International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Operating Publisher
SciFormat Publishing Inc.
ISNI: 0000 0005 1449 8214

2734 17 Avenue SW,
Calgary, Alberta, T3E0A7,
Canada
+15878858911
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ARTICLE TITLE	MELANOMA RISK IN AIRLINE PILOTS AND CABIN CREW: A NARRATIVE REVIEW OF OCCUPATIONAL AND NON-OCCUPATIONAL FACTORS
DOI	https://doi.org/10.31435/ijitss.3(51).2026.6328
RECEIVED	11 June 2026
ACCEPTED	02 September 2026
PUBLISHED	16 September 2026
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MELANOMA RISK IN AIRLINE PILOTS AND CABIN CREW: A NARRATIVE REVIEW OF OCCUPATIONAL AND NON-OCCUPATIONAL FACTORS

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ABSTRACT
Cutaneous malignant melanoma is one of the most aggressive skin cancers, with a steadily increasing incidence worldwide. Epidemiological studies suggest that airline pilots and cabin crew have approximately twice the melanoma risk of the general population. The aim of this review was to summarize current evidence regarding melanoma risk factors in flight personnel. A literature review was conducted using PubMed and related scientific databases, focusing on cohort studies and meta-analyses, and a report evaluating melanoma incidence and associated risk factors among airline crews. Current evidence indicates that melanoma risk in flight personnel is multifactorial. Major occupational factors include increased exposure to ultraviolet A (UVA) radiation at cruising altitude, cosmic ionizing radiation, and circadian rhythm disruption related to shift work and transmeridian travel. Lifestyle-related intermittent sun exposure during stopovers and holidays may further increase risk. Individual susceptibility is associated with fair skin phototypes, light hair color, and a high number of melanocytic naevi. Understanding these interacting occupational and individual factors may improve prevention strategies, including enhanced UV protection, occupational monitoring, and regular dermatological screening.

KEYWORDS
Cutaneous Malignant Melanoma, Airline Pilots, Cabin Crew, Ultraviolet Radiation, Cosmic Radiation

CITATION
Kacer, J., Chołast, J., Łuniewska, W., Jabłoński, M., Kacer, J., Niepokój, J., Jurga, K., Kobaka, L., & Modrzyk, M. (2026). Melanoma risk in airline pilots and cabin crew: A narrative review of occupational and non-occupational factors. *International Journal of Innovative Technologies in Social Science*, 3(51). https://doi.org/10.31435/ijitss.3(51).2026.6328

1. Introduction

Cutaneous malignant melanoma is a significant global health challenge affecting many people, particularly those with light-pigmented skin (1). Melanoma is among the leading causes of cancer-related mortality in young adults (2). In many nations worldwide, the incidence of melanoma has been steadily increasing over the past five decades (1). A better understanding of the risk factors for cutaneous malignant melanoma will facilitate the development of more effective prevention and treatment strategies. One group that is considered to be at higher risk of developing melanoma is aviation personnel, including pilots and cabin crew (3–5). However, the association between flight-related occupations and the risk of cutaneous malignant melanoma remains incompletely understood, as epidemiological evidence is inconsistent, with some studies reporting an elevated melanoma incidence among aviation personnel, while others have found no significant association (8, 11). Nevertheless, the most recent meta-analysis, involving more than 266,000 participants, reported a standardized incidence ratio (SIR) of approximately 2.2 for melanoma among pilots and cabin crew (6). Cutaneous malignant melanoma in airline pilots and cabin crew has been proposed for inclusion in the list of prescribed occupational diseases (7). Among the occupational risk factors the following are distinguished: heightened altitude-related exposure to cosmic ionizing radiation and ultraviolet (UV) radiation, specifically UVA. Furthermore, behavioral and lifestyle factors associated with work-specific such as higher frequency of sun holidays, intense intermittent ultraviolet (UV) exposure during leisure time and stopovers in sunny, equatorial destinations, and the disruption of circadian rhythms, have been identified as another major contributing factors (6–8). Additionally, individual constitutional traits such as fair skin phototypes, a high total count of melanocytic naevi, and family history also significantly influence susceptibility. A comprehensive understanding of all these risk factors is necessary for better prevention, earlier detection, and improved clinical results. Thus, the aim of this review is to classify and describe the specific risk factors associated with the development of melanoma among commercial and military airline pilots and cabin crew.

