Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(5), 656-665 | ISSN:2251-6727

An Overview on Skin Cancer and Emerging Treatment Approaches

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(Received: 16 July 2025 Revised: 20 August 2025 Accepted: 02 September 2025)

KEYWORDS

Flavonoids, Polyphenols, Immunotherapy, Aartificial tools.

ABSTRACT:

In the next 20 years, skin cancer is predicted to rise significantly if it is not detected early. It is a worldwide threat to the healthcare system that is influenced by both genetic and environmental causes. The purpose of this manuscript is to examine current developments in skin cancer prevention and therapy, with an emphasis on the incorporation of plant-based medicines and developing technology. The greatest environmental risk factor for skin cancer is exposure to ultraviolet light which can cause melanoma as well as non-melanoma skin cancer (NMSC), which includes basal cell carcinoma (BCC) and squamous cell carcinoma (SCC). Plant-based chemicals are becoming more popular in the field of therapeutics because of their anti-cancer capabilities. Natural substances with UV-protective and anti-carcinogenic properties, such as flavonoids and polyphenols, show promise as supplements to conventional therapies. Additionally, novel approaches to treatment, like as immunotherapy and drug delivery systems based on artificial tools, are being investigated to maximise the effectiveness of conventional chemotherapies while reducing their adverse effects. The types, classifications, and advanced treatment methods for skin cancer are all thoroughly reviewed in this article. It also explores the promise of plant-based treatments and the growing significance of more recent therapeutic approaches in the treatment of skin cancer. The manuscript provides a forward-looking perspective on improving treatment outcomes and lowering the worldwide burden of skin cancer by analysing these innovative treatments. These revelations may open the door to the incorporation of cutting-edge treatments and technological advancements into clinical practice, enabling more efficient treatment of skin cancer.

1. INTRODUCTION

Skin cancer (SC) is the fifth most prevalent type of cancer and one of the most deadly diseases of the current decade. In the upcoming decades, it is also expected to overtake heart disease as the leading cause of death and the largest barrier to raising the average life span. [1]Cancer represents a heterogeneous group of diseases characterized by deregulated cellular proliferation, resistance to apoptosis, and the capacity to invade adjacent tissues and metastasize to distant sites. These malignant cells evade the body's intrinsic regulatory mechanisms, enabling unchecked growth and progression. Etiological factors contributing to carcinogenesis include genetic mutations, environmental exposures, lifestyle factors, ultraviolet (UV) radiation, and certain infections. Despite advances in oncology, cancer remains a leading cause of mortality globally. Early detection, effective treatment, and continuous research are pivotal in reducing the global cancer burden. Cancer can affect any part of the body and is caused by a combination of genetic, environmental, and lifestyle factors, including exposure to carcinogens, radiation, certain infections, and inherited genetic mutations. Early detection, effective treatment, and on-going research remain key components in reducing cancer-related mortality worldwide.[2]

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2. CLASSIFICATION OF CANCER

2.1 Carcinoma

Carcinomas are the most prevalent form of cancer and arise from epithelial cells lining the skin, glands, and internal organs. These tumors frequently form solid masses and include subtypes such as breast, lung, colorectal, and prostate carcinomas. Due to their potential for lymphatic and hematogenous spread, early diagnosis is essential for improving outcomes.[3]

2.2. Sarcoma

Sarcomas originate from mesenchymal tissues including bone, muscle, fat, and cartilage. Though relatively rare, these tumors are typically aggressive and capable of rapid local invasion and distant metastasis. Treatment often involves surgical resection complemented by chemotherapy or radiotherapy [4]

2.3. Leukemia

Leukemia is a hematological malignancy arising from bone marrow precursors, leading to the overproduction of dysfunctional white blood cells. It impairs normal haematopoiesis and compromises immune function. Leukemias are classified into acute and chronic forms, with treatment regimens tailored accordingly. [5]

2.4 Lymphoma

Lymphomas affect the lymphatic system and are divided into Hodgkin and non-Hodgkin subtypes. These malignancies commonly manifest with lymphadenopathy, systemic symptoms, and immune dysfunction. Multimodal treatment includes chemotherapy, radiation therapy, and immunotherapy. [6]

2.5 Myeloma

Multiple myeloma is a neoplasm of plasma cells within the bone marrow, leading to abnormal immunoglobulin production, skeletal lesions, anaemia, and renal dysfunction. Standard care includes chemotherapeutic agents, immunomodulators and autologous stem cell transplantation. [7]

