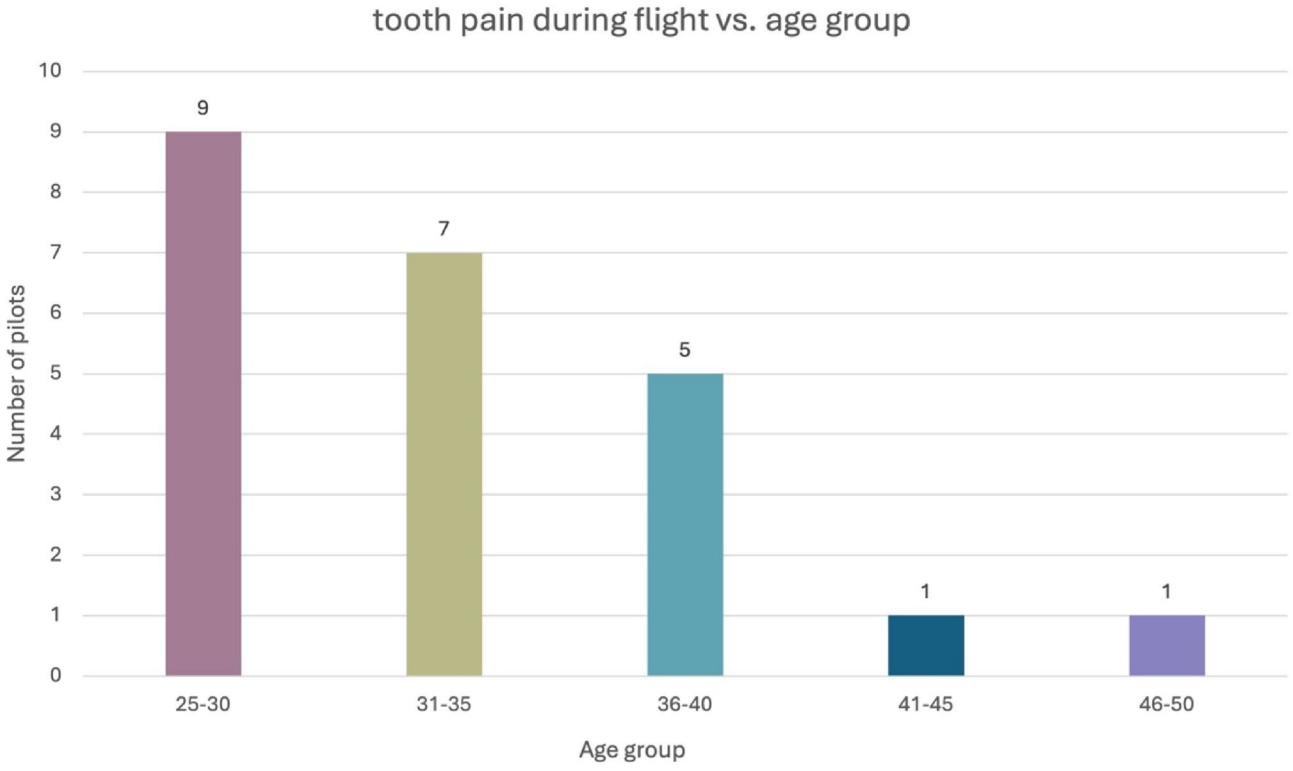

Fig. 1 Barodontalgia during flight across different age groups of Malaysian military pilots (*n*=190)

