Skin cancer risk factors among black South Africans — the Johannesburg Cancer Study, 1995–2016

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Abstract

Background

The Black population is known to have lower risk for skin cancers due to melanin content of the skin. Regardless, skin cancers still occur in Black populations. The aim of this study was to identify risk factors associated with skin cancer among Blacks presenting at selected tertiary hospitals in Johannesburg, South Africa.

Methods

A case-control study was conducted; cases were patients with keratinocyte cancers (KCs) and/or melanoma skin cancer (MSC) and controls were cardiovascular patients. Socio-demographic exposures (sex and residency), environmental exposures (heating and cooking fuels), smoking, and HIV status were assessed. The proportions of cases by skin cancer major subtype, demographics, histological spectrum and anatomical site of distribution were determined. A stepwise (backward elimination) logistic regression was done to identify risk factors associated with KC and MSC.

Results

More KCs (n = 160) were found compared to MSCs (n = 101). The majority of both KCs and MSCs were reported in ages 51-60-years (27%). The median age at KC and MSC diagnosis was similar in both sexes; 50-years (IQR:38–57) and 56-years (IQR:48–68), respectively. The KC histological spectrum showed that there were more squamous cell carcinomas (SCCs) (78/160 in females, and 72/160 in males) than basal cell carcinoma (BCC). The SCC lesions were mostly found on the skin of the head and neck in males (51%, 38/72) and on the trunk in females (46%, 36/78). MSC was shown to affect the skin of the lower limbs in both males (68%, 27/40) and females (59%, 36/61). Using females as the reference group, when age, current place of residency, type of cooking fuel used currently, smoking, and HIV status were adjusted for, males had an odds ratio (OR) of 2.04 for developing KC (CI:1.08–3.84, p = 0.028). Similarly, when age, current place of residency, place of cooking (indoors or outdoors) were adjusted for, males had an OR of 2.26 for developing MSC (CI:1.19–4.29, p = 0.012).

Conclusions

Differences in anatomical distribution of KCs by sex suggest different risk factors between sexes. Rural dwelling was a newly found association to skin cancer and warrants further investigation. This study highlights the importance of skin cancer awareness campaigns and interventions especially in rural areas.

Introduction

Skin cancers are the most frequently diagnosed malignancies worldwide (1). There are two types of skin cancers namely; keratinocyte cancers (KCs) formerly known as non-melanoma skin cancers (NMSCs), and melanoma skin cancers (MSCs) (1). Skin cancer have a multifactorial aetiology including environmental exposures, inherent factors and adopted lifestyle behaviours (2). Environmental risk factors include ultraviolet radiation (UVR) mostly through sun exposure (a primary skin cancer risk factor that accounts for more than 80% of skin cancer incidences); geographic location (living near the equator or in higher altitudes and living in areas where the ozone layer has been depleted); and a long history of sunburns (3–5). Inherent risk factors include ethnicity (being of Caucasian origin); lightness in complexion; sex (being male); older age; oculocutaneous albinism; light-coloured eyes (blue, green, grey); light-coloured hair; and many melanocytic nevi during childhood (6–12). Lifestyle associated behaviours such as sunbed use, tobacco smoking, and alcohol consumption have shown significant association with skin cancer in different research studies across the globe (13–18). There are other newly emerging associations with skin cancer such as HIV infection, and use of anti-hypertensive drugs (i.e. thiazide diuretics) (12, 19).

Common misperceptions about skin cancer exist among the Black populations including the belief that having darker skin (i.e. abundant melanin skin pigmentation) offers full protection against the damaging effects of UVR (20). However, it has been shown that given enough exposure to UVR some DNA damage is observed in dark skin, although not as severe as that which may occur in lighter skin (21). In South Africa (SA), non-Black population groups have higher incidence of skin cancers compared to the Black population (10, 22). A study by Norval *et al*. on incidence of skin cancers in the population groups of SA from 2000–2004 showed that the White population is the most susceptible population group to skin cancer, followed by Mixed-race population, Indian/Asian population, then the Black population (23). The age-standardized incidence rates (ASIRs) of KCs were reported to be 4.76 per 100,000 in the non-White populations and 19.2 per 100,000 in the White population in SA (23). The incidence rates of skin cancer are relatively well documented in SA but the risk factors associated with skin cancer especially in the Black population have not been explored (23).

