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Solar ultraviolet radiation in Africa: a systematic review and critical evaluation of the health risks and use of photoprotection

Robyn M. Lucas,[a] Mary Norval[b] and Caradee Y. Wright*[c]

Most information on the harmful health effects of solar ultraviolet radiation (UVR) has been obtained in populations in which the majority has fair skin. Here a systematic review of evidence on diseases related to solar UVR in Africa was undertaken, and the appropriateness of effective photoprotection for these people considered. There are few population-based studies on UV-induced skin cancers (melanoma, squamous and basal cell carcinomas) in Africa, although limited reports indicated that they occur, even in people with deeply pigmented skin. The incidence of melanoma is particularly high in the white population living in the Western Cape of South Africa and has increased significantly in recent years. Cataract is extremely common in people of all skin colours and is a frequent cause of blindness, particularly in the elderly. For both skin cancer and cataract, the proportion of the disease risk that is attributable to exposure to solar UVR in African populations, and therefore the health burden caused by UV irradiation is unclear. There was little published information on the use of sun protection in Africa. The potential disease burden attributable to solar UVR exposure of Africans is high, although accurate data to quantify this are sparse. Information is required on the incidence, prevalence and mortality for the range of UV-related diseases in different populations living throughout Africa. Photoprotection is clearly required, at least for those subpopulations at particularly high risk, but may be limited by cost and cultural acceptability.

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Introduction

Africa comprises more than 55 countries and spans latitudes between 40° North and 34° South. Its topographical landscape includes mountain ranges, coastal plains and high altitude plateaus. Maximum ambient daytime temperatures (excluding humidity effects) may exceed 35 °C. Cloud and rainfall are

[a]*National Centre for Epidemiology and Population Health, The Australia National University, Canberra, Australia*
[b]*Biomedical Sciences, University of Edinburgh, Edinburgh, UK*
[c]*South African Medical Research Council and University of Pretoria, Pretoria, South Africa. E-mail: cwright@mrc.ac.za*

Robyn M. Lucas

Professor Robyn Lucas is a medically trained epidemiologist and public health physician. She is Head of the National Centre for Epidemiology and Population Health at the Australian National University. Her research focuses on the risks and benefits of sun exposure for human health, and possible associations with autoimmune diseases such as multiple sclerosis.

Mary Norval

Mary Norval is Professor Emeritus at the University of Edinburgh in Scotland. Her research interests are based on the effects of ultraviolet radiation on human health, especially immunological aspects.

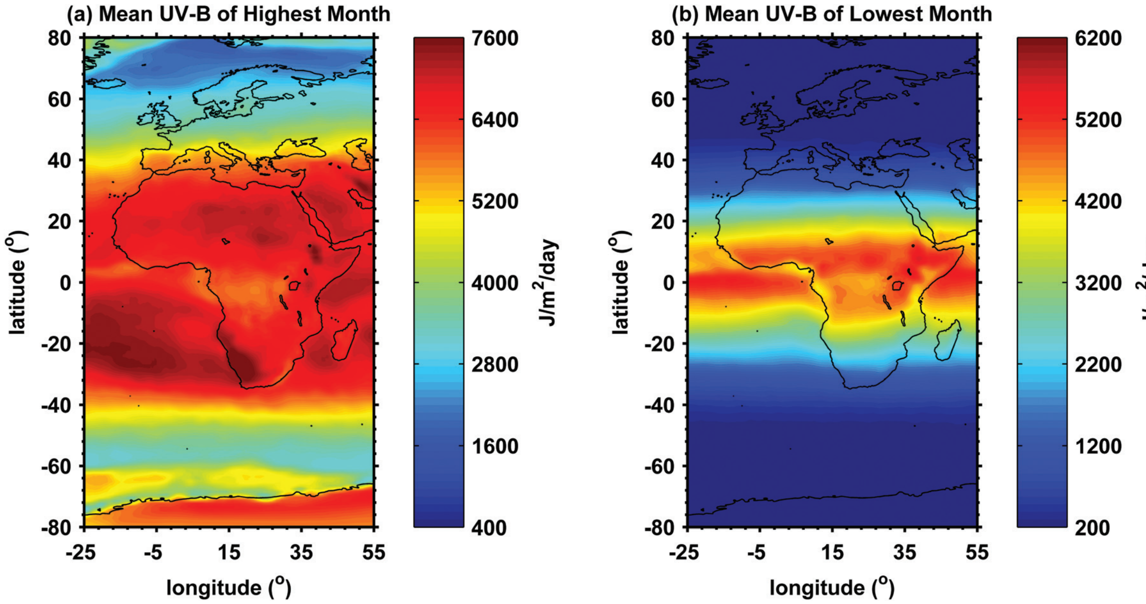

Fig. 1 (a) Mean ambient UVB of highest month and (b) mean ambient UVB of lowest month over the continents of Africa and Europe. Figure compiled by Ilias Fountoulakis (Aristotle University of Thessaloniki, Greece) using data from http://www.ufz.de/index.php?en=32688.

