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ORIGINAL RESEARCH

Epidemiological and Pathological Trends in Skin Cancer: A Hands-On Analysis of 10 Years of Data from the Saudi Cancer Registry

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Background: Skin cancer is a major global health issue. Current literature focuses on Western countries whose characteristics of skin tone and cultures differ vastly from Saudi Arabia.

Objective: To analyze skin cancer patterns in Saudi Arabia, focusing on regional differences and cancer types in a country with high sun exposure.

Design: Retrospective cohort study utilizing the Saudi Health Council's Cancer Registry for the requisite data for this study.

Data Source: Ethical approval (637/2024) was prior to the beginning of this study. The Saudi Health Council's Cancer Registry supplied the requisite data for this study.

Subjects and Methods: We reviewed 6381 cases of skin cancer diagnosed in Saudi Arabia from 2010 to 2021. Inclusion Criteria was all histologically confirmed cases of primary skin cancer; exclusion criteria included tumors of secondary origin or cases with incomplete diagnostic data. Data on demographics, tumor types and regional trends were analyzed using IBM SPSS 27.0.1.

Main Outcome Measures: Tumor factors were collected along with demographic variables.

Results: A total of 6381 skin cancer cases were recorded. Skin cancer was more common in older men, who made up 62.7% of cases, with an average age of 62.5 years. Basal Cell Carcinoma was the most common type (49.5%), followed by Squamous Cell Carcinoma (25.6%). Most cases (76.6%) were caught early, with the Central region reporting the highest number of cases (31.8%), followed by the Western (26.3%) and Eastern (20.1%) regions.

Conclusion: This study reveals significant differences in skin cancer rates across Saudi Arabia, particularly among older men and in specific regions. The results can help establish awareness programs targeting vulnerable populations and focusing on early detection and intervention, such as initiating targeted skin cancer screening or sun-protection campaigns in high-burden regions. They emphasise the need for the allocation of resources in the Central and Western regions.

Limitations: The retrospective nature of the study does not allow for the full scope of patient behaviour or risk factors; there were also gaps in the data.

Keywords: skin cancer, basal cell carcinoma, squamous cell carcinoma, Saudi Arabia

Introduction

Skin cancer is a significant global health concern, with its prevalence increasing steadily over the years. It is most common in regions with high sun exposure, specifically in areas with a predominance of fair-skinned populations and intense ultraviolet radiation.[1,2] In 2020, there were over 150,000 new cases of melanoma, making it the 17th most common cancer globally, and non-melanoma skin cancer (NMSC), including Basal Cell Carcinoma (BCC) and Squamous Cell Carcinoma (SCC), was far more common but often underreported due to its relatively lower mortality

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rate.[3] NMSC contributed significantly to the 135,860 global skin cancer deaths recorded in 2020.[3] Melanoma alone is projected to rise by 7.3% in new cases and 3.8% in deaths by 2024, reflecting its growing impact on global health.[4]

Despite its widespread occurrence, research into skin cancer has disproportionately focused on fair-skinned populations, leaving darker-skinned populations underrepresented. Studies show that while melanin offers some natural protection against UV-induced damage, individuals with darker skin are still at risk, particularly for advanced and aggressive forms of skin cancer that are often detected late due to diagnostic challenges and limited awareness.[5,6] Addressing this gap is critical, as underrepresentation has contributed to poorer outcomes for darker-skinned individuals, including delays in diagnosis and limited access to tailored treatments.[5]

In Saudi Arabia, the combination of high UV exposure, limited sunscreen use, and occupational hazards faced by outdoor workers may contribute to increased risk, despite cultural practices such as wearing traditional clothing, which may provide partial protection.[7,8] Furthermore, genetic predispositions and environmental factors unique to the region likely play a role in the observed trends. Existing studies in Saudi Arabia have shown that BCC and SCC are the most prevalent forms of skin cancer, with notable regional variations in incidence rates and demographic patterns.[7,9]

Cultural and environmental factors may also influence skin cancer prevalence and prevention in Saudi Arabia. For instance, traditional clothing, while reducing sun exposure, may limit early detection of skin abnormalities. Limited public awareness campaigns about the risks of UV radiation and misconceptions among darker-skinned populations may further compound these risks. Occupational UV exposure among outdoor workers and the lack of routine sunscreen use are additional contributing factors.[7,8]

Globally, skin cancer prevention and management guidelines are largely based on studies conducted in Western populations. However, applying these guidelines to populations in Saudi Arabia poses challenges due to differences in skin pigmentation, cultural practices, and healthcare access. For example, while Western guidelines emphasize sun protection for fair-skinned individuals, they often overlook the risks to individuals with darker skin, who may not perceive themselves to be at significant risk.[6,10,11] This highlights the need for region-specific studies to tailor strategies for prevention, diagnosis, and treatment.

This study aims to address the existing literature gap by analysing data from 6381 cancer cases diagnosed in Saudi Arabia between 2010 and 2021. By analyzing this data, regional differences in diagnosis and outcomes, and demographic trends will be studied. Furthermore, it aims to address these trends across the histopathological features of skin cancer as well as the temporal trends across 10 years. The findings will help identify gaps in public health and plan appropriate interventions.

Patients and Methods

This retrospective study involved all patients diagnosed with primary skin cancer, from 1 January 2010 to 31 December 2021. The exclusion criteria skin cancer of a secondary origin. Ethical approval (637/2024) was obtained prior to the beginning of this study from Imam Mohammed Ibn Saud Islamic University, Riyadh, Saudi Arabia. Due to the retrospective nature of the study, and the use of anonymized patients' data, an informed consent was waived by the institutional review board. All data were handled in accordance with institutional policies on patient confidentiality, and the study was conducted in compliance with the principles of the Declaration of Helsinki. The Saudi Health Council's Cancer Registry supplied the requisite data for this study.