The high burden of HIV infection in the Black population of SA leads to susceptibilities to many diseases (including cancer) due to immunosuppression (7–9, 24). In the antiretroviral era, HIV positive patients live longer and are thus susceptible to chronic diseases like cancer (7–9, 24). Skin cancer is no exception; the squamous cell carcinoma (SCC) subtype of KC has been shown to be associated with HIV infection [OR 2.6, 95% CI (1.4–4.9)] (25). Therefore, skin cancer is of public health concern in SA due to the dual risk of the country's high ambient UVR environment and high burden of HIV (10). Understanding skin cancer incidence patterns and aetiology in the South African Black population, the largest population group in SA, is critical for planning, prevention, treatment strategies, and allocation of medical resources (10). The aim of this study was to describe the histological and anatomical distribution of skin cancer subtypes and identify risk factors associated with skin cancer among Black South Africans.

Methods

Study design, data sources and study setting

We conducted a case-control study where cases were patients with a diagnosis of skin cancer (KC or MSC) and controls were non-cancer patients. This was a secondary data analysis of the data collected by the parent study, the Johannesburg Cancer Study (JCS). The JCS was conducted by the National Cancer Registry (NCR) of SA between 1995 and 2016 (26). In brief, the JCS recruited adult (18 + years old) consenting, self-identified Black patients who were newly diagnosed with cancer and attending public referral hospitals for oncology and radiation therapy in Johannesburg (26). The JCS, collected socio-demographic data and environmental exposure data by conducting face-to-face interviews, using a paper-based questionnaire which was administered by qualified nurses. Data were collected from a total of 24 971 cancer patients between the years 1995 to 2016 (inclusive). A set of non-cancer controls (n = 1 177) were recruited using a convenience sample framework, from the cardiology department in one of the hospitals.

Study participants and data collection

Black patients who were 18 years of age and older at the time of recruitment that had a pathology confirmed diagnosis of skin cancer (KC and/or MSC) were included in this analysis. Skin malignancies that did not form part of the two main skin cancer subtypes (KC and MSC) were excluded from the study. Controls were randomly selected from a JCS controls dataset. Cancer coding consistency was evaluated using the International Classification of Diseases for Oncology, version 3 (ICD-O3) (27). Observations which had an ICD-O3 topography codes for skin (C44.0 to C44.9) and ICD-O3 morphology codes for KCs and MSCs were selected for this analysis.

For the current study, two subsets of data were extracted from the JCS database: a KC dataset comprising of 160 cases and 160 randomly selected controls and an MSC dataset comprising of 101 cases and 101 randomly selected controls. New variables were created namely; histological spectrum and anatomical site. The histological spectrum variable (created from the ICD-O3 morphology code) differentiated the two main types of KCs (SCC-squamous cell carcinoma, and BCC-basal cell carcinoma) and MSC. The anatomical site variable (created from the ICD-O-3 topography code) marked records according to their site of origin; i.e. the skin of the head and neck, skin of the upper limbs, skin of lower limbs, skin of the trunk, and overlapping skin sites (i.e. found in multiple skin sites that do not fall under the same topography code).

Variables

A binary outcome variable was created (0-no cancer, 1-skin cancer) in both the KC and MSC case-control datasets. The exposure variables of interest that were analysed in this study were socio-demographic variables (i.e. sex, age, province of birth, rural/urban (termed urbanicity) dweller in the province of birth, province of current residency, rural/urban dweller at current province of residency, and level of education), environmental variables (i.e. type of walls of the house the patient lives in, whether they cook indoors/

outdoors currently and in the past, type of cooking fuel used currently and in the past, and type of fuel used for heating currently and in the past), behavioural variables (i.e. smoking status and snuff use), and HIV status.