highly variable. The levels of ambient solar ultraviolet radiation (UVR) throughout most of the year over much of the African continent are high (Fig. 1), with the UV Index (UVI) being frequently extreme (11+).[1,2] In 2010, about 60% of Africans lived within rural areas[3] and were therefore likely to be out-of-doors for most of the daylight hours. The health consequences of this combination of high ambient UVR and long periods outdoors depend on individual skin phototypes and sun protection behaviours. The peoples of Africa belong to several thousand ethnic groups with a wide range of skin colours. Sub-Saharan Africa is dominated by Black populations and northern Africa by Arabs. In some sub-Saharan countries, White people of European origin account for a significant proportion of the population, for example 8.8% in South Africa.

Caradee Y. Wright

Dr Caradee Wright is a Specialist Scientist at the Environment and Health Research Unit of the South African Medical Research Council and leads the Climate and Health Research Programme. She is also affiliated with the University of Pretoria. Her research focuses on personal solar ultraviolet radiation exposure, personal dosimetry, health risk assessment and skin cancer prevention.

Sun exposure has both beneficial and adverse effects on health. The major positive outcome is the production of vitamin D which is required for bone health and possibly for protection against a range of diseases.[4] Here we focus on the most common negative health outcomes of exposure to solar UVR within the context of the varying climate and diverse peoples of Africa. Strategies for, and use of, personal photoprotection of African populations are also reviewed.

Review methods

A systematic review of the evidence on skin and eye diseases known to be caused by sun exposure in Africa, and on practices relating to photoprotection was conducted using the PRISMA guidelines.[5] PubMed was searched for studies with full texts in English, published between 1990 and 2014. When none or very few articles were found in this time period, earlier years were included. The terms listed in Table 1 were used for the separate searches, and Africans were defined as people living in Africa. We also searched the reference lists of included papers to ensure that no studies were omitted.

Table 2 shows the number of records identified from the database search and the number of studies included in the review, using an adapted schematic from Moher *et al.*[5] The search yielded many articles on skin cancer and ocular effects in Africa but the majority were not relevant as they consisted solely of case reports or clinical management, or were part of reviews. All studies that provided estimates of incidence or prevalence in defined populations groups were included. Several included a small number of participants, and were limited to people with a specific underlying disorder such as

Table 1 Search strategy

Term Group 1	Term Group 2	Term Group 3	Combinations
Skin cancer OR Melanoma OR Non-melanoma skin cancer OR Basal cell carcinoma OR Squamous cell carcinoma OR Cataract OR Pterygium OR Eye tumour OR Sunburn OR Polymorphic light eruption	Sun protection OR Sun exposure OR Shade OR Sunglasses OR Sunscreen OR Umbrella	Africa OR African OR Name of each African country	Term from Group 1 plus Term from Group 3 until all combinations exhausted Term from Group 2 plus Term from Group 3 until all combinations exhausted

Table 2 Adapted PRISMA 2009 Flow Diagram in tabular format illustrating records identified and included in this review

		Skin cancer	Ocular effects	Sun protection
Identification	Records identified by title through database searching	852	1079	640
	Records identified through other sources	30	35	16
Screening	Records after duplicated records removed	294	471	132
	Records screened by Abstract	200	317	68
	Records excluded	94	54	64
Eligibility	Full-text articles assessed for eligibility	50	154	31
	Full text articles excluded (case report, clinical management or review)	26	41	13
Included	Studies included in qualitative synthesis	24	113	12

oculocutaneous albinism (OCA).[6] Only three studies reported on the acute health effects of sun exposure.[7–9] These are considered separately in the following section and are not included in Table 2. There was a notable lack of studies about sun protection practices in Africa.