Data Collection

The Saudi Cancer Registry under the Saudi Health Council (SHC) provided the required data for this study, which included tumor data from hospitals across the Kingdom of Saudi Arabia, including hospitals from the private sector, Ministry of Health, and military hospitals. The data from the five regional offices of the SHC are sent to the main office in Riyadh, which is responsible for data analysis and periodic reports. All the eligible patients were included. Tumor factors were collected, including the basis of diagnosis, the origin of the tumor, histopathological group, histopathological subtype, tumor behavior, stage of the tumour, and laterality. In addition, demographic variables such as age, region of residency, and year of diagnosis were collected. The registrars trained by the Saudi Cancer Registry (SCR) extracted data from patient medical records using clinical and/or histological diagnosis. The gathered data includes personal identifiers (ID number, gender, and age), demographic information (such as City, and nationality), and specific tumor characteristics (such as date of diagnosis, primary site, histology, behavior, grade, stage). The primary site and histology of the tumors were classified and coded using the International Classification of Diseases for Oncology, 3rd Edition (ICD-O-3), as published by the World Health Organization in 2000. Starting in 2001, the registry made modifications to the coding of cancer kinds, behaviours, and staging using the SEER Summary Stage 2000.

Data on place of residence at the time of diagnosis were used for regional classification; however, no information was available regarding long-term residential history or patient migration across regions, which could influence regional incidence trends. Additionally, the registry did not collect data on regional ultraviolet (UV) exposure levels, which limits the ability to correlate skin cancer distribution with environmental UV radiation exposure.

These changes were adopted to improve the precision and uniformity of stage coding. Every piece of information, such as age, marital status, region of residence, year of diagnosis, and survival status over a span of 10 years, was painstakingly documented. The SCR guarantees precise coding and consolidation of each malignancy for statistical analysis utilizing the CanReg software created by the International Agency for Research on Cancer (IARC). This software was used for data entry and the creation of incidence tables, guaranteeing that each malignancy is only counted once to ensure analytical precision.

Handling of Missing Data

Variables with missing values, particularly tumour grade and extent of disease, were retained in the dataset, and analyses were conducted using available-case methods (ie, only complete data were analysed for each variable). The proportion of missing data was acknowledged, but no imputation or statistical correction was applied.

Statistical Analysis

Descriptive Statistics

Descriptive statistics were employed to summarize the demographic and clinical characteristics of the study population. Frequencies and percentages were calculated for categorical variables such as gender, nationality, region, topography, histopathological grouping, behavior, grade, extent, and laterality. Continuous variables, including age, were reported as means with standard deviations (SD) or medians with interquartile ranges (IQR), depending on the distribution of the data.

Inferential Statistics

Inferential statistical analyses were conducted to examine associations between various demographic factors and clinical outcomes. For categorical variables, Chi-square, Fisher's Exact, and Fisher-Freeman-Halton Exact tests were used to assess differences in proportions across groups. The Kruskal–Wallis test was applied for continuous variables to compare medians between categories. In addition, binary logistic regression analyses were performed to identify independent predictors of specific clinical outcomes, such as the year of diagnosis and extent of disease (localized vs regional/metastatic). Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were reported to quantify the strength and direction of associations while controlling for potential confounders.

For binary logistic regression, the extent of skin cancer was recoded into two categories: Localized (including In situ and Localized) representing early-stage disease, and Regional/Distant Metastatic (including Regional and Distant Metastasis) representing advanced-stage disease, enabling comparison between limited and widespread involvement.

Significance Level

A significance level of P <0.05 was established for all statistical tests. Results with P values <0.05 were considered statistically significant, indicating that the observed differences were unlikely to have occurred by chance.

Software

All statistical analyses were conducted using IBM SPSS Statistics, version 27.0.1. This software facilitated the execution of descriptive and inferential statistical methods, providing reliable results for the study's analyses.

Results

Demographic and Regional Distribution of Skin Cancer Incidence (2010-2021)

Table 1 provides an overview of skin cancer incidence in Saudi Arabia across various demographic and regional categories from 2010 to 2021. Among the cases, males accounted for the majority, with N = 4004 (62.7%), while females comprised N = 2377

Table 1 Demographic and Regional Distribution of Skin Cancer Incidence (2010–2021)

		N/ Mean	%/SD
Gender	Female	2377	37.3%
	Male	4004	62.7%
Age		62.47	47.41
Age Groups (yr)	0-19	49	0.8%
	20-39	824	12.9%
	40-59	2178	34.1%
	60-79	2348	36.8%
	80+	982	15.4%
Nationality	Non-Saudi	2152	33.7%
	Saudi Arabia	4229	66.3%
Regions Combined	Central	2027	31.8%
	Eastern	1282	20.1%
	Southern	1093	17.1%
	Northern	303	4.7%
	Western	1676	26.3%
Diagnosis Year	2010	601	9.4%
	2011	570	8.9%
	2012	510	8.0%
	2013	552	8.7%
	2014	523	8.2%
	2015	583	9.1%
	2016	588	9.2%
	2017	589	9.2%
	2018	585	9.2%
	2019	496	7.8%
	2020	329	5.2%
	2021	455	7.1%
Diagnosis Year (Grouped)	2010-2015	3339	52.3%
	2016-2021	3042	47.7%