2.6 Central Nervous System Cancers

CNS tumors affect the brain and spinal cord, with gliomas, meningiomas, and medulloblastomas being the most common. These neoplasms can cause profound neurological symptoms like neuropathy pain, convulsions, temperament alteration depending on their location and size. Management is complex, often involving surgery, radiotherapy, and chemotherapy. [8]

3. SKIN CANCER

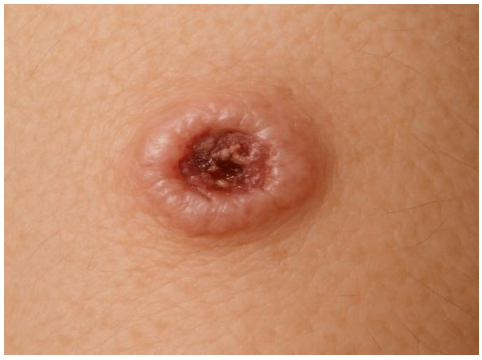
Skin cancer is the most common form of cancer globally and arises from the uncontrolled growth of abnormal skin cells. Possible UV radiation can cause skin cancer in some parts of the body that are often exposed to the sun, such as the face, neck, and arms. There are three main kinds of skin cancer: basal cell carcinoma, squamous cell carcinoma, and malignant melanoma. Possible - Skin cancers that are not melanoma are more frequent and easier to cure. - Melanoma is a skin cancer that is harder to treat and can be deadly if not found early.[9]

4. TYPES OF SKIN CANCER

Skin cancer is the most frequently diagnosed malignancy worldwide, primarily driven by UV radiation exposure. Skin cancers are categorized into melanoma and non-melanoma types (including basal cell carcinoma and squamous cell carcinoma). While non-melanoma skin cancers (NMSCs) are more prevalent and usually treatable, melanoma poses a significant mortality risk if not detected early.

4.1 Basal Cell Carcinoma (BCC)

BCC accounts for approximately 80% of skin cancers and originates from the basal cells in the epidermis. Though it rarely metastasizes, it can cause significant local tissue destruction as shown in figure 01.Chronic sun exposure and mutations in the Hedgehog signaling pathway are primary risk factors. Treatment includes surgical excision, cryotherapy, and topical agents. [10]



.Figure 01: Basal carcinoma affected skin

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JCHR (2025) 15(5), 656-665 | ISSN:2251-6727

4.2 Squamous Cell Carcinoma (SCC)

SCC arises from keratinocytes in the upper epidermis and is the second most common form of skin cancer. Clinically, it presents as scaly, crusted lesions on sun-exposed areas as depicted in figure 02.Risk factors include chronic UV exposure, chronic inflammation, and immunosuppression. SCC carries a higher risk of metastasis than BCC and is typically managed with surgery or radiation. [11]

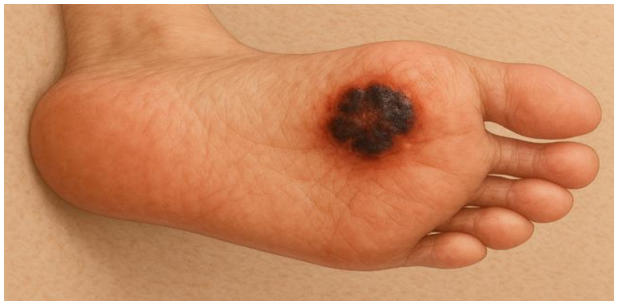

Figure 02: Squamous carcinoma affected nail

4.3 Malignant Melanoma

Melanoma originates from melanocytes and, despite accounting for fewer cases, is responsible for the majority of skin cancer-related deaths (figure 03). Risk factors include intermittent intense UV exposure, genetic predisposition, and the presence of atypical nevi. Early identification using the ABCDE (Asymmetry, Border, Colour, Diameter and Evolution) criteria is crucial. Treatment options include wide local excision, immunotherapy, targeted therapy, and chemotherapy. [12]