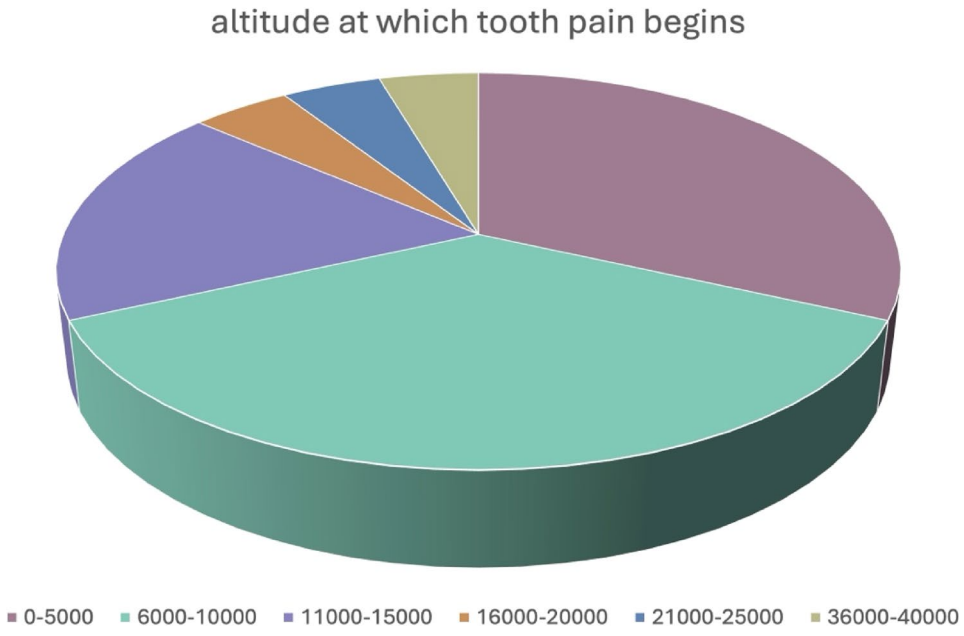

Fig. 2 Altitude at which barodontalgia begins during flight among Malaysian military pilots (*n*=190)

Saudi Arabia and Kuwait [2, 6, 9]. Meanwhile, the finding that barodontalgia is most common between 6,000 and 10,000 feet, with worsening symptoms at two different altitude ranges, aligns with the physiological mechanisms of pressure change. Rapid changes in barometric pressure during ascent or descent can exacerbate differential pressures within compromised dental structures, particularly those with untreated caries, defective restorations, or pulp pathologies [13]. Nevertheless, this finding contradicts those reported in Saudi Arabia, Kuwait, and India [6, 9], suggesting that climatic and environmental differences may play a role. Malaysia's humid tropical