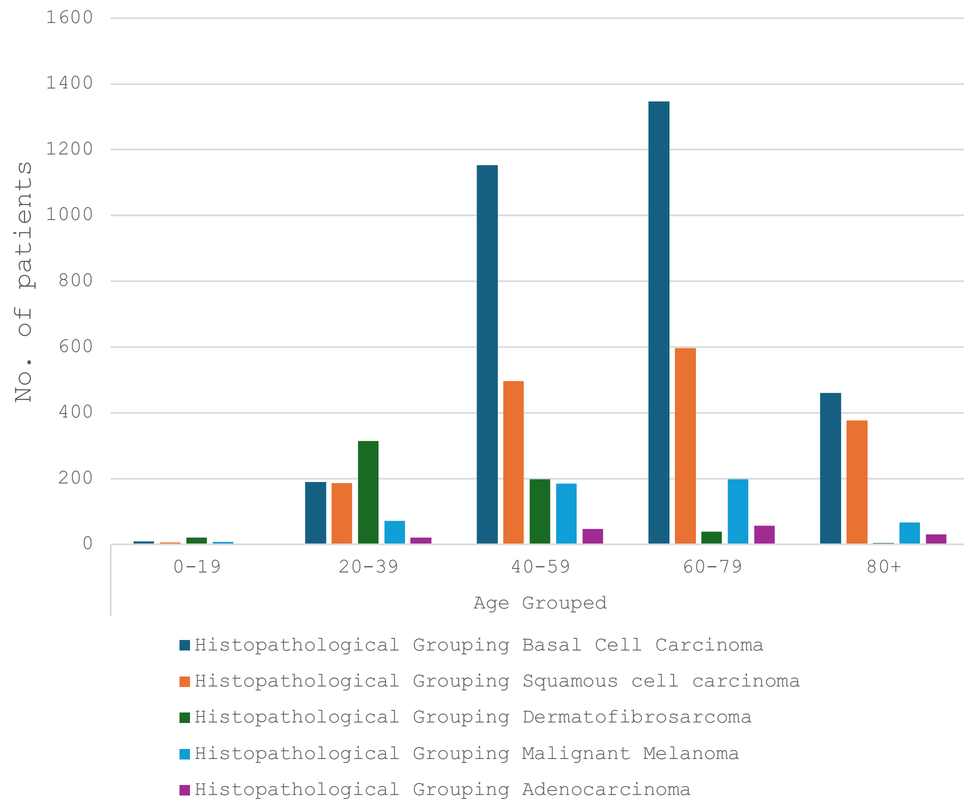

Figure 1 Distribution of histological diagnoses by age. Overall, patients aged 60–79 years constitute the majority of the sample. Basal cell carcinoma is the most common type of skin cancer among all age groups, except for those below 40 years of age, where dermatofibrosarcoma is more common than basal cell carcinoma.

(37.3%). The mean age was 62.47 years (SD = 47.41), with the largest age groups being 60–79 years at N = 2348 (36.8%) and 40–59 years at N = 2178 (34.1%). Younger age groups, including those aged 0–19 years, represented a smaller portion of cases, with N = 49 (0.8%) (Figure 1). The majority of patients were Saudi nationals, N = 4229 (66.3%), compared to non-Saudis at N = 2152 (33.7%). Regional distribution indicated that most cases were concentrated in the Central region, N = 2027 (31.8%), followed by the Western region with N = 1676 (26.3%), and the Eastern region with N = 1282 (20.1%). Cases were evenly distributed across the years, with diagnosis peaks in 2010, N = 601 (9.4%), and relatively fewer cases in 2020, N = 329 (5.2%). When binned by diagnosis period, 52.3% of cases (N = 3339) were reported between 2010 and 2015, while 47.7% (N = 3042) were diagnosed between 2016 and 2021. This distribution reflects trends in demographic and regional incidence over time (Table 1).

Distribution of Skin Cancer Topography and Histopathological Types

Table 2 outlines the distribution of skin cancer cases in Saudi Arabia by anatomical location and histopathological type. The most commonly affected site was the skin on other and unspecified parts of the face, accounting for N = 2117 (33.2%) of cases, followed by the head and neck region with N = 1546 (24.2%). Other sites included the trunk, N = 892 (14.0%); lower limbs and hips, N = 750 (11.8%); and upper limbs and shoulders, N = 438 (6.9%), with a smaller number of cases categorized as overall lesion/unknown sites, N = 638 (10.0%). In terms of histopathology, Basal Cell Carcinoma was the most prevalent, comprising nearly half of the cases, N = 3160 (49.5%), followed by Squamous Cell Carcinoma at N = 1634 (25.6%) and Dermatofibrosarcoma at N = 576 (9.0%). Other types included Malignant Melanoma, N = 527 (8.3%); Adenocarcinoma, N = 155 (2.4%); Basosquamous Carcinoma, N = 110 (1.7%); and several rare forms, such as Merkel Cell Carcinoma, N = 17 (0.3%), and Adenoid Cystic Carcinoma, N = 22 (0.3%). This data provides insight into the distribution of skin cancer types and affected anatomical regions in the studied population (Table 2).

Table 2 Distribution of Skin Cancer Topography and Histopathological Types

		N	%
Topography	Skin, other & unspecified parts of face	2117	33.2%
	Head and Neck	1546	24.2%
	Lower limb and Hip	750	11.8%
	Trunk	892	14.0%
	Upper limb and Shoulder	438	6.9%
	Other (Overall lesion/Unknown)	638	10.0%
Histopathological Grouping	Basal Cell Carcinoma	3160	49.5%
	Squamous cell carcinoma	1634	25.6%
	Dermatofibrosarcoma	576	9.0%
	Malignant Melanoma	527	8.3%
	Adenocarcinoma	155	2.4%
	Basosquamous carcinoma	110	1.7%
	Verrucous carcinoma	48	0.8%
	Squamous cell carcinoma	27	0.4%
	Adenoid cystic carcinoma	22	0.3%
	Skin appendage carcinoma	19	0.3%
	Merkel cell carcinoma	17	0.3%
	Extramammary Paget disease	17	0.3%
	Sclerosing sweat duct carcinoma	10	0.2%
	Pilomatrix carcinoma	9	0.1%
	Eccrine poroma	9	0.1%
	Spindle cell carcinoma	8	0.1%
	Mucoepidermoid carcinoma	8	0.1%
	Nodular hidradenoma, malignant	7	0.1%
	Basosquamous carcinoma	7	0.1%
	Trichilemmocarcinoma	5	0.1%
	Adenosquamous carcinoma	3	0.0%
	Malignant eccrine spiradenoma	2	0.0%
	Epithelial-myoepithelial carcinoma	1	0.0%