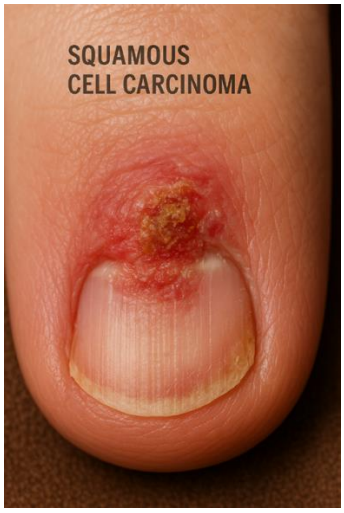

Figure 03: Malignant carcinoma in foot sole

4.4 Merkel Cell Carcinoma (MCC)

MCC is a rare but aggressive neuroendocrine carcinoma of the skin, commonly affecting older individuals or immune compromised patients. It often presents as a firm, painless nodule and has a high propensity for recurrence and metastasis as shown in figure 04. Merkel cell polyomavirus and UV radiation are associated etiologies. Treatment includes surgical excision, radiotherapy, and immune checkpoint inhibitors. [13]

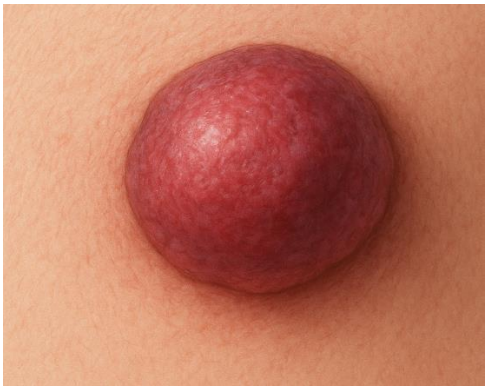

Figure 04: Markel carcinoma affected skin

4.5 Sebaceous Carcinoma

This uncommon malignancy arises from sebaceous glands and is most frequently located near the eyes as shown in figure 05. Clinically, it may resemble benign lesions, causing diagnostic delays. Risk factors include prior radiation therapy and Muir- Torre syndrome. It has the potential for both regional and distant organ spread. Surgical excision is the primary treatment, sometimes accompanied by lymph node dissection. [14 & 15]

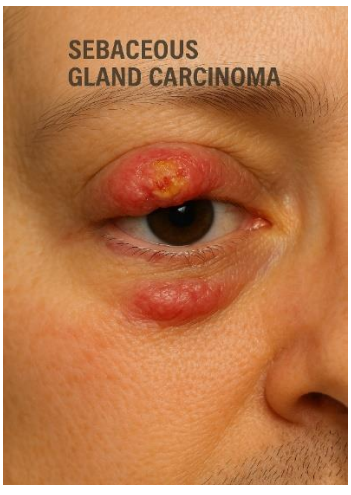

Figure 05: Sebaceous carcinoma of eye

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5. WORLD-WIDE PREVALENCE

According to GLOBOCAN 2022 data, melanoma ranks as the 17th most diagnosed cancer globally, with an estimated 331,722 new cases and 58,667 deaths annually as shown in figure 06. In contrast, non-melanoma skin cancers rank 5th in incidence, with approximately 1.23 million new cases and 69,416 deaths each year. The highest incidence rates are reported in regions such as Oceania, North America, and Europe, particularly in countries like Australia. A notable correlation exists between higher Human Development Index (HDI) scores and melanoma incidence, while an inverse correlation is observed for non-melanoma mortality.