Acute adverse health effects of sun exposure

Sunburn. Sunburn is the best known acute effect of excessive sun exposure.[10] People with fair skin are at highest risk of sunburn, but those with dark skin can also experience it.[11,12] The natural sun-protection factor (SPF) of black skin is about 13 compared with about 3 in light skin.[13] One of only two reports focusing on sunburn in Africa found that 56% of children aged 11–14 years, attending South African primary schools, were sunburnt during the previous summer (60% with white/light brown skin, 42% with brown/black skin).[8] The second found that sunburn was experienced by outdoor workers during hot weather in South Africa.[7] Episodes of sunburn have been associated with an increased risk of cutaneous melanoma (CM)[14] and basal cell carcinoma (BCC)[15] [see section below].

Photoconjunctivitis and photokeratitis

Photokeratitis, inflammation of the cornea, and photoconjunctivitis, inflammation of the conjunctiva, are considered as sunburn of the tissues on the surface of the eyeball and eyelids. No information on the incidence of either disorder in African populations was located. Nevertheless, considering the high solar UVR and the clear skies and reflective terrain over parts of Africa, acute ocular damage is likely to occur. In support, in a preliminary study based in South Africa, outdoor workers reported painful eyes and blurring of vision during the hottest weather which may indicate ocular sunburn.[7] Conjunctivitis (diagnosed as allergic conjunctivitis) was significantly more common in technical/outdoor workers than in non-technical/indoor workers in the Delta State of Nigeria which lies near the Equator,[9] and thus may represent photoconjunctivitis due to high dose exposure to solar UVR.

Light-sensitive dermatoses

The light-sensitive dermatoses, such as polymorphic light eruption, are less common in people with pigmented skin and rarely occur in regions near the Equator; therefore they are unlikely to constitute a major health problem. Indeed in the only report found from an African country, as few as 0.4% (64 cases) of patients attending a dermatology clinic in Lagos, Nigeria, had light sensitive dermatoses, the majority being hydroquinone-induced.[16]

Chronic adverse health effects of sun exposure

Skin cancer. Studies carried out on non-white populations, mainly in the USA[11,17–20] indicate that a high content and proportion of cutaneous eumelanin (giving a brown-black colour to the skin) confer protection against the development of skin tumours – estimated as a 60-fold decrease in black compared with white skin.[17,21] In fair-skinned people, the commonest skin tumours are BCCs, followed by squamous cell carcinomas (SCCs) with CMs least frequent. Solar UVR is the major environmental risk factor for these cancers in such populations:[22] cumulative sun exposure for SCC, intermittent solar UVR, particularly in childhood and adolescence, for BCC, and sunburning episodes from childhood onwards together with cumulative sun exposure for CM.

The 24 reports which investigated skin cancer in African countries are listed in Table 3, together with a summary of each set of findings.[23–46] The majority comprised a small

Table 3 Skin cancer in African countries (listed alphabetically in each of the three sections according to name of country)