Distribution of Skin Cancer Behavior, Grade, Extent, and Laterality

Table 3 presents a comprehensive overview of the behavior, grade, extent, and laterality of malignant skin cancer cases in Saudi Arabia. All reported cases were classified as malignant, totaling N = 6381 (100.0%). In terms of histological grading, Grade I (well differentiated) was observed in N = 742 (11.6%) of cases, while Grade II (moderately differentiated) accounted for N = 683 (10.7%). Cases classified as Grade III (poorly differentiated) comprised N =

Table 3 Distribution of Skin Cancer Behavior, Grade, Extent, and Laterality

		N	%
Behavior	Malignant	6381	100.0%
Grade	Grade I (Well diff)	742	11.6%
	Grade II (Mod diff)	683	10.7%
	Grade III (Poor diff)	222	3.5%
	Grade IV (Undiff Anaplastic)	34	0.5%
	Missing values	4700	73.7%
Extent	In situ	41	0.6%
	Localized	4888	76.6%
	Regional: with or without lymph nodal involvement	450	7.1%
	Distant Metastasis	282	4.4%
	Missing values	720	11.3%
Laterality	Not paired (Unknown, ill defined)	1664	26.1%
	Right	1812	28.4%
	Left	1785	28.0%
	Bilateral Involvement	59	0.9%
	Paired site, laterality not stated	1061	16.6%

222 (3.5%), and Grade IV (undifferentiated anaplastic) represented N = 34 (0.5%). A significant portion of cases had missing grade information, totaling N = 4700 (73.7%). Regarding the extent of the disease, localized cases were the most prevalent, with N = 4888 (76.6%), followed by regional cases with or without lymph nodal involvement at N = 450 (7.1%), and distant metastasis at N = 282 (4.4%). In situ cases were notably low, at N = 41 (0.6%), with a small number of cases also reporting missing extent data (N = 720; 11.3%). As for laterality, a considerable number of cases had unknown or ill-defined laterality, N = 1664 (26.1%), while right-sided involvement was noted in N = 1812 (28.4%) and left-sided involvement in N = 1785 (28.0%). Bilateral involvement was rare, with N = 59 (0.9%), and N = 1061 (16.6%) cases had paired sites with unspecified laterality. This analysis highlights the significant proportion of localized cases and the prevalence of missing data in grading and extent assessments (Table 3).

Comparison of Demographic and Clinical Characteristics of Skin Cancer Patients Diagnosed Between 2010-2015 and 2016-2021 (Figure 2)

The analysis of skin cancer diagnosis from 2010 to 2021 reveals notable differences in demographics and clinical characteristics. Among the cases, N = 3339 (52.3%) were diagnosed between 2010 and 2015, while N = 3042 (47.7%) were recorded from 2016 to 2021. Gender distribution showed that females constituted N = 1195 (50.3%) in the earlier period and N = 1182 (49.7%) in the later period, with a statistically significant difference ($p = 0.012$). Males represented N = 2144 (53.5%) in the first period and N = 1860 (46.5%) in the second. Age medians increased slightly from 60.00 years (IQR 48.00–73.00) in 2010–2015 to 61.00 years (IQR 49.00–75.00) in 2016–2021 ($p < 0.001$). Notably, individuals aged 0–19 saw a significant decrease in diagnosis from 63.3% to 36.7% ($p < 0.001$), while older age groups generally exhibited higher percentages. Non-Saudi patients accounted for N = 1195 (55.5%) in 2010–2015 and N = 957 (44.5%) in 2016–2021 ($p < 0.001$), indicating a significant change in nationality distribution. Regionally, there were significant shifts, particularly in the Central region, with N = 1001 (49.4%) diagnosed in the earlier period compared to N = 1026 (50.6%) later ($p < 0.001$). The

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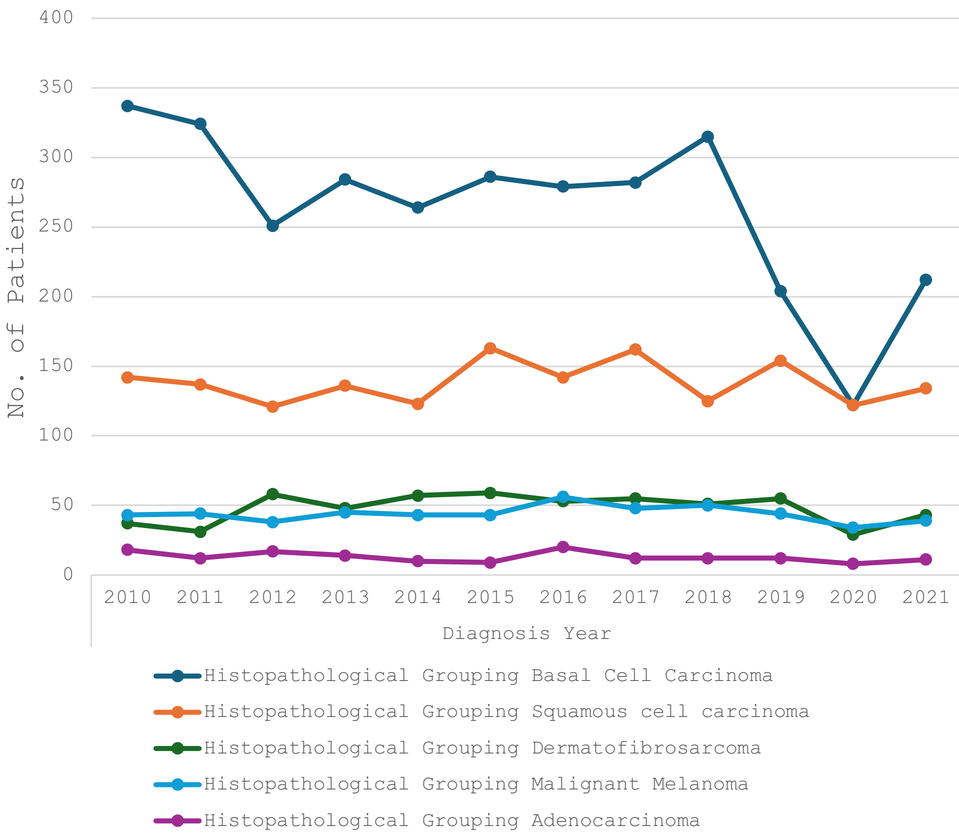