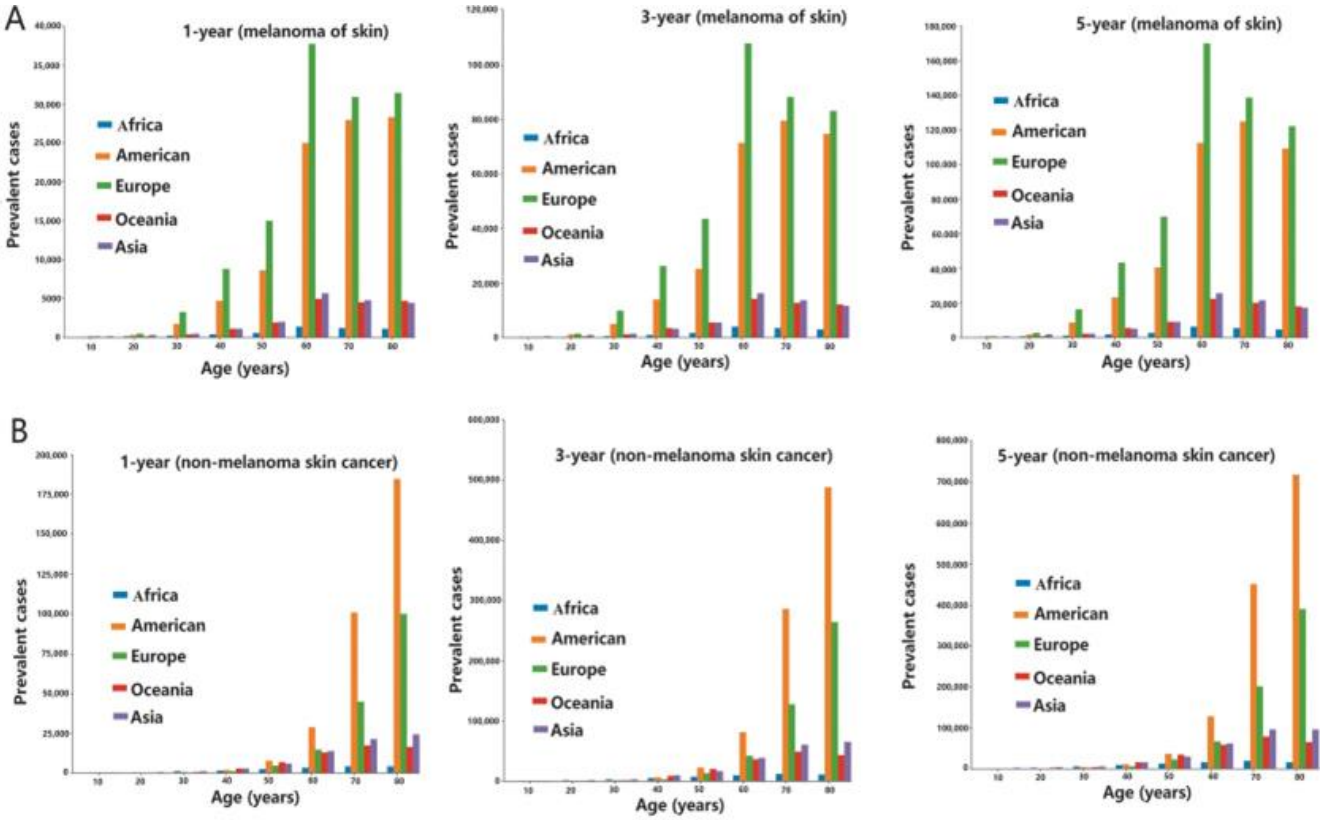

Figure 06: Chronological case study; A section for melanoma skin cancer and B section for non-melanoma skin cancer survey [16]

We analysed melanoma and non-melanoma cancers based on the most recent upgrade of the GLOBOCAN 2022. Skin cancers, particularly non-melanoma skin cancers, account for a huge extent of cancers globally. [16]

If 2022 statistics remain stable, the global burden from melanoma is estimated to increase to 510000 new cases and 96000 deaths by 2040.[17]

6. TREATMENT OF SKIN CANCER

6.1 Conventional Treatment Strategies

I. Surgical Excision

Surgical removal remains the gold standard for skin cancer, especially for BCC and SCC. Mohs micrographic surgery is preferred for facial or high-risk tumors, allowing real-time histological assessment and maximal tissue conservation.[18]

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II. Cryotherapy

Cryosurgery involves the application of liquid nitrogen to destroy superficial cancer cells. It is commonly used for actinic keratosis and superficial BCCs. While cost-effective and minimally invasive, it is less effective for deeper tumors. [19]

III. Radiation Therapy

Radiation is indicated for patients who are poor surgical candidates or for tumors located in anatomically complex regions. It is effective for elderly patients or those with comorbidities. It is also used as an adjunct for recurrent lesions. Potential side effects include dermatitis, fibrosis, and secondary malignancies. [20]

IV. Curettage and Electrodessication

This technique combines mechanical tumour removal with electrical cauterization. It is commonly used in outpatient dermatology clinics. It is suitable for small, superficial lesions but has a relatively higher recurrence rate compared to excision. [21]

V. Topical Chemotherapy

Topical agents like 5-fluorouracil and imiquimod are used for superficial BCCs and SCC in situ. These treatments allow localized targeting of neoplastic cells with minimal systemic toxicity. Treatment spans several weeks and can cause inflammation, redness, and crusting. It serves as a successful non-invasive option for individuals looking to evade surgery, especially for growths on the face or scalp. [22]