Data analysis and statistical methods

Proportion percentages of cases were described according to the two major skin cancer groups (KC and MSC) and stratified by sex. The analysis defined proportion percentages between males and females by number of cases, median age (IQR), and 10-year category age-grouping. The KCs were further described by histological spectrum (BCC and SCC) and anatomical site (skin of head and neck, upper limbs, lower limbs, and trunk). This was an exploratory study of skin cancer risk factors in the Black population of SA. We used both data-driven and biological plausibility approaches to build our regression model. We then performed a stepwise (backward elimination) regression analysis to identify factors associated with each skin cancer subtype. A multivariable, adjusted model was presented, separately for KC and MSC. Analyses were performed using Stata version 15 (StataCorp Ltd, College Station, TX, USA). Variables which were excluded from the model due to insignificant p-values from the stepwise regression, but with biological plausibility were included in the final model, regardless of them being insignificant e.g. age and place of cooking (indoors or outdoors). Age explains more about the duration of exposure to the skin cancer risk factors. The place of cooking was used as a proxy to measure sun exposure which is a well-established skin cancer risk factor.

Model stability

For model stability, we excluded variables that had insufficient data points for individual categories (e.g. province of residence in the past and at present). We combined gas and paraffin under cooking fuels used because gas use had insufficient events and could be grouped together with paraffin as combustible materials. We removed variables that showed collinearity with other variables e.g. we kept fuel used for cooking and excluded fuel used for heating. These two variables had the same responses as it is more likely that the same kind of cooking fuel will be used as a heating fuel too. Exposure-wise, it is likely that a person is exposed to cooking fuel more than they are exposed to heating fuel because in SA winter only lasts for a few months, but cooking is done throughout the year. The latter also played a role in achieving a parsimonious model that explains the relationship between sex and skin cancer, adjusting for all the other variables that were kept in stepwise regression. We kept variables with a known association with skin cancer, i.e. age, and we used age as a continuous variable as opposed to categorized in order to have a less strained model. The first model improvements were tested using the likelihood ratio test to identify the best fit model.

Results

Demographics

There were 160 KC cases and 53% (n = 85) were females. The males with KC were older than females: 51 (IQR: 41–59) vs 46 (IQR: 36–56) years. The KC cases were distributed across 10-year age groups and most cases were recorded in age group 51–60 years (28%, 44/160). There were 101 MSC cases and 60% (n = 61) were females. The median age at diagnosis was similar in both males: 55 (IQR: 49–68) and females: 56 (IQR: 47–68) years. Most MSC cases were recorded in age group 51–60 years (28%, 28/101), see Table 1.

Table 1: Case distribution of keratinocyte cancers and melanoma skin cancers cases in the Johannesburg Cancer Study, 1995-2016. Note: Numbers may not add to 100% due to rounding.

	KERATINOCYTE CANCERS			MELANOMA SKIN CANCERS		
	All	Males	Females	All	Males	Females
N (row %)	160 (100)	75 (47)	85 (53)	101 (100)	40 (40)	61 (60)
Age median in years (IQR)	49 (38-57)	51 (41-59)	46 (36-56)	56 (48-68)	55 (49-68)	56 (47-68)
Age-groups in years, n (column %)						
18-30	17 (11)	4 (5)	13 (15)	2 (2)	1 (3)	1 (2)
31-40	33 (21)	14 (19)	19 (22)	10 (10)	3 (8)	7 (13)
41-50	40 (25)	19 (25)	21 (25)	21 (21)	9 (3)	12 (20)
51-60	44 (28)	26 (35)	18 (21)	28 (28)	12 (30)	16 (27)
61-70	21 (13)	10 (13)	11 (13)	17 (17)	7 (18)	10 (16)
71-80	3 (2)	1 (1)	2 (2)	17 (17)	5 (13)	12 (20)
81+	2 (1)	1 (1)	1 (1)	6 (6)	3 (8)	3 (5)