Figure 2 Over half of the cases were reported between 2010 and 2015, with basal cell carcinoma and squamous cell carcinoma being the most common subtypes. The remaining (47.7%) were diagnosed between 2016 and 2021 with a clear decline in the incidence of basal cell carcinoma compared to the period of 2010–2015.

topographical data revealed a decrease in skin cancer cases affecting the skin, other and unspecified parts of the face from N = 1242 (58.7%) to N = 875 (41.3%) ($p < 0.001$). The overall behavior of malignancy remained constant at 100%, but the extent of disease diagnosis changed significantly, with localized cases remaining prevalent. Missing values were notably high across grades and extent, emphasizing gaps in data collection. Laterality analysis showed a rise in unknown or ill-defined cases from N = 634 (38.1%) to N = 1030 (61.9%) ($p < 0.001$). These findings underscore the evolving landscape of skin cancer diagnoses, with significant shifts in gender, age distribution, nationality, regional diagnosis, and data completeness (Table 4).

Table 4 Comparison of Demographic and Clinical Characteristics of Skin Cancer Patients Diagnosed Between 2010–2015 and 2016–2021

		Diagnosis Year (Binned)				
		2010-2015		2016-2021		P value$^{C/F/K}$
		N/Median	Row %/IQR	N/Median	Row %/IQR	
Gender	Female	1195	50.3%	1182	49.7%	0.012*
	Male	2144	53.5%	1860	46.5%	
Age		60.00	48.00–73.00	61.00	49.00–75.00	<0.001*

(*Continued*)

Table 4 (Continued).

		Diagnosis Year (Binned)				
		2010-2015		2016-2021		P value$^{C/F/K}$
		N/Median	Row %/IQR	N/Median	Row %/IQR	
Age (Binned)	0-19	31	63.3%	18	36.7%	<0.001*
	20-39	429	52.1%	395	47.9%	
	40-59	1197	55.0%	981	45.0%	
	60-79	1219	51.9%	1129	48.1%	
	80+	463	47.1%	519	52.9%	
Nationality	Non-Saudi	1195	55.5%	957	44.5%	<0.001*
	Saudi Arabia	2144	50.7%	2085	49.3%	
Regions Combined	Central	1001	49.4%	1026	50.6%	<0.001*
	Eastern	710	55.4%	572	44.6%	
	Southern	513	46.9%	580	53.1%	
	Northern	165	54.5%	138	45.5%	
	Western	950	56.7%	726	43.3%	
Topography-C	Skin, other and unspecified parts of face	1242	58.7%	875	41.3%	<0.001*
	Head and Neck	780	50.5%	766	49.5%	
	Lower limb and Hip	390	52.0%	360	48.0%	
	Other (Overall lesion/Unknown)	184	28.8%	454	71.2%	
	Trunk	497	55.7%	395	44.3%	
	Upper limb and Shoulder	246	56.2%	192	43.8%	
Behavior	Malignant	3339	52.3%	3042	47.7%	-
Grade	Grade I (Well diff)	365	49.2%	377	50.8%	0.127
	Grade II (Mod diff)	344	50.4%	339	49.6%	
	Grade III (Poor diff)	128	57.7%	94	42.3%	
	Grade IV (Undiff Anaplastic)	19	55.9%	15	44.1%	
	Missing values	2483	52.8%	2217	47.2%	
Extent	In situ	0	0.0%	41	100.0%	<0.001*
	Localized	2416	49.4%	2472	50.6%	
	Regional: with or without lymph nodal involvement	232	51.6%	218	48.4%	
	Distant Metastasis	138	48.9%	144	51.1%	
	Missing values	553	76.8%	167	23.2%	

(*Continued*)

Table 4 (Continued).

		Diagnosis Year (Binned)				
		2010-2015		2016-2021		P value[C/F/K]
		N/Median	Row %/IQR	N/Median	Row %/IQR	
Laterality	Not paired (Unknown, ill defined)	634	38.1%	1030	61.9%	<0.001*
	Right	997	55.0%	815	45.0%	
	Left	1001	56.1%	784	43.9%	
	Bilateral Involvement	32	54.2%	27	45.8%	
	Paired site, laterality not stated	675	63.6%	386	36.4%	

Notes: [C]Person Chi-Square test. [F]Fischer's/Fischer-Freeman-Halton Exact Test. [K]Independent Samples Kruskall-Wallis Test. *p<0.05, Significant.

Binary Logistic Regression Analysis of Factors Associated with Skin Cancer Diagnosis Period (2016–2021 vs 2010–2015)

Binary logistic regression was conducted to assess factors associated with the likelihood of skin cancer diagnosis during the later period (2016–2021 vs 2010–2015). Males were slightly less likely than females to be diagnosed in the later period (AOR = 0.966, p = 0.758, 95% CI = 0.773 to 1.206), though the result was not statistically significant. Age showed a marginal association with a higher likelihood of later diagnosis (AOR = 1.003, p = 0.063, 95% CI = 1.000 to 1.006). Nationality had no significant effect (AOR = 1.095, p = 0.467, 95% CI = 0.858 to 1.397). Compared to the Central region, patients in the Eastern region were significantly less likely to be diagnosed in the later period (AOR = 0.399, p < 0.001, 95% CI = 0.287 to 0.556), as were those in the Northern (AOR = 0.508, p = 0.012, 95% CI = 0.299 to 0.863) and Western regions (AOR = 0.735, p = 0.031, 95% CI = 0.555 to 0.972), while the Southern region showed no significant difference (AOR = 0.841, p = 0.280, 95% CI = 0.615 to 1.151). Regarding tumor topography, lesions categorized as "Other" (overall/unknown) were significantly more likely to be diagnosed in the later period (AOR = 2.855, p < 0.001, 95% CI = 1.713 to 4.757), whereas those on the upper limb and shoulder were significantly less likely (AOR = 0.636, p = 0.026, 95% CI = 0.427 to 0.947). Histological grade did not show statistically significant differences, though Grade III (poorly differentiated) approached significance (AOR = 0.711, p = 0.051, 95% CI = 0.504 to 1.002). Tumor extent variables (localized, regional, distant) had extremely large negative coefficients and near-zero odds ratios, indicating model instability due to limited or unbalanced data (all p = 0.998). For laterality, bilateral involvement was significantly less likely in the later period (AOR = 0.253, p = 0.050, 95% CI = 0.064 to 0.998), as was "paired site, laterality not stated" (AOR = 0.609, p = 0.023, 95% CI = 0.397 to 0.935). These findings suggest that regional distribution, specific lesion locations, and certain laterality classifications significantly influenced the likelihood of being diagnosed in the later period, possibly reflecting changes in reporting practices, healthcare access, or diagnostic patterns over time (Table 5).

