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# COMPARATIVE ANALYSIS OF MELANOMA DEVELOPMENT AND PREVENTION OF ULTRAVIOLET RADIATION EXPOSURE IN UKRAINE AND ITALY

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The most common cause of melanoma is exposure to ultraviolet radiation due to ultraviolet mutagenesis. The purpose of the study was to highlight and make a comparative analysis of the incidence of melanoma in Ukraine and Italy, taking into account different levels of insolation, and to assess the effectiveness of existing preventive measures to protect against ultraviolet radiation. A search, systematic review, and meta-analysis of publications were conducted using scientific literature databases, including MEDLINE, Scopus®, ResearchGate, PubMed, and Google Scholar. The comparative analysis of melanoma incidence in Ukraine and Italy revealed a clear upward trend in both countries. However, even with moderate UV index levels in Ukraine, an increase in diagnosed melanoma cases has been observed, emphasizing the relevance of identifying and preventing the impact of UV radiation. At the same time, studies indicate insufficient adherence to individual sun protection measures among both adults and children in Italy, which is a significant risk factor for melanoma development.

**Key words:** ultraviolet radiation, risk factors, melanoma, prevention, Ukraine, Italy.

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# ПОРІВНЯЛЬНИЙ АНАЛІЗ РОЗВИТКУ МЕЛАНОМИ ТА ПРОФІЛАКТИКИ ВПЛИВУ УЛЬТРАФІОЛЕТОВОГО ВИПРОМІНЮВАННЯ В УКРАЇНІ ТА ІТАЛІЇ

Найпоширенішою причиною виникнення меланоми є дія ультрафіолетового випромінювання за рахунок ультрафіолетового мутагенезу. Метою роботи було висвітлити та зробити порівняльний аналіз захворюваності на меланому в Україні та Італії з урахуванням різних рівнів інсоляції, оцінити ефективність існуючих профілактичних заходів щодо захисту від ультрафіолетового випромінювання. Проведений пошук, систематичний огляд і метааналіз публікацій за допомогою баз даних наукової літератури MEDLINE, Scopus®, ResearchGate, PubMed та Google Scholar. Порівняльний аналіз захворюваності на меланому в Україні та Італії засвідчив наявність чіткої тенденції до зростання випадків в обох країнах. Однак навіть за помірних показників ультрафіолетового індексу в Україні спостерігається зростання кількості діагностованих випадків меланоми, що підкреслює актуальність питання визначення та профілактики впливу ультрафіолетового випромінювання. Водночас дослідження демонструють недостатнє дотримання заходів індивідуального захисту від сонячного випромінювання як серед дорослого населення, так і серед дітей в Італії, що є високим фактором ризику розвитку меланоми.

**Ключові слова:** ультрафіолетове випромінювання, фактори ризику, меланома, профілактика, Україна, Італія.

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Skin melanoma arises from skin melanocytes predominantly in the white race and is classified as a malignant neoplasm [11, 12, 26]. In the Western population, there is one case of melanoma for every 50 individuals. Compared to other oncological diseases, the incidence of melanoma is increasing at a faster rate [8, 11].

The etiology of melanoma is multifactorial, with environmental factors, genetic predisposition, and other factors influencing its development. However, the most common cause of melanoma (60–70 %) is exposure to natural (solar radiation) and artificial (tanning bed) ultraviolet (UV) radiation, which induces ultraviolet mutagenesis [8, 29].

Obesity is considered a well-established risk factor for the development of various malignancies, including melanoma. It may influence not only the increased likelihood of tumor occurrence but also the effectiveness of antitumor therapy. In particular, excess body weight can reduce the efficacy of melanoma immunotherapy and chemotherapy, as well as increase the risk of therapy-induced complications [40].

Many patients with melanoma have a history of sunburns and tanning bed usage [6, 19, 27]. UV radiation exposure that exceeds the skin's natural protective ability to tan leads to burns of varying degrees. Scientific evidence shows that regular use of tanning beds increases the risk of developing melanoma by 15 %, with the risk being higher in individuals who first used tanning beds before the age of 35 [3].