2. Review methodology

A narrative literature review was conducted using the PubMed database to identify studies evaluating risk factors for cutaneous malignant melanoma among airline pilots and cabin crew. The literature search covered publications from 1990 to 2026 and included the following keywords and combinations: "melanoma," "cutaneous malignant melanoma," "pilots," "aircrew," "flight attendants," "airline crew," "ultraviolet radiation," "cosmic radiation," and "circadian disruption". Only articles published in English were considered. Additionally, a backward literature search was conducted based on the references cited in the identified articles. A total of 42 articles were initially identified through database searching. After screening titles, abstracts, and full texts for relevance and scientific quality, 14 studies were included in the final review. Eligible publications comprised cohort studies, epidemiological studies, systematic reviews, a report, and meta-analyses focusing on melanoma incidence, mortality, and occupational or behavioral risk factors in flight personnel. Studies unrelated to aviation medicine, lacking melanoma-specific outcomes, or providing insufficient epidemiological data were excluded. Particular emphasis was placed on large population-based cohort studies and recent publications with significant epidemiological and occupational health relevance.

Occupational Risk Factors

3.1 Ultraviolet (UV) radiation

Ultraviolet (UV) radiation is classified as a Group 1 human carcinogen and is the primary environmental driver of cutaneous melanoma, with up to 90% of all skin cancer cases attributable to its effects (9). It operates as a complete carcinogen, meaning it acts as both an initiator of cellular damage and a promoter of malignancy, often through systemic mechanisms such as immunosuppression (10). The underlying pathogenesis involves two distinct pathways: UVB radiation (280 - 315 nm) induces direct DNA damage in the skin's epidermal layer, whereas UVA radiation (315 - 400 nm) penetrates more deeply into the dermis, causing indirect oxidative DNA damage (7). Notably, melanocytes are especially vulnerable because they continue to accumulate DNA damage for several hours after exposure has ceased through the chemiexcitation of melanin derivatives (7). Altitude amplification is a critical factor in the occupational risk of melanoma, as ultraviolet (UV) radiation intensity increases significantly with elevation. Research indicates that UV intensity rises by approximately 15% for every 900 meters (3,000 feet) of gain in altitude (6). As a result, at a typical commercial cruising altitude of 9,000 meters (30,000 feet), the UV levels are roughly twice as high as those recorded at sea level. This exposure can be further intensified by environmental factors such as thick cloud layers or snow fields, which can reflect up to 85% of UV radiation back into the aircraft (6,7). Although aircraft windshields, whether glass or plastic, effectively block over 99% of the most potent UVB radiation, they offer inconsistent protection against UVA radiation (3). Glass-laminated composite windshields can allow up to 54% of UVA rays to penetrate the cockpit, while plastic (polycarbonate) materials block UVA almost entirely (6). Research has demonstrated that a pilot flying for 56.6 minutes at 30,000 feet receives a carcinogenic UVA dose equivalent to a 20-minute session in a tanning bed (4). While some experts attribute high melanoma incidence in aircrew to recreational sun exposure during stopovers, the doubling of risk observed after 5,000 aggregated flying hours suggests cockpit-based UVA exposure may represent an important contributing occupational factor (7).

3.2 Cosmic Ionizing Radiation

Cosmic radiation is a form of ionizing radiation from outer space that increases with altitude because of reduced atmospheric protection. Cosmic radiation at cruising altitudes of 30,000 feet (approximately 9000 meters) or higher is considered a potential occupational concern for airline crews, as it consists of a complex mixture of gamma rays, heavy nuclei, and neutrons. (3,7,8,11,12) Neutrons are recognized as carcinogenic components of ionizing radiation, however their specific role in melanoma pathogenesis remains unclear. (3,5,7,13) Flight personnel receive estimated annual doses of 2-6 mSv, which is roughly double the ionizing radiation dose received by the general population from natural and medical sources. (7,12–15) While some epidemiological research has demonstrated a positive dose-response relationship, notably among Nordic pilots, where melanoma risk was found to increase significantly with cumulative radiation doses exceeding 20 mSv. The overall evidence remains inconsistent across different studies. (3,12) Some analyses conclude that these occupational radiation levels are relatively low and may not definitively account for the approximately doubled risk of melanoma seen in flight personnel compared to the general public. (7,8,13) Consequently, the precise causal role of cosmic radiation in melanoma development remains a subject of ongoing debate, as it is often difficult to disentangle from other occupational hazards. (7,11,16)