Histological spectrum and anatomical site

There were more SCCs in both females (n = 78) and males (n = 72) compared to BCC (female: 7; male: 3). The distribution of SCC in females showed that most cases were recorded on the skin of the head and neck, 30/78 (38%) and skin of trunk, 36/78 (46%). In males 37/72 (51%) SCCs were recorded on the skin of the head and neck and 13/72 (18%) on the skin of the trunk. The MSC was recorded the most commonly on the skin of lower limbs in both females and males, 36/61 (59%) and 27/40 (68%), respectively, see Fig. 1.

Risk factor analysis: Keratinocyte cancers

Univariable results

In the univariable analysis, males were shown to have an odds ratio (OR) of 2.56 of developing KC when compared to females (CI: 1.60–4.10, $p < 0.001$) (Table 2). This model (with only sex) explained 4% of the variation observed in the outcome (Table 2). Individual regressions of province of birth (Gauteng, Mpumalanga, North West, and Free State), being born in a rural area, residing in (Gauteng, North West, and Free State), living in a rural area, a history of using paraffin or gas as a heating fuel, current smoking and being HIV positive showed significantly higher odds of association with KC at a p-value of ≤ 0.05

(Table 2). Individual regression of current snuff use showed negative association with KC (Table 2). No significant relationship was found between age, level of education, type of house walls, place of cooking (current or in the past), cooking fuel used (currently or in the past), and type of fuel used for heating in the past with KC (Table 2).

Multivariable results

In the final model, we retained age and place of cooking (indoors or outdoors) for biological plausibility and as a sunlight exposure proxy. We removed province of residence because this was infrequently answered in the questionnaire. We also removed the type of walls of the house the participant lives in because there was no biological plausibility for this association. We removed fuel for heating because of collinearity with cooking fuel. The final model showed that when age, current urbanicity, type of cooking fuel used currently, smoking, and HIV status were adjusted for, males had an OR of 2.04 for having KC (CI: 1.08–3.84, p = 0.028) (Table 2). This model explained 11% of the variation observed in KC outcome. Significant associations of smoking and HIV infection with KC were found: current smokers (OR = 2.65, CI: 1.24–5.64, p-value = 0.012) and HIV positive (OR = 2.00, CI:1.09–3.53, p-value = 0.024). Marginal significance of urbanicity and cooking fuel with KC was observed: rural dwellers (OR = 4.5, CI: 1.58–13.06, p-value = 0.005) and using wood as cooking fuel showed protective effects for KC (OR = 0.16, CI:0.02–1.13, p-value = 0.065). Age was kept in the final model for face validity, as it is known as a risk factor for cancer and should always be adjusted for in models.

Table 2: Univariable and multivariable logistic regression of non-melanoma skin cancer risk factors in black South Africans, JCS 1995-2014.

	Univariable logistic regression (p≤0.25)			Multivariable logistic regression analysis (p≤0.05)		
	Unadjusted Odds Ratios	95% Confidence Intervals	P-values	Adjusted Odds Ratios	95% Confidence Intervals	P-values
SOCIO-DEMOGRAPHIC VARIABLES	n=320, R^2=0.0356, p=0.000			n=293, R^2=0.1133, p=0.000		
Gender (n=320)						
Female (ref)	1			1		
Male	2.56	1.60-4.10	0.000	2.04	1.08-3.84	**0.028**
Age (n=320)	0.98	0.97-1.00	0.040	0.99	0.97-1.01	0.591
Rural/Urban dweller currently (n=316)						
Urban (ref)	1			1		
Rural	2.70	1.25-5.84	0.011	4.5	1.58-13.06	**0.005**
ENVIRONMENTAL VARIABLES						
Place of cooking currently (n=313)						
Inside (ref)	1			1		
Outside	5.10	0.59-44.15	0.139	7.42	0.50-110.90	0.146
Type of cooking fuel used currently (n=316)						
Electricity (ref)	1			1		
Wood	1.46	0.45-4.73	0.528	0.16	0.02-1.13	0.065
Coal	0.91	0.43-1.95	0.814	0.69	0.28-1.71	0.422
Paraffin_Gas	1.53	0.76-3.09	0.236	0.92	0.41-2.09	0.845
BEHAVIOURAL VARIABLES						
Smoking (n=316)						
Never smoked (ref)	1			1		
Smoked in the past	1.60	0.91-2.81	0.103	1.73	0.88-3.39	0.113
Current smoker	3.08	1.74-5.46	0.000	2.65	1.24-5.64	**0.012**
HIV STATUS (n=300)						
Negative (ref)	1					
Positive	1.72	1.06-2.78	0.028	2.00	1.09-3.53	**0.024**