Binary Logistic Regression Analysis of Factors Associated with Regional/Distant Metastatic Skin Cancer vs Localized Disease

In the binary logistic regression model assessing factors associated with advanced skin cancer (regional/distant metastatic vs localized), several predictors were significantly associated with increased odds of presenting with regional/distant metastatic disease. Saudi nationals had significantly higher odds compared to non-Saudis (AOR = 1.893, p < 0.001, 95% CI = 1.373 to 2.609). Patients from the Western region were more likely to present with advanced disease than those from the Central region (AOR = 1.526, p = 0.015, 95% CI = 1.087 to 2.142). Those diagnosed between 2016–2021 had lower odds of advanced disease compared to the 2010–2015 cohort (AOR = 0.740, p = 0.029, 95% CI = 0.565 to 0.969), indicating an improvement over time. Anatomical site also influenced extent; cancers located on the trunk were less likely to be advanced (AOR = 0.552, p = 0.018, 95% CI = 0.337 to 0.904). Tumor grade was a strong predictor—Grade II (AOR = 2.404, p < 0.001, 95% CI = 1.768 to 3.270), Grade III (AOR = 5.497, p < 0.001, 95% CI = 3.761 to 8.035), and Grade IV (AOR = 5.965, p < 0.001, 95% CI = 2.707 to 13.142) tumors had progressively higher odds of being diagnosed at a regional/metastatic stage compared to Grade I. Laterality also

Table 5 Binary Logistic Regression Analysis of Factors Associated with Skin Cancer Diagnosis Period (2016–2021 vs 2010–2015)

Variables in the Equation							
		B	S.E.	Adjusted Odds Ratio	95% C.I for AOR		P value
					Lower	Upper	
Gender	Female	Ref	Ref	Ref	Ref	Ref	Ref
	Male	−0.035	0.113	0.966	0.773	1.206	0.758
Age (Years)		0.003	0.001	1.003	1.000	1.006	0.063
Nationality	Non-Saudi	Ref	Ref	Ref	Ref	Ref	Ref
	Saudi Arabia	0.091	0.124	1.095	0.858	1.397	0.467
Regions Combined	Central	Ref	Ref	Ref	Ref	Ref	Ref
	Eastern	−0.918	0.168	0.399	0.287	0.556	<0.001*
	Southern	−0.173	0.160	0.841	0.615	1.151	0.280
	Northern	−0.677	0.270	0.508	0.299	0.863	0.012*
	Western	−0.308	0.143	0.735	0.555	0.972	0.031*
Topography-C	Skin, other and unspecified parts of face	Ref	Ref	Ref	Ref	Ref	Ref
	Head and Neck	−0.113	0.171	0.893	0.638	1.250	0.510
	Lower limb and Hip	−0.120	0.173	0.887	0.632	1.246	0.490
	Other (Overall lesion/Unknown)	1.049	0.261	2.855	1.713	4.757	<0.001*
	Trunk	−0.254	0.187	0.776	0.538	1.119	0.174
	Upper limb and Shoulder	−0.452	0.203	0.636	0.427	0.947	0.026*
Grade	Grade I (Well diff)	Ref	Ref	Ref	Ref	Ref	Ref
	Grade II (Mod diff)	−0.065	0.120	0.937	0.741	1.186	0.590
	Grade III (Poor diff)	−0.341	0.175	0.711	0.504	1.002	0.051
	Grade IV (Undiff Anaplastic)	−0.461	0.389	0.631	0.294	1.352	0.236
Extent	In situ	Ref	Ref	Ref	Ref	Ref	Ref
	Localized	−20.966	9257.396	0.000	0.000		0.998
	Regional: with or without lymph nodal involvement	−21.217	9257.396	0.000	0.000		0.998
	Distant Metastasis	−21.276	9257.396	0.000	0.000		0.998
Laterality	Not paired (Unknown, ill defined)	Ref	Ref	Ref	Ref	Ref	Ref
	Right	−0.319	0.175	0.727	0.516	1.024	0.068
	Left	−0.307	0.176	0.735	0.521	1.039	0.081
	Bilateral Involvement	−1.374	0.700	0.253	0.064	0.998	0.050*
	Paired site, laterality not stated	−0.496	0.219	0.609	0.397	0.935	0.023*

Notes: Variable(s) entered on step 1: Gender, Age, Nationality, Regions Combined, Topography-C, Grade, Extent, Laterality. *Significant P value.

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played a role, with bilateral involvement significantly increasing the likelihood of advanced disease (AOR = 4.652, p = 0.012, 95% CI = 1.403 to 15.427). These findings suggest that patient nationality, tumor grade, diagnosis year, anatomical location, and tumor laterality are important predictors of disease extent at diagnosis, and they highlight the need for targeted screening and earlier detection efforts in high-risk groups (Table 6).

Discussion

This study examines the patterns of skin cancer in Saudi Arabia from 2010 to 2021, highlighting temporal, regional, and demographic variations in incidence, histopathological subtypes, and disease extent.