6.2 Emerging and Targeted Therapy

New therapies for skin cancer have progressed quickly, emphasizing targeted therapy, immunotherapy, and photodynamic therapy (PDT). [23]

I. Immunotherapy

Immunotherapy has significantly advanced the management of advanced melanoma. Checkpoint inhibitors such as pembrolizumab and nivolumab enhance immune-mediated tumour recognition by blocking PD-1/PD-L1 and CTLA-4 pathways. This approach has significantly improved survival in metastatic melanoma. However, immune-related adverse effects such as colitis or dermatitis may occur. Their use is expanding into non-melanoma skin cancers like MCC. It represents a shift toward durable, long-term cancer control compared to traditional therapies. [24]

II. Targeted Therapy

Targeted agents inhibit oncogenic mutations driving tumour growth. In melanoma, BRAF mutations are frequently targeted with agents like vemurafenib or dabrafenib, often combined with MEK inhibitors. While effective, resistance may develop, necessitating combination regimens. Combining targeted agents has shown improved outcomes compared to monotherapy. These treatments are most effective when tumors are genetically profiled beforehand.[25]

III. Photodynamic Therapy

PDT utilizes photosensitizing agents activated by light to generate cytotoxic oxygen species. It is mainly employed for precancerous lesions and superficial skin cancers and is valued for its cosmetic outcomes and minimal invasiveness. However, it may cause temporary redness, swelling, and photosensitivity. It's less effective for deep or nodular tumors and is currently under evaluation for combination with immunotherapy.[26]

6.3 Pharmacological Approaches

I. Synthetic Drugs

There are many marketed drugs are available to treat various types of skin cancer. A list of chemotherapeutic agents is given in table 01, which is based on their mechanism of action.

Table 01: List of synthetic anti-skin cancer drugs [27-37]

S. No.	Name of Drug	Mechanism of Action
1	Dabrafenib, Vemurafenib, Encorafenib	BRAF enzyme inhibitor
2	Trametinib, Selumetinib, Cobimetinib, Binimetinib	MEK1/2 inhibitor
3	Idelalisib, Copanlisib, Duvelisib, Alpelisib, Umbralisib	PI3K inhibitor
4	Capivasertib	Akt inhibitor

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5	Rapamycin, Everolimus, Temsirolimus	mTOR inhibitor
6	Vismodegib, Sonidegib	Hedgehog pathway inhibitor
7	Itraconazole	PI3K/mTOR, and Hedgehog/Wnt pathways inhibitor
8	Cemiplimab mono clonal antibody	T-cell inactivation blocker
9	Imiquimod cream	Toll-like receptor (TLR7) activator
10	Tazarotene cream	Retinoic acid receptors activator
11	5-fluorouracil cream	DNA synthesis disruption

II. Herbal and Plant-Derived Agents

Several photochemical demonstrate anticancer potential as show in table 02. These agents are being investigated for their role in chemoprevention and as adjuncts to conventional therapy.

Table 02: List of herbals with their anti-skin cancer constituents [38-46]

S. No.	Plant	Parts	Chemical constituent
1.	Grapes Family: Vitaceae Biological Name:*Vitis vinifera L.*	Seeds	Proanthocyanidins
2.	Aloe Vera Family: Asphodelaceae Biological Name: *Aloe Vera(L.) Burm.f.*	Leaves	Aloin, Aloi-emodin
3.	Turmeric Root Family: Zingiberaceae Biological Name: *Curcuma longa*	Rhizome	Curcumin
4.	Ginger Root Family: Zingiberaceae Biological Name: *Zingiber officinale*	Rhizome	6-gingerol, 6-paradol, zingerone
5.	Clove Family: Myrtaceae Biological Name: *Eugenia aromaticum*	Flower Buds	Eugenol, caryophyllene
6.	Green Tea Family: Theaceae Biological Name: *Camellia sinensis (L.) O. Kuntze*	Leaves	Catechins, (-) epigallocatechin-3-gallate
7	Onions Family: Amaryllidaceae Biological Name: *Allium cepa*	bulb	Diallyl trisulfide, S-allyl cysteine, quercetin
8	Sadabahar Family: Apocynacea Biological name: *Catharanthus roseus*	Leaves and roots	Vinblastine, vincristine
9	Dried- Saffron Family: Iridaceae Biological Name: *saffron crocus*	Stigma	Crocin, crocetin