Risk factor analysis: Melanoma skin cancer

Univariable results

In the univariable analysis, males were shown to have OR of 1.99 for having MSC when compared to females (CI: 1.09–3.64, p = 0.025) (Table 3). This model (with only sex) explained 2% of the variation observed in the outcome (Table 3). Individual regressions of: province of birth (Gauteng, Limpopo, North West, Free State, and Eastern Cape), being born in a rural area, residing in Gauteng and Limpopo Provinces, living in a rural area, using wood and coal as a cooking fuel, using wood, coal, paraffin or gas as a warming fuel, a history of cooking outdoors, history of using wood both as a cooking and a warming fuel showed significantly higher odds of association with MSC at a p-value of ≤ 0.05 (Table 3). Being HIV positive showed negative association with MSC (Table 3). No significant relationship was found between

age, level of education, type of house walls, current place of cooking, smoking, and snuff use with MSC (Table 3).

Multivariable results

The final model showed that when age, current urbanicity, place of cooking (indoors or outdoors) were adjusted for, males had an OR of 2.26 for having MSC (CI: 1.19–4.29, p = 0.012) (Table 3). This model explained 9% of the variation observed in MSC outcome (Table 3). Significant association of living in rural areas was found with higher risk among rural dwellers (OR = 2.88, CI: 1.01–8.18, p-value = 0.048) versus urban dwellers. Place of cooking was kept in the model because it served as a proxy for sun exposure.

Table 3: Univariable and multivariable logistic regression of melanoma skin cancer risk factors in black South Africans, JCS 1995-2014.

	Univariable logistic regression (p≤0.25)			Multivariable logistic regression analysis (p≤0.05)		
	Unadjusted Odds Ratios	95% Confidence Intervals	P-values	Adjusted Odds Ratios	95% Confidence Intervals	P-values
SOCIO-DEMOGRAPHIC VARIABLES	n=202, R^2=0.0183, p=0.023			n=201, R^2=0.0890, p=0.000		
Gender (n=165)						
Female (ref)	1			1		
Male	1.99	1.09-3.64	0.025	2.26	1.19-4.29	**0.012**
Age (n=202)	1.03	1.01-1.06	0.001	1.04	1.02-1.06	**0.001**
Rural/Urban dweller at current residency (n=201)						
Urban (ref)	1			1		
Rural	3.08	1.23-7.69	0.016	2.88	1.01-8.18	**0.048**
ENVIRONMENTAL VARIABLES						
Place of cooking currently (n=201)						
Inside (ref)	1			1		
Outside	3.03	0.31-29.64	0.341	1.42	0.12-17.41	1.784

Discussion

More KCs were observed than MSCs in this study population. The majority of KC lesions were in the skin of head and neck in males and skin of trunk in females and the majority of MSC were on the skin of the lower limbs. HIV infection, living in a rural area, and smoking was positively associated with KC. Living in a rural area was also positively associated with MSC.