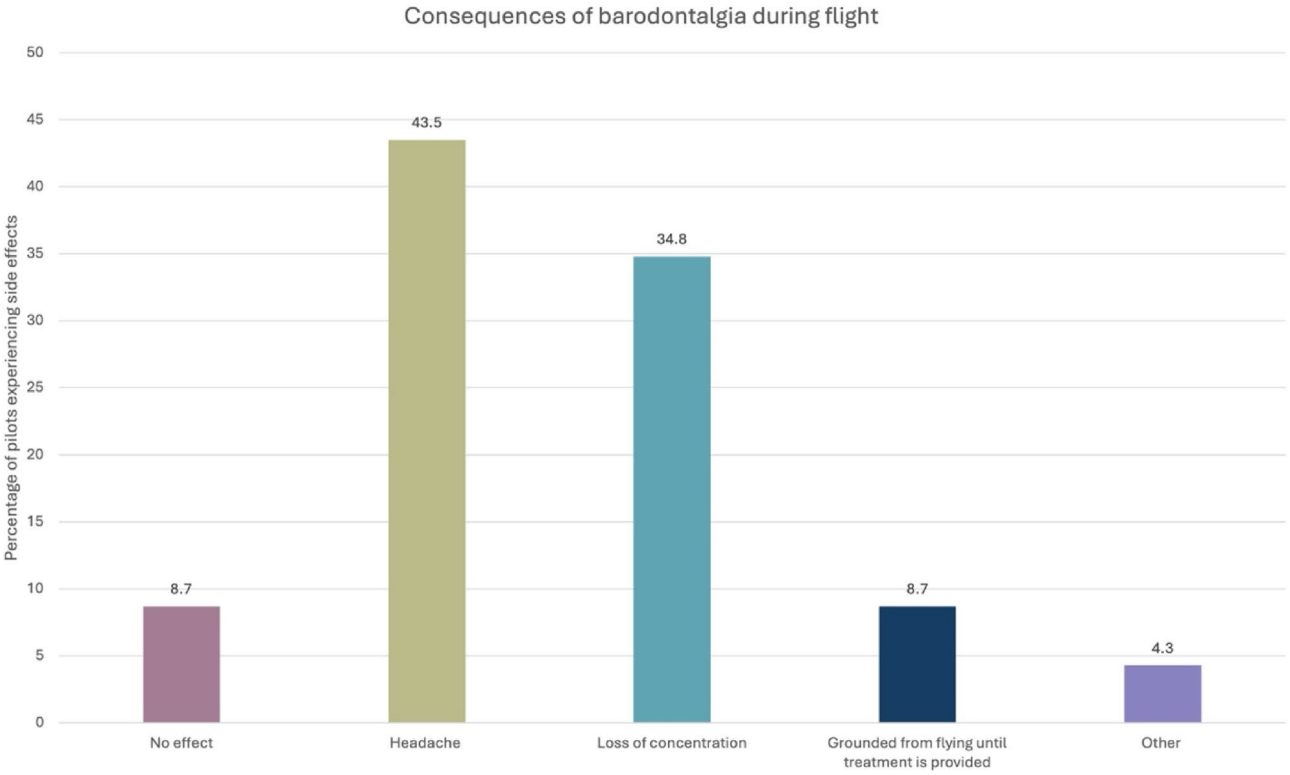

Fig. 3 Consequences of barodontalgia during flight among Malaysian military pilots (*n*=190)

Table 2 Multivariable logistic regression analysis of predictors of barodontalgia among Malaysian military pilots (*n* = 190)

Predictor	β (Coefficient)	Odds Ratio (OR)	95% CI for OR	*p*-value
Age (years)	–0.1505	0.86	0.75–0.97	0.023*
Years of service	–0.0140	0.99	0.92–1.07	0.442
Flight times	–0.0003	1.00	0.99–1.00	0.809

OR Odds Ratio, *CI* Confidence Interval

*significant level at 0.05

climate could potentially reduce dehydration, leading to a distinct pressure-related pain pattern compared to the arid conditions of the other regions [17]. The variation in altitude thresholds for pain onset and exacerbation could also be explained by differences in the pressurisation levels of aircraft, types of missions, and the pilots' dental health statuses.

Transport pilots in the present study were found to have a higher prevalence of barodontalgia, contrasting with findings from Jordan and Turkey [2, 5], where helicopter and fighter jet pilots, respectively, exhibited higher incidences of the condition. The variation in the prevalence of barodontalgia across different aircraft types likely reflects differences in operational conditions, flight profiles, and the specific physical demands associated with each type of aircraft. However, in the current study, aircraft type was not found to have a statistically significant association with dental pain. Headache and loss of concentration were noted to be the most common symptoms among Malaysian aviation pilots, highlighting their potential to impair pilot performance. This finding is consistent with the outcomes reported among Jordanian military pilots [2]. Dental pain can trigger referred pain pathways involving the trigeminal nerve, potentially causing headaches or facial discomfort [18]. Furthermore, the cognitive load associated with managing in-flight tasks under the influence of pain may compromise situational awareness and decision-making, posing risks to flight safety.

Based on the present findings, cavitated or decayed teeth were identified as the primary cause of barodontalgia, followed by fractured or faulty restorations and pulpitis or periodontitis. These findings differ from those reported among Jordanian military pilots, where faulty restorations were the leading cause, and Israeli military pilots, where recent restorative treatment was most frequently implicated [2, 11]. Similarly, a previous review highlighted that the most common causes of barodontalgia included faulty dental restorations and dental caries without pulp involvement [19]. These discrepancies may reflect differences in dental care practices, treatment standards, and pre-existing oral health conditions across regions. It also emphasises the need for high-quality restorative dental care, tailored to withstand the unique

pressure variations experienced in aviation [20]. Preventive strategies, including regular dental screenings and prompt treatment of potential vulnerabilities, are critical to reducing the burden of barodontalgia [5].

The present study revealed a statistically significant difference in the mean age between pilots with and without dental pain, with those aged 25 to 30 years being the most affected. Moreover, age remained a significant factor even after controlling for years of service. Regression analysis demonstrated that increasing age was negatively associated with barodontalgia, indicating that younger pilots were more likely to be affected. However, it contradicts a previous study that reported no correlation between barodontalgia and age [8]. The human body changes with age, and younger adults might be more sensitive to rapid barometric pressure changes due to relatively more active pulpal tissue [21]. Thus, this heightened physiological response could increase their susceptibility to barodontalgia compared to older pilots, whose pulp tissue might be less reactive due to calcification or reduced vascularity [22]. Another plausible explanation could be that pilots in this age group are typically at a stage in their careers where they have gained sufficient experience to handle demanding missions, but may still be subjected to rigorous high-altitude flying schedules [23].