7. FUTURE PROSPECT

Over the past decade, the therapeutic landscape for skin cancer has evolved significantly, transitioning from traditional modalities such as surgery, radiotherapy, and chemotherapy to more sophisticated molecularly targeted treatments and immunotherapeutic approaches. These advancements mark a paradigm shift in the

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management of advanced and metastatic skin cancers, particularly melanoma.[47]

7.1 Advancements in Targeted Therapies

The identification of BRAF mutations in melanoma between 2011 and 2012 catalysed the development of BRAF inhibitors (e.g., vemurafenib, dabrafenib) and MEK inhibitors (e.g., trametinib). These agents demonstrated substantial survival benefits in patients harboring the BRAF V600E mutation. [48]As of 2025, the combination therapy of BRAF and MEK inhibitors has become the standard of care, effectively delaying resistance mechanisms and enhancing long-term outcomes. [49]

7.2 Breakthrough in Immunotherapy

The introduction of immune checkpoint inhibitors—including anti-CTLA-4 (ipilimumab) and anti-PD-1 agents (nivolumab, pembrolizumab)—between 2014 and 2016 revolutionized the treatment of metastatic melanoma. By 2025, these agents are being employed not only for advanced disease but also in earlier stages and in combination regimens, offering durable responses even in aggressive tumour phenotypes. [50]

7.3 Artificial Intelligence in Early Detection

Since 2017, artificial intelligence (AI) and deep learning algorithms have been increasingly integrated into dermatological diagnostics. By 2025, AI-driven dermato-scopic systems have surpassed average clinician accuracy in identifying malignant lesions, facilitating earlier diagnosis and timely intervention, thereby improving curative potential. [51]

7.4Emergence of Plant-Based and Natural Therapies

There has been growing interest in phytochemicals such as curcumin, resveratrol, and epigallocatechin gallate (EGCG) from green tea due to their anti-skin cancer activity. While not yet incorporated into standard protocols, these agents are under investigation as adjuncts to conventional therapies, with potential roles in chemoprevention and supportive care. [52]

7.5 Personalized & Precision Oncology

Since 2015, the implementation of genomic profiling has enabled tailored therapeutic strategies based on the unique molecular characteristics of individual tumors. [53] As of 2025, emerging technologies—including liquid biopsies, next-generation sequencing, and CRISPR-based gene editing—are under clinical evaluation, positioning precision oncology as an integral component of future skin cancer management. [54]

7.6On-going Challenges & Outlook

Despite these innovations, several challenges persist, including therapeutic resistance, treatment-related costs, and disparities in early diagnosis. Future directions involve the integration of AI, nano-medicine, and gene therapy into current treatment frameworks. Emphasis on low-toxicity, highly targeted, and patient-specific therapies is anticipated to define the next generation of skin cancer therapeutics.

8. CONCLUSION

Skin cancer, particularly malignant melanoma, continues to pose a substantial public health challenge worldwide. Advances in the understanding of the molecular underpinnings of skin carcinogenesis have catalyzed the development of novel diagnostic tools and therapeutic strategies. While conventional interventions such as surgery, radiotherapy, and chemotherapy remain essential—especially for early-stage cancers—innovative treatments including targeted therapies, immunomodulatory agents, and precision medicine have significantly improved outcomes in advanced cases.

The incidence and clinical behavior of skin cancers are influenced by geographical, ethnic, and demographic factors. A disproportionately higher burden is observed in older individuals, males, and fair-skinned populations with prolonged ultraviolet (UV) exposure. Early intervention and timely treatment are critical for favourable prognosis. Public health initiatives focusing on sun protection, early detection, and targeted screening of high-risk groups are crucial in reducing morbidity and mortality.

Future research should prioritize elucidating the complex etiopathogenesis of skin cancers to facilitate the development of more effective preventive and therapeutic strategies. The future of skin cancer management lies in multi-modal, personalized, and minimally invasive approaches empowered by advancements in genomics, nanotechnology, and artificial intelligence. Enhancing public awareness,

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promoting early detection, and ensuring equitable access to care will be fundamental in mitigating the global burden of skin cancer.

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