The biological effect of UV radiation depends on the spectral region of the range:

– UVC rays are completely absorbed by the ozone layer and practically do not reach the Earth’s surface, with a wavelength of 190–280 nm;

– UVB rays cause tanning and sunburns, with a wavelength of 280–320 nm;

– UVA rays cause photoaging of the skin, pigmentation, and wrinkles, with a wavelength of 320–400 nm [9].

According to this classification, it is UVA and UVB rays that penetrate the epidermis and dermis of the skin and affect biological processes [34].

The main indicator of UV radiation levels is the ultraviolet index, the intensity of which depends on many factors such as geographic latitude, angle of inclination of the sun, altitude, ozone layer status, atmospheric pollution, weather conditions, season and time of day, and surface reflectivity (snow, sand, water). The UV index ranges from 0 to 13, with the following classifications: 1–2 (low), 3–5 (moderate), 6–7 (high), 8–10 (very high), and 11 or more (extremely high). The UV index value determines the hygienic aspects of preventive measures against the negative biological effects of UV radiation on the human body.

**The purpose** of the study was to analyse the incidence of melanoma in Ukraine and Italy, considering different levels of solar radiation exposure, and to assess the effectiveness of existing preventive measures against ultraviolet radiation based on a meta-analysis of literary sources, clinical guidelines, and the results of multicenter studies.

The search, systematic review, and meta-analysis of publications were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and consisted of three stages:

1. Identification stage – a primary automated search was performed using scientific literature databases, including MEDLINE, Scopus®, ResearchGate, PubMed, and Google Scholar. The keywords describing the underlying paradigms included: ultraviolet radiation, statistics, skin cancer, melanoma, skin cancer prevention, sunburn prevention, epidemiology, Ukraine, and Italy.

2. Screening stage – the titles and abstracts of the retrieved publications were reviewed for compliance with the inclusion/exclusion criteria.

3. Eligibility stage – a more in-depth assessment of full-text publications was conducted to ensure their relevance to the study criteria.

Among all types of skin cancer, melanoma accounts for a smaller percentage of incidence but a significant proportion of skin cancer-related mortality. The existing risk factors for melanoma development can be classified into two groups, which determine the focus of further prevention strategies, specifically targeting modifiable risk factors, as outlined in Table 1 [35, 36].

Table 1

**Risk factors for melanoma**

| Modifiable | Nonmodifiable |
|---|---|
| UV radiation | Age |
| Sunburns | Sex |
| Indoor tanning | Race |
| Early life UV radiation exposure | Genetic predisposition |
| Immune suppression | Fitzpatrick skin types I and II |
| Sun exposure | Hair color: red, blond, light brown |
| Chronic trauma to the skin | Eye color: blue, green |
| Organ transplantation | Common nevi |
| Herbicides | Freckling |

As mentioned above, the most common cause of melanoma development is the impact of UV radiation (UVA and UVB rays). The International Agency for Research on Cancer (IARC) included the use of UV-emitting tanning devices in the list of type 1 carcinogens, thus defining it as “carcinogenic to humans”.

In Italy, melanoma ranks third among all cancers in terms of the frequency of diagnosis among people under 50 years of age [43]. According to the report “The Number of Cancer Cases in Italy in 2024”, presented by the Italian Association of Medical Oncology, there was a sharp increase in melanoma incidence in Italy in 2024, reaching an unprecedented level of 17,000 new cases – an increase of 4,300 diagnoses compared to 2023.

A retrospective analysis of melanoma incidence dynamics in the Veneto region in northeastern Italy and its alpine area (Belluno province) from 1990 to 2017 revealed a significant increase in the frequency of this pathology. The incidence rates in alpine regions were notably higher than those among the rest of the regional population. While epidemiological data and clinicopathological characteristics confirm the key role of ultraviolet radiation in melanoma development, the younger age of affected women, who constitute the majority of cases, suggests the possible influence of additional etiological factors related to individual

biological characteristics. These findings emphasize the importance of implementing effective primary and secondary prevention strategies [4].