Reference	Study years	Location	Study population/sample	Main findings
I. Descriptive studies of skin cancer incidence:				
23	1968–1997	Cancer Registry, Kenya	74 cases BCC	Extrapolated to calculate race-specific annual incidence rate per million population in Kenya as 58.5 in Caucasians, 0.065 in Africans
24	1966–1975	Soweto, South Africa	Survey of skin tumours in Blacks; 101 cases SCC, 83 CM, 9 BCC	SCC mainly on head/neck/lower limbs; 84% CM on lower limbs. Average annual incidence of CM per 100 000 black population of Soweto estimated as 0.78 in men, 0.87 in women
25	1990–1995	Cape Town, South Africa	595 primary invasive CMs in whites	Annual age-standardised incidence per 100 000 white population in Cape Town estimated as 27.2 in men, 22.2 in women. Most on lower extremity and trunk, with superficial spreading type commonest
26	2000–2004	Cancer Registry, South Africa	All histologically confirmed cases of skin cancer, totalling 44 716	See Table 5 for incidence of SCC, BCC and CM in the 4 population groups of South Africa
II. Studies of determinants of skin cancer:				
27	1992	Alexandria, Egypt	Case-control study: 136 NMSCs, 145 controls with black, brown, olive and fair skin	Increased relative risk of NMSC with fair skin, ease of sun burning, outdoor occupation, degree of sun exposure and lack of clothing
28	1962–1972	Sudan	1225 skin cancer biopsies	63% SCC (North Sudan, light brown skin, most on head/neck; South Sudan, black skin, most on legs in pre-existing ulcers); 19% CM (almost all in North Sudan with 61% on soles of feet); 15% BCC (73% on head/neck)
29	2001–2010	Northwestern Tanzania	64 OCAs with histopathological diagnosis of skin cancer	Median age 30 years; 84% outdoor workers, late presentation common, head/neck most frequent body site; 75% SCC, 23% BCC, 2% CM
III. Descriptive studies of type, histology and body site of skin cancers:				
30	1985–2004	Cotonou, Benin	16 cases of skin cancer	Skin cancer rare; 5 CM, 6 SCC and 5 BCC in 5 OCAs, 1 White and 10 Blacks
31	1989–2004	Upper Egypt	262 histologically confirmed cases of skin cancer in Arabs with light to olive skin	77% BCC (most of face), 15% SCC (most on face and extremities), 8% CM (on face and lower limbs)
32	1999–2005	Addis Ababa, Ethiopia	50 cases primary CM	96% nodular; 64% on foot; poor prognosis
33	2007–2013	Addis Ababa, Ethiopia	2343 cutaneous biopsies	22% malignant of which 8% SCC (in sites of chronic ulceration/previous burns), 4% CM, 3% BCC
34	2007–2010	Lilongwe, Malawi	406 surgical oncology cases	6% CM; women : men 2 : 1
35	1960–1967	Ibadan, Nigeria	435 epidermal cancers in Blacks	67% SCC (25% on head/neck), 24% CM (most on foot), 5% BCC
36	1984–1987	Port Harcourt, Nigeria	18 cases of histologically confirmed skin cancer including in 3 OCAs	SCC (on several body sites, 3 OCA participants), 22% BCC (on face); late presentation very common
37	1978–1989	Zaria, Nigeria	775 histologically confirmed skin cancers	67% SCC (13% on face, 58% on extremities, most on leg), 19% CM (89% on foot), 2% BCC (on head and neck); late presentation very common
38	2000–2004	Calabar, Nigeria	63 histologically confirmed skin cancers	37% SCC (commonest on lower limb), 8% CM (commonest on lower limb), 8% BCC (commonest on head/neck/upper limb)
39	2006–2007	Calabar, Nigeria	19 Blacks (including 2 OCAs) with histological diagnosis of SCC	SCCs represented 51% of all skin malignancies; 58% SCC on lower limbs in Blacks in site of chronic ulceration/inflammation but on head in OCAs; poor prognosis due to late presentation
40	2000–2009	Calabar, Nigeria	Histologically confirmed skin cancers in 146 Blacks and 16 OCAs	In Blacks, 36% SCC, 10% CM, 1% BCC (49% on lower limb, 22% on head/neck). In OCAs, 56% SCC, 38% BCC and 6% CM
41	2001–2013	Lagos, Nigeria	197 skin tumour biopsies	31% malignant with SCC commonest, followed by CM
42	1982–2007	Benin City, Nigeria	694 skin biopsies	27% malignant of which 33% CM, 24% SCC, 10% BCC; leg and foot commonest sites; increasing number of cases with time
43	1950–1970	Dakar, Senegal	972 skin cancer biopsies from Blacks	79% SCC (80% on lower limbs), 9% CM (67% on foot), 2% BCC (89% on head/neck)
44	1972–1985	Cape Town, South Africa	40 Blacks with CM	68% acral lentiginous CM, delay in presentation/advanced disease; 5-year survival rate of 25%
45	1969–1983	Pretoria, South Africa	175 Blacks with acral lentiginous CM, confirmed by histology	98% CM on foot; relatively advanced stage at initial presentation; 73% died within 1 year of presentation, 17% survived more than 3 years
46	1971–1983	Nyankunde, Zaire	794 biopsies from patients with malignant diseases (skin colour not specified but probably all black)	24% skin cancers of which 9% SCC, 6% CM, 1% BCC; 43% occurred in sites of trauma/chronic ulcer

BCC basal cell carcinoma, CM cutaneous melanoma, NMSC non-melanoma skin cancer, OCA oculocutaneous albinism, SCC squamous cell carcinoma.

number of individuals, sometimes of a single ethnicity, living in a geographically defined area of one country. Generally, SCCs were the commonest dermatological malignancy found in black people, and were most frequently located on the lower limb in sites of chronic ulceration and previous burns.[24,26,33,36–42,45,46] CMs were the next most common in black people and were mainly acral, located on the foot. Thus there are marked differences between the body sites of SCCs and CMs in those with black and fair skin in Africa. This could be due to the more frequent occurrence of chronic scarring following burns and injury and of inflammation caused by parasitic and other skin infections on the feet and legs in Blacks compared with Whites which may provide an opportunity for tumour development in these body sites. In contrast to the relative proportions of the different types of skin cancer in Whites, BCCs were the least frequent, although had a similar presentation and body site distribution in Blacks as in Caucasians. The SCCs and CMs tended to present late and were frequently more aggressive and prone to metastasise in Blacks compared with Caucasians.[36,40,44,45] This may be explained by the difficulty in diagnosing tumours in black skin, the lack of self-examination and screening, and for cultural and financial reasons plus the shortage of clinical facilities for many Black people.