Non-occupational Risk Factors

3.3 Circadian Rhythm Disruption

Circadian rhythm disruption is a significant hypothesized factor contributing to the increased risk of cutaneous melanoma among airline crews, arising from frequent shift work, night duties, and transmeridian travel across multiple time zones (7,8,14). This occupational environment can lead to "jet lag," a condition characterized by the desynchronization of the body's internal biological clock with external environmental light (8,14). A primary consequence of this disruption is the suppression of melatonin, a neurohormone with established anti-cancer properties that is typically secreted by the pineal gland at night (17). Melatonin plays a critical role in the skin's defense systems by facilitating the nighttime repair of DNA damage induced by ultraviolet (UV) and cosmic radiation(7,13). While biological mechanisms for oncogenesis are plausible, epidemiological evidence specifically linking circadian disruption to melanoma in aircrews remains complex and sometimes inconsistent (7). For instance, a study of Icelandic pilots found a higher incidence of melanoma among those crossing more than five time zones (SIR 25.0) compared to those who did not (SIR 9.09), though these results did not reach statistical significance (7). Similarly, research on U.S. flight attendants noted non-significant associations between melanoma risk and time spent working during standard sleep intervals (7) . Conversely, some large-scale Nordic studies on cabin crew found no clear dose-response relationship between melanoma and the number of time zones crossed (8). Despite these varied findings, the International Agency for Research on Cancer (IARC) has classified night shift work involving circadian disruption as probably carcinogenic to humans (Group 2A) (4). Currently, many experts conclude that circadian disruption likely interacts synergistically with other hazards, such as cockpit UVA exposure, to double the melanoma risk for flight personnel (7). Overall, current evidence supports circadian disruption as a plausible but insufficiently established cofactor in melanoma development among flight personnel.

3.4 Leisure and Behavioral Factors

Leisure-time activities and behavioral factors are significant hypothesized contributors to the elevated melanoma risk in airline personnel, often linked to the high socioeconomic status associated with the profession (7,11,18). This status frequently correlates with a higher frequency of sun holidays and intense intermittent ultraviolet (UV) exposure during leisure time and stopovers in sunny, equatorial destinations (11,13,15). In fact, aircrew members often report higher rates of sunscreen use and more frequent sunny vacations compared to the general population (5,7,19). While some experts argue that high melanoma rates primarily reflect these sun-seeking behaviors rather than occupational exposures, others note that the doubling of risk observed in flight personnel cannot be solely explained by lifestyle, given that their overall risk-factor profiles are largely similar to population controls (5,7).

3.5 Individual Risk Factors

Individual susceptibility to cutaneous malignant melanoma is fundamentally determined by constitutional risk profiles, specifically the number and type of melanocytic naevi and an individual's skin phototype (7,11,12). A high total count of benign acquired naevi (exceeding 100) carries a risk ratio of approximately 2.5, while the presence of atypical or dysplastic naevi is a well-established predictor often associated with the superficial spreading melanoma subtype (5,7). However, research indicates that the prevalence of high naevi counts among flight personnel (5.4%) remains comparable to that of the general population (4.2%) (5,7). Additional phenotypic characteristics, often classified according to the Fitzpatrick scale, are associated with melanoma risk, with phototypes I and II carrying the highest risk. Traits such as red or blonde hair and light-coloured eyes are strongly associated with increased incidence, with overall relative risk reported to be as high as 2.6 (11,12,19). Sun sensitivity serves as a critical risk predictor, and studies of British flight personnel show that 46% of males and 57% of females report skin that burns easily when exposed to sunlight (13). Despite these individual factors, extensive comparative data from Nordic populations consistently show that the distribution of these phenotypic traits and family histories of skin cancer among airline pilots and cabin crew does not differ substantially from population controls (5,19). Current evidence suggests that constitutional susceptibility alone is unlikely to explain the elevated melanoma incidence observed among flight personnel.

4. Conclusions

Studies suggest that airline pilots and cabin crew may experience a higher incidence of cutaneous malignant melanoma than the general population. The increased melanoma incidence observed in flight personnel is likely multifactorial and may reflect a combination of occupational exposures, lifestyle-related ultraviolet exposure, and individual susceptibility. Individual susceptibility factors, including fair skin phototypes and a high number of melanocytic naevi, may additionally contribute to melanoma development. Improved understanding of these interacting factors may support more effective prevention strategies, including enhanced cockpit UV protection and regular dermatological screening programs for flight personnel. Further research is needed to better clarify the role and interaction of occupational exposures in melanoma pathogenesis.

Author's contribution Statement: Writing and editing: Jakub Kacer, Jakub Chołast, Wiktoria Łuniewska, Maurycy Jabłoński, Julia Kacer, Jakub Niepokój, Klaudia Jurga, Laura Kobaka, Marta Modrzyk

All authors have read and agreed with the published version of the manuscript.

Funding Statement: The study did not receive special funding.

Conflict of Interest Statement: The authors report no conflict of interests.

Declaration of the use of generative AI and AI-assisted technologies in the writing process: In the preparation of this manuscript, the authors used the ChatGPT-5.5 language model to assist with language editing and improve the readability of the text. After using this tool, the authors have reviewed and edited the content as needed and accept full responsibility for the substantive content of the publication.

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