The study of melanoma incidence in Ukraine is becoming increasingly important as wartime events elevate the likelihood of skin cancer development [1]. According to official data from the National Cancer Registry of Ukraine, as of 12 June 2024, a total of 21,885 people diagnosed with skin melanoma have already been registered in the Unified Electronic Healthcare System of Ukraine. The negative dynamics of melanoma prevalence affected the population of all regions of Ukraine without exception.

According to the National Health Service of Ukraine, 3,139 cases of this disease were diagnosed in 2024 alone, compared to 2,403 cases in 2022 and 2,648 cases in 2023, indicating a clear upward trend in melanoma among the Ukrainian population.

A strategic assessment of available data revealed that during the initial months of the armed conflict in Ukraine, approximately 60–70 % of oncology care was disrupted. A single melanoma immunotherapy procedure costs around €4,000 and must be administered at intervals of 21 or 42 days. In response, the European Union in collaboration with Ukraine, launched the MedEvac program, aimed at the medical evacuation and treatment of Ukrainian oncology patients. An analysis of patient data from the Ukrainian Ministry of Health between April 2022 and April 2023 showed that the highest percentage of evacuated cancer patients were those diagnosed with melanoma (33.5 %, n=94) [15]. Evacuated Ukrainians in Italy faced many difficulties that were not accounted for in the medical evacuation agreement, including the lack of interpreters, accommodation during treatment, food provisions, transportation, and assistance during medical visits and therapies. However, numerous organizations in Italy, such as Caritas, Red Cross, Green Cross, and others, provided essential support to Ukrainian cancer patients, including those diagnosed with melanoma.

Based on a study of the increase in the incidence of common oncological diseases in Ukraine from 2003 to 2012, a forecast was made predicting an overall rise in cancer cases by 18 % from 2012 to 2022 [38].

At the same time, some scientific sources describe an analysis of melanoma incidence, mortality, and survival rates in Ukraine from 2002 to 2013. The study found that the incidence rate was higher among women (age-standardized rate – 5.3 per 100,000 population in 2013; average annual increase – 3.5 %) than among men (5.1 per 100,000; 4.1 %). In most cases (approximately 50 %), melanoma was diagnosed in individuals over 60 years old. Unfortunately, compared to European countries, survival rates in Ukraine were lower [20].

A comparative analysis of UV radiation levels in both countries, presented in Table 2, indicates a higher risk of melanoma development in Italy than in Ukraine.

Table 2

**Level of UV radiation in Ukraine and Italy**

| Indicators | Ukraine | Italy |
|---|---|---|
| Average UV index in summer | 5–7 | 8–11 |
| Number of sunny days per year | 170–220 | 230–300 |
| Risk of sunburn in summer | Moderate | High |
| Duration of high UV activity | 3–4 months | 6–8 months |

The higher the UV index, the more aggressive the sun exposure, and consequently, the higher the risk of skin and eye damage caused by ultraviolet radiation. In Ukraine, the average UV index is high, necessitating the use of all preventive measures, especially for individuals prone to sunburn and those belonging to high-risk groups for melanoma, despite the relatively short duration of high UV activity throughout the year. However, in Italy, the UV index is very high/extremely high and persists for more than six months of the year, which limits the possibility of outdoor activities, as exposure without proper preventive measures can lead to painful sunburns.

Given that skin melanoma among outdoor workers ranks among the leading occupational diseases, this issue requires attention and becomes a significant concern for public health organizations and occupational safety [16, 25].

The perception of UV radiation risks and attitudes toward sun protection measures among outdoor workers play a crucial role in shaping their behaviour regarding the prevention of sun exposure in the workplace. Despite the interest of many workers in improving their protective measures, the specific needs of this category of employees remain insufficiently addressed. Outdoor work is predominantly performed by men, who are likely to have limited awareness of skin melanoma, engage in riskier behaviors, and may exhibit lower levels of health literacy [41].

According to data from the CAREX (Carcinogen Exposure) database, ultraviolet radiation is classified as an occupational risk in Italy, as a significant proportion of workers carry out their activities in open spaces, being exposed to intense solar radiation for approximately 75 % of their working hours. On the other hand, current legislation on occupational risk prevention in Europe and Italy does not contain specific requirements for comprehensive exposure to UV radiation in the workplace [22, 28].