Table 6 Binary Logistic Regression Analysis of Factors Associated with Regional/Distant Metastatic Skin Cancer vs Localized Disease

Variables in the Equation							
		B	S.E.	Adjusted Odds Ratio	95% C.I for AOR		P value
					Lower	Upper	
Gender	Female	Ref	Ref	Ref	Ref	Ref	Ref
	Male	0.226	0.140	1.254	0.954	1.649	0.105
Age (Years)		−0.006	0.004	0.994	0.987	1.002	0.127
Nationality	Non-Saudi	Ref	Ref	Ref	Ref	Ref	Ref
	Saudi Arabia	0.638	0.164	1.893	1.373	2.609	<0.001*
Regions Combined	Central	Ref	Ref	Ref	Ref	Ref	Ref
	Eastern	0.133	0.210	1.142	0.757	1.722	0.526
	Southern	−0.300	0.205	0.741	0.496	1.107	0.143
	Northern	0.095	0.321	1.100	0.586	2.066	0.767
	Western	0.423	0.173	1.526	1.087	2.142	0.015*
Diagnosis Year (Binned)	2010-2015	Ref	Ref	Ref	Ref	Ref	Ref
	2016-2021	−0.301	0.137	0.740	0.565	0.969	0.029*
Topography-C	Skin, other and unspecified parts of face	Ref	Ref	Ref	Ref	Ref	Ref
	Head and Neck	−0.183	0.211	0.833	0.551	1.259	0.386
	Lower limb and Hip	0.017	0.214	1.018	0.669	1.547	0.935
	Other (Overall lesion/Unknown)	−0.007	0.292	0.994	0.560	1.761	0.982
	Trunk	−0.594	0.252	0.552	0.337	0.904	0.018*
	Upper limb and Shoulder	−0.078	0.249	0.925	0.568	1.505	0.753
Grade	Grade I (Well diff)	Ref	Ref	Ref	Ref	Ref	Ref
	Grade II (Mod diff)	0.877	0.157	2.404	1.768	3.270	<0.001*
	Grade III (Poor diff)	1.704	0.194	5.497	3.761	8.035	<0.001*
	Grade IV (Undiff Anaplastic)	1.786	0.403	5.965	2.707	13.142	<0.001*

(*Continued*)

Table 6 (Continued).

Variables in the Equation								
		B	S.E.	Adjusted Odds Ratio	95% C.I for AOR		P value
					Lower	Upper	
Laterality	Not paired (Unknown, ill defined)	Ref	Ref	Ref	Ref	Ref	Ref
	Right	0.130	0.213	1.139	0.751	1.728	0.541
	Left	−0.008	0.217	0.992	0.648	1.517	0.970
	Bilateral Involvement	1.537	0.612	4.652	1.403	15.427	0.012*
	Paired site, laterality not stated	−0.288	0.289	0.750	0.426	1.320	0.319

Notes: Variable(s) entered step 1: Gender, Age, Nationality, Regions Combined, Diagnosis Year (Binned), Topography-C, Grade, Laterality. *Significant P value.

Study findings show that BCC is the most common type of skin cancer in Saudi Arabia, making up 49.5% of cases. This is similar to trends in many countries, where BCC is the most frequent type of skin cancer due to its slow growth and low likelihood of spreading.[12,13] However, SCC, which is the second most common type in Saudi Arabia (25.6%), occurs more frequently than in many European populations but less often than in Australia, where high UV exposure leads to more SCC cases.[14,15] The comparison with Australia and Northern Europe, however, must be interpreted cautiously. While skin pigmentation plays a role in susceptibility to UV-related skin cancers, the intensity of UV radiation is significantly higher in Australia than in Northern Europe, which can independently affect incidence rates.

Compared to other Gulf countries, such as the UAE, where skin cancer prevalence is reported at 14.5%, Saudi Arabia appears to have a slightly higher burden of skin cancer. However, differences in population size, ethnic diversity, skin phototypes, healthcare access, and cancer registry coverage could also explain this variation and must be considered before drawing direct comparisons. Melanoma, a more aggressive form of skin cancer, is less common in Saudi Arabia, similar to trends in other regions with darker-skinned populations. This is likely due to the protective role of melanin, which reduces the risk of UV damage to the skin.[5] Still, darker skin is not immune to UV damage. Non-melanoma skin cancers can and do occur in darker-skinned populations, especially under conditions of prolonged or intense sun exposure.

The unique patterns of skin cancer in Saudi Arabia may be linked to a combination of genetic, environmental, and cultural factors. Darker-skinned individuals in Saudi Arabia may have some natural protection against skin cancer due to higher melanin levels, which shield the skin from UV damage. However, this protection is not complete, and they remain at risk for non-melanoma types like BCC and SCC. Studies show that genetic mutations in skin cells caused by UV exposure may still occur, especially with long-term sun exposure, leading to cancer.[5,6]

Cultural and religious practices also play a protective role. Traditional clothing—such as abayas for women and thobes for men—offers significant physical coverage from the sun. Religious norms promoting modest dress likely contribute to reduced UV exposure, particularly among women. However, sunscreen use remains low, and certain occupational groups, especially outdoor labourers, are still vulnerable.[16] Our study found higher incidence rates in the Central and Western regions. While environmental exposure may partly explain this, attributing it solely to sun-related factors ignores other important contributors. These regions include major cities like Riyadh, Jeddah, and Mecca, where healthcare access and diagnostic capabilities are more advanced. Consequently, the apparent high incidence may reflect better detection and reporting rather than true differences in disease occurrence. Additionally, these urban centres have higher population densities, which naturally increase case counts.

To reduce the burden of skin cancer, Saudi Arabia needs focused public health campaigns. These campaigns should educate people about the importance of sun protection, such as wearing sunscreen, protective clothing, and avoiding direct sunlight during peak hours.[17] Providing affordable or subsidized sunscreen could encourage its widespread use.