Four studies included data on the incidence of skin cancer (Table 3, section I). The earliest, based on 83 histologically confirmed cases of CM in Blacks living in Soweto, South Africa, in 1966–75 gave an estimated annual incidence per 100 000 Blacks in Soweto (population approximately one million) of 0.78 for men and 0.87 for women.[24] Based on 595 histology reports, Saxe *et al.*[25] estimated the age-standardised incidence rate in 1990–1995 for primary invasive CM in the White population of Cape Town (approximately 490 000) as 27.5 per 100 000 for men and 22.2 per 100 000 women. No change in the annual incidence rate over the period of the study occurred. In a retrospective study of all BCCs documented in the Kenya Cancer Registry from 1968 to 1997, the race-specific mean annual incidence rates of BCC per million of the Kenyan population were 58.5 for Caucasians and 0.065 for Blacks.[23] However this calculation was based on only a small number of BCC cases: 35 in Caucasians and 39 in Blacks.

The results of a survey of all histologically confirmed cases of skin cancer (n = 44 716) in South Africa that were reported to the National Cancer Registry between 2000 and 2004 are shown in Table 4.[26] The South African population is divided into four to reflect the pre-1994 legislated groupings: Black, White, Coloured (mixed ancestry between White and Black or between Black and Asian/Indian with skin colour ranging from pale to dark brown), and Asian/Indian (commonly called Asian in South Africa). There was no change in the incidence rates over the years of the survey. The highest incidence of all three skin cancers occurred in the Whites, followed by the Coloured, then Asian/Indian, and then Black. CM was the least frequent skin tumour and BCC the most frequent, except in black people. It is noteworthy that the incidence of CM in Blacks was about half of the incidences of SCC and BCC, which was a higher proportion than in the other three population groups. This difference could be explained by acral lentiginous melanoma being the commonest melanoma type only in the Black population where it is unlikely that solar UVR present a direct risk factor.[26] It is also possible that there are a higher number of undiagnosed BCCs and SCCs in the Black compared with the other three population groups, resulting in different ratios. As Blacks comprise almost 80% of the population of South Africa, even the low incidences of SCC, BCC and CM in this group may be significant in terms of national health burden. Although accurate data were not available after 2004, the South African Melanoma Advisory Board estimated an incidence in 2009 of 69 cases of CM per 100 000 Caucasians living in the Western Cape[47] (white population around 1.4 million); this rate is amongst the highest in the world and is almost double the annual incidence reported in 2000 to 2004 in white South Africans.[26]

Table 4 Mean annual age-standardised incidence of reported basal and squamous cell carcinomas and cutaneous melanoma per 100 000 persons in the Black, Asian/Indian, Coloured and White population groups of South Africa, 2000–2004[41]

	Black	Asian/ Indian	Coloured	White	All
Basal cell carcinoma	4.7	13.0	85.7	311.1	76.7
Squamous cell carcinoma	4.6	7.0	41.5	101.3	29.3
Cutaneous melanoma	2.2	1.8	10.0	37.0	9.2

In contrast to the studies based in sub-Saharan Africa where the majority of the population has deeply pigmented skin, similar work in Egypt, where people of Arab ancestry with brown/olive skin predominate, presents a different picture. Here BCCs were the most common skin cancer, followed by SCC and then CM very rarely.[31] In Alexandria, Egypt, the relative risk of developing a non-melanoma skin cancer (NMSC) (BCC and SCC combined) was calculated as 2.3 for olive-skinned and 3.8 for fair/medium-skinned individuals compared with brown-skinned individuals.[27] There was a fifteen-fold increased risk of NMSC for fair/medium skinned people with extensive exposure compared with brown/black skinned people with light or moderate sun exposure. It was concluded that over 60% of the risk of developing NMSC could be attributed to sun exposure and about 45% to skin colour.[27] In North Sudan where most people have light brown skin, SCCs tended to occur on the head and neck which are amongst the most frequently sun exposed body sites, while in South Sudan where most have black skin, SCCs tended to occur on the legs in sites of pre-existing ulcers or trauma.[28] In the latter, exposure to solar UVR may not represent a strong direct risk factor for the development of these tumours. The incidence of skin tumours in the Northern African countries has not been recorded.