Studies conducted in five European countries using individual dosimeters have made it possible to assess the level of occupational UV radiation exposure among bricklayers working outdoors. It was found that the average daily radiation dose in Italy is the highest among the five studied regions, ranging between 342.4 and 640.8 J/m², significantly exceeding the permissible limit of the standard erythemal dose (SED) and amounting to 1–1.3 SED over an 8-hour working day (equivalent to 100 J/m²), which was established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [34, 39].

Similar measurements were conducted among Italian fishermen during the spring season, where recorded daily UV radiation exposure doses ranged from 65 to 542 J/m² [30]. The results confirm the significant level of occupational UV radiation exposure among outdoor occupational groups in Italy and indicate the need to strengthen protective measures for workers.

In Ukraine, ultraviolet radiation is widely used in medical practice, industry, water purification, and scientific research. However, unfortunately, scientific databases lack studies assessing the impact of UV radiation on workers in these sectors. This is particularly important given the classification of UV radiation as a carcinogenic factor in the processing industry. However, according to monitoring data, the UV index in the country did not exceed a value of 7 throughout 2019, indicating a relatively moderate level of solar radiation exposure compared to regions with higher insolation [2].

The health risks caused by occupational exposure to solar UV radiation remain largely overlooked. Future threats to workers are contrasted with the current state of affairs, particularly regarding the legal recognition of this risk, access to treatment for affected patients, and compensation provisions [16].

Despite the fact that millions of workers worldwide experience significant occupational exposure to carcinogenic solar UV radiation for the majority of their working hours, this occupational health risk still lacks proper official recognition in occupational safety regulations and directives in many countries [21].

Studies conducted in Italy to identify the most common occupational carcinogens have determined that the highest percentage is attributed to UV radiation [5].

An analysis of the scientific literature on hygienic approaches to preventing UV radiation exposure among the civilian and working populations in Italy has revealed significant gaps in compliance with sun protection measures.

According to a questionnaire survey conducted among students and workers in the construction and agricultural sectors in northern Italy, a low level of personal protective equipment usage against solar radiation was identified. A significant proportion of both students and workers do not use sunglasses, sunscreen, specialized clothing, or hats for UV radiation protection. In addition, the incidence of sunburns among students was twice as high as among the working population [29].

Similar results were obtained in a study that analyzed the behavioral characteristics of parents and elderly people who supervised children under 12 during a two-week summer period in France, Italy, Germany, Spain, and the United States. The study found that a significant portion of the adult population fails to follow key hygienic recommendations for UV radiation prevention. In particular, the older generations tend to take children outdoors during peak solar activity hours (11:00 AM–5:00 PM), which increases the risk of sunburn and photodamage [9].

These findings indicate the need to raise public awareness of preventive measures aimed at minimising exposure to ultraviolet radiation, especially among risk groups that regularly spend time outdoors.

Studies conducted in the Tuscany region (Italy) on the effectiveness of shading structures (such as tents, canopies, and umbrellas) as protective measures for beach infrastructure workers have demonstrated their high efficiency. The coverage transmittance coefficient was measured using broadband radiometers. It was found that the use of these structures reduces UV radiation exposure by 90 %, confirming their relevance as a preventive measure to prevent excessive solar exposure among workers performing professional activities in open spaces [14].

In Italy, a survey was conducted among skin carcinoma patients regarding their use of preventive measures while being exposed to the sun during work and/or recreational activities. The majority of respondents reported that they had never worn hats or used sunscreen and had a history of chronic sunburns [23].

Based on the analysis of the main indicators related to the organization and functioning of medical care for patients with skin cancer revealed several issues. These included low effectiveness in the early diagnosis of tumours, particularly during preventive medical examinations, and insufficient coverage of specialized treatment for skin cancer patients at stages I–II [17].

The impact of UV radiation is the most common and modifiable risk factor for melanoma development. Therefore, most prevention strategies worldwide focus on UV protection and can be categorized as physical (limiting exposure), local (sunscreens), and systemic [10, 28].