Interestingly, when controlling for years of service, gender differences in dental pain became statistically significant. This may indicate that while pilots' experience (measured by years of service) does not directly influence dental pain, gender differences may become more apparent when the confounding effect of years of service is removed. The absence of a significant relationship between years of service and dental pain suggests that experience alone may not be a protective factor against the occurrence of barodontalgia among military pilots. Instead, age may reflect cumulative dental health risks more accurately than years of service.

The absence of significant associations between smoking, brushing frequency or dental awareness and barodontalgia occurrence in the present study suggests that general oral hygiene practices, while important, may not be sufficient to mitigate this condition. Instead, barodontalgia appears more closely tied to specific structural and pathological dental factors [13]. For instance, the pathogenesis of barodontalgia associated with pulpitis is attributed to barometric pressure changes, which force oral fluids out of dentinal tubules, causing pain or sensitivity. Hence, this finding highlights the need for targeted interventions, such as using pressure-resistant materials in restorations and more frequent dental evaluations for pilots.

Years of service and flight times were found to have minimal influence on dental pain. Similar findings were also reported among Brazilian aviation pilots, noting a low correlation between barodontalgia and length of service [15]. Barodontalgia is primarily associated with specific dental conditions, such as untreated cavities, defective restorations, or periodontal disease [5, 13], rather than the length of a pilot's career or cumulative flight hours. These conditions can affect pilots at any stage of their service, irrespective of their experience or total flight time. This explains the weak or negligible correlation between barodontalgia and service duration or flight times. While barodontalgia management aligns with standard dental practices, military aviation requires specific considerations [24].

Several limitations could be identified in the current study. First, the study relied on self-reported questionnaires, which are subject to recall bias and may not fully align with documented clinical practice [25]. Second, no clinical dental examinations were performed to confirm the diagnoses reported by the pilots. This limits the ability to establish definitive correlations between barodontalgia and its underlying dental causes. Third, factors such as general health status, dietary habits, and stress levels, which may influence the prevalence and severity of barodontalgia, were not considered in the analysis. Fourth, we did not conduct additional reliability testing, such as internal consistency (Cronbach's alpha) or test–retest reliability, owing to the practical constraints of working with an active military population where repeated testing was not feasible. Moreover, as this was a cross-sectional study, the temporal sequence between risk factors and barodontalgia cannot be established, and therefore, causal inferences cannot be drawn. Nonetheless, the insight obtained from the present study can be used to inform evidence-based preventive strategies and contribute to improving the operational readiness and safety of military pilots in Malaysia. Future studies should incorporate longitudinal designs with clinical dental examinations to validate self-reported data, explore the effectiveness of preventive dental care, and assess the long-term impact of barodontalgia on pilot performance across diverse aviation settings.

Conclusion

Barodontalgia presents a notable occupational health concern for military pilots, particularly among younger pilots, with potential implications for military aviation safety. The present study highlights the importance of addressing dental health as a critical component of aviation medicine, especially in high-risk environments such as military aviation. While age emerged as a significant predictor of barodontalgia, the lack of associations with other modifiable factors warrants the need for a more comprehensive investigation. Understanding the interplay between physiological, operational, and dental factors can inform targeted preventive strategies, ultimately

enhancing pilot well-being and flight performance. Future research should further explore these relationships, including longitudinal studies to monitor the long-term effects of dental care interventions on barodontalgia prevalence.

Abbreviations

CVI	Content Validity Index
IAM	Institute of Aviation Medicine
RMAF	Royal Malaysian Air Force
SPSS	Statistical package for the social sciences

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Authors' contributions
S.A. contributed to study design, data collection, data analysis, research administration, and drafting of the article; S.A.M.N., N.M. and M.S.M.D. contributed to data collection, data analysis and drafting of the article; both M.H.H. and M.S.A.M. contributed to data analysis, and article preparation; G.S.S.L. contributed to data validation and review the manuscript. All authors read and approved the final version of the manuscript.

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Data availability
All data generated or analysed during this study are included in this published article.

Declarations

Ethics approval and consent to participate
The study was approved by the International Islamic University Malaysia (IIUM) Research and Ethics Committee with registration number IREC 2020 – 112. Permission to distribute the questionnaire was also obtained from the Chief of the Royal Malaysian Air Force Office with Reference Number MTU.PTU100-2/4-(81). Informed consent was obtained from all participants included in the study. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki. All subjects' rights were protected, and all data were kept confidential.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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