Skin cancer screening programs are another important step. Regular skin check-ups, especially for high-risk groups like outdoor workers, can help detect cases early, when treatment is most effective. Training healthcare professionals to recognize skin cancer in darker-skinned individuals is also essential, as delays in diagnosis are common in these populations.[5]

Rising temperatures and increasing UV exposure due to climate change are likely to make skin cancer more common in the future. Prolonged sun exposure and higher UV intensity will put more people at risk, especially in Saudi Arabia, where outdoor work is widespread.[18] These environmental changes make it even more urgent to promote sun safety habits and strengthen skin cancer prevention programs.

Our study found that the Central region (31.8% of cases) and the Western region (26.3%) had the highest rates of skin cancer in Saudi Arabia. There are several possible reasons for this. The Central region includes Riyadh, the capital, which has a dense population and better access to healthcare. This may result in more cases being diagnosed and reported. Occupational factors could also contribute, as many outdoor workers in these regions face constant UV exposure.[19,20] The Western region, which includes Jeddah and Mecca, has unique environmental factors. Proximity to the Red Sea may cause more UV reflection, increasing sun exposure.[21] Urban centers in this region have better diagnostic facilities, meaning more cases are likely to be identified.

One particularly interesting finding was a decline in BCC cases after 2015. Although our data does not include variables to fully explain this trend, potential factors may include changes in cancer registry practices, diagnostic reclassification, improved awareness, or healthcare policy shifts affecting reporting. Public health interventions and electronic medical record integration could have also played a role. Future studies are needed to explore the causes of this decline more systematically.

Based on the findings presented in our study, a notable temporal trend was observed in the incidence of skin cancer in Saudi Arabia between 2010 and 2021. While the number of diagnosed cases remained relatively stable across most years, a modest decline in reported cases was noted after 2015, particularly for basal cell carcinoma. When comparing the two time periods (2010–2015 vs 2016–2021), the proportion of diagnoses shifted slightly, with 52.3% of cases occurring in the earlier period and 47.7% in the later one. Additionally, the proportion of non-Saudi patients declined significantly in the second half of the study period, which may reflect changes in population demographics or healthcare access. A significant increase in the proportion of in situ diagnoses after 2015 may suggest improved early detection, while a concurrent reduction in missing data regarding disease extent points to enhancements in data quality. These temporal shifts could also be influenced by public health initiatives, climate-related behavioral changes, or evolving diagnostic practices. However, due to the absence of direct data on sun exposure, healthcare-seeking behavior, or public awareness interventions, interpretations of these trends should be made cautiously.

The regression analyses in our study revealed several important factors associated with both the timing of diagnosis and the extent of skin cancer at presentation. Patients from the Eastern, Northern, and Western regions were significantly less likely to be diagnosed during the later period (2016–2021) compared to the Central region, which may reflect regional disparities in healthcare access or reporting practices. Additionally, lesions on the upper limbs and shoulders were less likely to be diagnosed in the later period, while cases categorised as "other/unknown site" were significantly more common, possibly indicating evolving diagnostic patterns or data entry limitations. When examining predictors of advanced disease, Saudi nationality and residence in the Western region were associated with significantly higher odds of presenting with regional or distant metastasis, suggesting potential gaps in early detection or awareness in these populations. Furthermore, higher tumor grade (Grades II–IV) and bilateral involvement were strong predictors of advanced disease, highlighting the importance of early identification and accurate histopathological evaluation. Notably, patients diagnosed in the later period were less likely to have advanced disease, which may reflect improvements in early detection and healthcare delivery over time.

Our study used administrative regions for geographic categorization because detailed province-level UV radiation data were unavailable—a notable limitation, as UV exposure is a key environmental risk factor for skin cancers like basal cell carcinoma (BCC) and squamous cell carcinoma (SCC).[22] Without granular UV data, we could not directly analyze the relationship between skin cancer incidence and UV intensity across regions.

Despite this, several environmental studies confirm that Saudi Arabia consistently experiences high levels of ultraviolet radiation. A long-term monitoring effort in Riyadh (2005–2010) recorded peak UV irradiance of approximately 16.6 W/m² in July and lower values (~8.3 W/m²) in December, confirming pronounced seasonal variation with very high summer exposures.[23] Another decade-long study in Riyadh (1997–2005) characterized monthly and yearly UV radiation patterns and improved understanding of effects from ozone, aerosols, and reflection.[24] More recently, a climatological analysis using satellite and ground-based UVA data (2015–2020) reported mean midday UVA irradiance of over 21 W/m² under clear skies in Riyadh, with overall solar global irradiance averaging ~549 W/m²—indicating consistently high ambient UV across a range of weather conditions.[25]

Limitations and Future Recommendations

This study had several limitations. Most importantly, a significant amount of missing data was found in tumour grading (73.7%) and extent of disease (11.3%). These gaps limit the ability to fully assess disease severity and staging and may have introduced bias in interpretation.

Our study has missing data, which warrants further exploration. This is a limitation of our study. Utilising robust databases with no missing data may provide more insights into the trends studied.

Future research should address these limitations by collecting more complete and standardised data on tumour characteristics, sunscreen use, occupational exposure, and healthcare access. Incorporating multivariable analysis and linking registry data with clinical and environmental variables would help clarify causal relationships and strengthen the evidence base for targeted interventions. Genetic studies can also help identify why some people in Saudi Arabia are more likely to develop skin cancer. Population-based GWAS efforts in Saudi Arabia could also help identify genetic risk factors unique to this population.[26] Expanding research to include more regions and rural areas will ensure a more accurate picture of skin cancer across the country.

Conclusion

Skin cancer is common in Saudi Arabia, especially among older men, with BCC being the most frequent type. Regional differences, such as higher cases in the Central and Western areas, highlight the need for targeted public health efforts. Policymakers should focus on creating nationwide awareness campaigns about sun protection, making sunscreen affordable, and improving access to dermatology services. Future research should involve experts in genetics, climate change and public health to better understand the effects of UV exposure, genetic risks and environmental factors on skin cancer. These findings can also help other UV-rich regions worldwide develop better strategies for preventing and managing skin cancer. By prioritizing these efforts, Saudi Arabia can reduce the impact of skin cancer and set an example for similar countries.

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