Findings from this study are consistent with the world cancer report statistics that KCs account for the majority of skin cancers reported with the age at diagnosis in the mid-60's (1, 28). Generally, males are diagnosed with KCs more often than females (14, 17, 28). However, in the current study more females were diagnosed with KCs compared to males (may be due to having more females in the JCS than males) and females were diagnosed at a younger age (37% at ages ≤ 40 years). The differences in reported numbers between the two sexes may be a result of health-seeking behavioural differences

between the two sexes (14). Females are reportedly more likely than males to seek medical help over a suspicious looking lesion on the skin (14).

The skin cancer subtype that was reported more frequently in this study population was SCC compared to MSC, consistent with literature that the Black population is mostly affected by SCC (29–31). However, the distribution of histological subtypes of KC in the SA general population (all ethnicities) shows that BCC is the most abundant subtype, followed by SCC (32, 33). This pattern is due to the overwhelming numbers of BCC diagnosed in the White population in SA. However, when population group specific analysis was conducted, SCC was the leading skin cancer in the Black population, followed by BCC (23).

The differences in KC histological subtypes distribution suggest different risk factors among different population groups. A risk factor for SCC in the Black population is hypothesized to be immunosuppression resulting from HIV infection (18). SA has one of the world's largest HIV epidemics and the Black population is the most affected population (18). A rise of SCC incidence in the Black population of SA was observed after the beginning of the HIV epidemic (18). Shortly after the introduction of anti-retroviral treatment, a significant decline of SCC incidence was seen in SA and this is consistent with the theory that relates SCC to immunosuppression resulting from HIV infection (18). Being HIV positive however showed negative association with MSC on univariable analysis, this may suggest different risk factors for KCs and MSCs.

Skin cancer is known to develop on areas of the skin that are exposed to sunlight as a result of UVR exposure (3, 13). This phenomenon is explained by a lack of melanin in non-Black populations which predisposes to skin injury from UVR exposure, increasing the risk of skin cancer (6). Interestingly, the Black SA population in this study showed that the skin of the head and neck, and trunk were more susceptible to KCs. The body area (trunk) that is normally covered by clothing and not normally exposed to the sun was susceptible to KC especially in females. These findings show that other than the main risk factor (solar UVR exposure), there may be additional risk factors associated with skin cancer in the Black population. The risk factor analysis results showed that being male resulted in double the odds of having skin cancer for both KC and MSC, as supported by other studies in other countries (14, 17). Sex differences exist in many physiological conditions and can be explained by various theories (14). Given sun exposure as a primary risk factor for KC susceptibility, the high incidence seen in males can be explained by the nature of jobs usually done by men (outdoor jobs) and by the behaviour during childhood (spending more time outdoors) which explains most of exposure to risk (8, 34). The Black SA economy relies on agricultural and mining activities. These activities increase exposure to risk factors and cause skin injuries and scar tissue, a precursor of skin cancer development (18).

In this study, a positive association of KC with smoking (current), and a positive HIV status was seen (17, 35, 36). Current smokers, and persons with a history of smoking have increased odds of being diagnosed with SCC (17). Our findings are consistent with literature on the association between smoking and KC. Univariable analysis showed that using wood for cooking increases the odds of KC, but multivariable analysis showed the association was not significant. In China, wood impregnators (the people who

introduce chemical substances into wood in order to improve its characteristics and impart new properties) have been shown to likely develop skin cancer (37). Upon burning, wood compounds can be absorbed by the skin and cause inflammation, increasing the risk for cancer (38). Univariable analyses showed that wood, coal, paraffin and gas (as either a cooking fuel or a fuel for heating) increased the odds of MSC, however, in multivariable analyses the association diminished. Literature has shown that industrial workers with paraffin exposure are at a higher risk of developing skin cancer (39–41).

The strength of the current study is that it addresses the existing gap in knowledge on the skin cancer risk factors in the Black population. Even though the study participants were recruited from one study site (limiting the generalizability of findings to SA Black population), the Johannesburg population is essentially a mixture of all SA provinces. Johannesburg is a central hub of economic activity in SA (42). People from all SA provinces migrate to Johannesburg for economic advancement, and for medical treatment; hence, this sample is a good representation of the Black SA population. Our findings were consistent with existing literature on the association between KC and smoking, and KC and HIV. New associations were also found; using coal as a cooking and a heating fuel, although not significant in the adjusted model (thereby warranting further investigation). Although risk factor information collected depended on self-reported data from participants, the diagnoses of skin cancers were definitive as all cases had a laboratory report confirming a diagnosis.