Prevention strategies aim to reduce exposure to environmental risk factors and identify individuals with phenotypic risk factors to enhance epidemiological surveillance [8]. The results of multicentre studies confirm the need to strengthen preventive measures, which include:

1. Primary prevention:

– Expanding public health education with a focus on the risks of excessive sun exposure and the necessity of proper preventive measures with the introduction of special programmes in educational institutions, social media, television, etc.

– Adhering to recommendations regarding the duration of sun exposure, avoiding direct sunlight during peak hours (11:00 AM to 5:00 PM).

– Implementing both public and individual protective measures: staying in shaded areas; wearing long-sleeved clothing, hats, and sunglasses; using specialized sunscreen products with SPF 30+ or SPF 50+ and reapplying them every two hours and after water exposure.

– Limiting exposure to artificial UV sources, including avoiding tanning beds.

2. Secondary prevention:

– Early diagnosis of skin changes through regular self-examinations and preventive screenings using dermatoscopy.

– Focusing on identifying high-risk groups, particularly individuals with fair skin and hair (Fitzpatrick skin types I and II), as well as those with a genetic predisposition to cancer.

3. Tertiary prevention:

– Government regulation to ensure compliance with hygiene standards and conduct specialized measurements of UV radiation levels in workplaces, especially for outdoor workers.

– Mandatory periodic preventive medical examinations to detect early stages of melanoma and other skin neoplasms [33, 34, 37].

The International Commission on Non-Ionising Radiation Protection (ICNIRP) also recommends installing sunscreen dispensers in workplaces.

The increasing prevalence of melanoma highlights the global demand for effective preventive measures around the world. To overcome current challenges in the field of preventive measures, it is necessary to use a wide range of available strategies. Achieving significant results in this area is only possible through a combination of collective and individual efforts, supported by policymakers, to facilitate long-term societal changes [41].

Due to lower use of sun protection measures and higher overall UV exposure compared to urban residents, rural populations may have an increased risk of developing melanoma. The obtained results indicate that rural residents experience more intense ultraviolet radiation than urban populations, highlighting the need to adapt preventive measures to account for these geographical differences [32].

Maintaining healthy skin, reducing post-inflammatory hyperpigmentation, and preventing photoaging and photocarcinogenesis depend on the use of photoprotection [13, 31].

Some findings confirm the urgent need to disseminate reliable information about the risks associated with the use of tanning beds. Targeted awareness campaigns should be conducted, addressing both the general public and policymakers, as indoor UV exposure is a modifiable risk factor. Particular attention should be given to young women, who are more susceptible to the tanning culture, increasing their likelihood of developing malignant neoplasms and consequently affecting their health throughout their lives [24].

Screening of the population based on risk factors can identify at-risk groups for further monitoring and direct prevention. Even filling out a questionnaire can help you to reflect and move on to the next steps [7].

Reducing the incidence of atypical moles and the potential prevention of malignant neoplasms can be a significant part of early intervention and education on sun safety [18].

## Conclusion

A comparative analysis of melanoma incidence in Ukraine and Italy has revealed a clear upward trend in the number of cases of this oncological disease in both countries. The increased level of insolation in Italy, particularly among workers in outdoor occupational groups, correlates with a higher risk of melanoma development in Italy compared to Ukraine.

Based on the results of the meta-analysis and multicenter studies, it can be concluded that comprehensive implementation of preventive measures and increasing public awareness are key tools for reducing melanoma incidence in both Ukraine and Italy. Education remains a crucial component of prevention and health improvement. Exposure to ultraviolet radiation and tanning typically begin at an early age, making it essential to protect children and young people from the sun. Special attention should be given to high-risk groups who are regularly exposed to UV radiation in their professional activities, as well as to children and young people, who are the most vulnerable populations.

The prospects for further research lie in the fact that the increasing melanoma incidence in both countries raises significant questions regarding its etiology and prevention, given that UV radiation exposure is the most common cause of melanoma.

The latest technologies for the use of artificial ultraviolet light are gaining a high demand in the 21st century. The use of UV radiation in the beauty industry is not subject to any control, either at the legislative or consumer level.

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