The limitations of this study are that UVR was not adjusted for in the analysis, as we did not have a measure of sun exposure (a well-established skin cancer risk factor). However, we did not anticipate that this would cause a problem in the analysis as both controls and cases were assumed to be exposed to the same degree of ultraviolet light as they live in the same country, hence exposure to the same intensity of UVR (same latitude and longitude). The study did not collect all risk factor information relating to skin cancer for example; family history of skin cancer, trauma to a site of skin cancer, information on albinism, among other factors, were not captured since the original study's aim was to collect major risk factors for all cancers. The conception of the original study did not focus on skin cancer risk factors. The selection of participants in the current study may have underestimated ratio of cases. We had very few BCC cases, as most of the BCC cases are referred to and excised in dermatology departments rather than radiation or medical oncology (where the participants of this study were recruited), thus there is a bias in the parent study in terms of selection of cases.

Conclusion

In this study KCs were the most diagnosed skin malignancy, consistent with global statistics (1). Although KC fatality rates are lower compared to those for MSCs, increased KC morbidity in the population would result in considerable budget expenditure for their management (10). The primary risk factor of skin cancer in non-Black skin is well established (the UVR exposure), however, more data is needed to explain risk factors in the Black population. The unexplained risks in the Black population shown in this study to be of possible importance were smoking, rural dwelling and HIV positive status for KC and being a rural dweller for MSC.

It is apparent that skin cancer does occur in a Black population. A recommendation is made to prevent HIV exposure and/or immunosuppression and to promote non-smoking behaviours. Rural dwellers should be made aware of the potential risk they have of skin cancers and therefore encouraged to do self-checking or screening of skin cancer especially on anatomic sites known to commonly experience skin cancer in the Black population group. The latter recommendation will help in early detection of skin cancer and therefore result in good prognosis of skin cancer. In addition, further research is required on combustible fuels and skin cancer development.

Abbreviations

ASIRs: Age-Standardized Incidence Rates; BCC: Basal Cell Carcinoma; CI: Confidence Intervals; DNA: Deoxyribonucleic Acid; HIV: Human Immunodeficiency Virus; ICD-O3: International Classification of Diseases for Oncology, Version 3; ICD-03 m: Morphology of cancer; ICD-03 t: Topography/site of cancer; JCS: Johannesburg Cancer Study; KCs: Keratinocyte Cancers; *lr:* Likelihood ratio test; MSCs: Melanoma Skin Cancers; NCR: National Cancer Registry; NHLS: National Health Laboratory Service; NMSCs: Non-Melanoma Skin Cancers; OR: Odds Ratio; P-value: Probability Value; SA: South Africa; SCC: Squamous Cell Carcinoma; UVR: Ultraviolet Rays

Declarations

Ethical considerations

Approval to conduct the study was obtained from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, clearance certificate number: M181191. Permission was obtained from the respective proprietors of the primary dataset.

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Authors' contributions

ES, MSM and BCN conceptualized the study. WCC provided the dataset. BCN, MSM and ES were responsible for data analysis. ES, MSM, and LK supervised the project. BCN wrote the first draft. CYW provided expert advice during the drafting of the manuscript. All authors corrected, revised, and approved the final manuscript.

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Availability of data and materials

The data set for this publication is not publicly available and can be obtained from the corresponding author on request.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

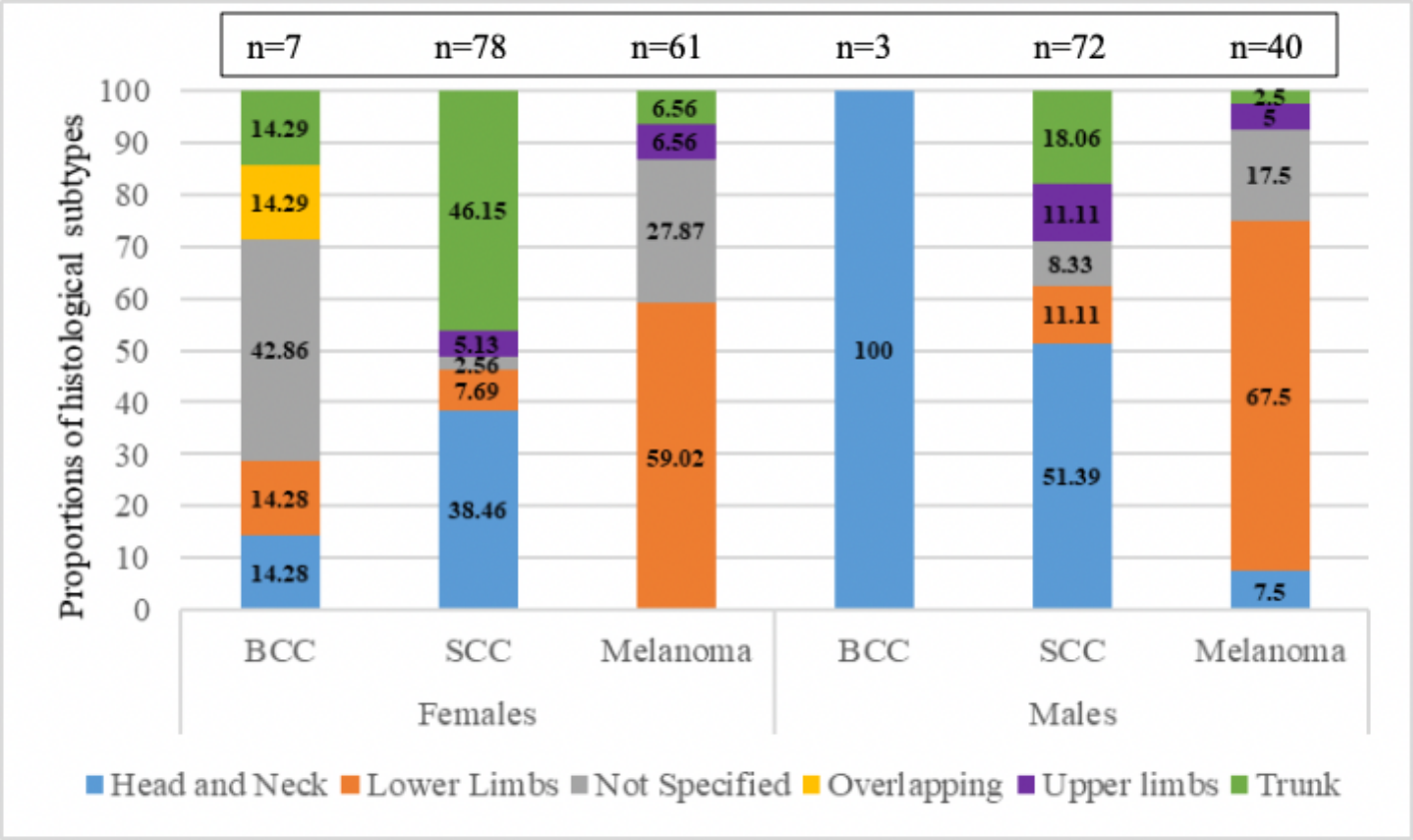

Figure 1

Histological spectrum and anatomical site of distribution of skin cancers in the Johannesburg Cancer Study, 1995-2016. Note: BCC – Basal cell carcinoma, SCC – Squamous cell carcinoma. Sites include 'head and neck', 'lower limbs', 'not specified' (i.e. unknown), 'overlapping' (could be in multiple anatomical categories), 'upper limbs' and 'trunk'.