Some ethnic groups in Africa have a significant proportion of people who have OCA, for example 1/1000 in the Tonga tribe in Zimbabwe,[48] and 1/1970 in the Vhavenda tribe in South Africa.[49] Individuals with this disorder have impaired formation of the UV-protective pigment, melanin, and are fair-skinned with light-coloured eyes, making them particularly sensitive to UVR.[6] As they have a considerably higher than normal risk of developing skin cancer, particularly SCCs,[6,29,50,51] the prevalence of OCA may thus affect estimates of skin cancer incidence in Black populations. Furthermore, the high prevalence of HIV infection in sub-Saharan Africa, currently estimated as 10% of the Black population, may lead to a higher-than-expected incidence of SCC in Blacks, probably due to the lack of an effective immune response to combat the initial or a progressive stage in tumour development.[52,53]

Eye diseases

Chronic UVR exposure is a major risk factor for several eye conditions that become more common with increasing age (and thus longer sun exposure) and may cause loss of vision. Pterygium is a wing-shaped invasive growth of the conjunctiva that can impinge on the cornea. A proportion of pterygia contain dysplastic and neoplastic changes, and pterygium may represent a continuum with SCC of the cornea or conjunctiva (SCCC).[54,55] The main risk factors for pterygium are repeated exposures to UVR and to dust, with both together, such as found in desert areas, presenting the highest risk. Pterygium is relatively common in Africa (Table 5)[9,56–70] with a higher prevalence in outdoor workers,[58] some occupational groups,[9,57,61–62,66] or in association with HIV infection.[68]

SCCC is a rare tumour caused by excessive exposure to UVR [70,71] which is more common at lower latitudes.[72] There is a significantly increased risk of SCCC in association with HIV/AIDS in both the USA[73] and Africa.[74,75] For example, the incidence rate (per 100 000 person years) rose from 0.2 in 1960–71 to 2.1 in 1995–7 in Uganda,[76] and from 0.17 in 1990 to 1.8 in 1999 in Zimbabwe,[77] believed to be due to the increased prevalence of HIV/AIDS. Evidence is equivocal currently regarding UVR as a risk factor for malignant melanoma of the eye,[78] an uncommon tumour in both Black and White populations.

Cataracts account for 50% of cases of blindness world-wide, and sub-Saharan Africa has the highest regional burden of blindness (20% of world's blindness and only 11% of world's population).[79] Solar UVR is a risk factor for cortical cataract, with weaker evidence for a similar role in nuclear cataract. There is a high prevalence of avoidable blindness across Africa, with "senile" cataract the main cause in most locations (Table 6).[80–133] It is not possible to define the contribution of UVR exposure to the cataract burden, although in studies from Nigeria, mixed and cortical cataracts were the most prevalent in those with visual impairment.[134,135] Cataract begins earlier in African populations than in comparable populations in the USA or India.[97] It is more common in rural than urban areas,[105,107] and the effects on vision are compounded by poorer access to surgical services in these regions. In addition to the prevalence estimates, it is worth considering the absolute numbers of people affected by cataract that is at least partly caused by solar UVR exposure: over one million in Nigeria alone.[105]

Any dependence of ocular damage on skin or eye colour is not known and, while some UV-induced eye disorders are more common in black than in white populations, the relationship to biological differences rather than to lifestyle differences has not been investigated.

Strategies for sun protection

Personal photoprotection can decrease the solar UVR dose and thus ameliorate its harmful effects. Strategies include wearing protective clothing, wide-brimmed hats and sunglasses, seeking shade and applying sunscreen. Few reports were found on photoprotection in the context of Africa (Table 7).[136–146]

Shade

Trees can provide effective shade, depending on the denseness of their foliage.[147] In Africa, tree species and their leaf canopies are variable, ranging from the thorny acacia to large baobab. Man-made shade, such as awnings, can be effective

Table 5 Prevalence of pterygium in African countries (listed alphabetically according to name of country)

Reference	Location	Study population	Prevalence of pterygium
9	Warri, Nigeria	Petroleum industry workers	20% technical workers, 8% non-technical
56	Douala, Cameroon	New patients	1.1% (mean age 41.2 y)
57	Tarkwa, Ghana	Industrial gold mine workers	25.8%
58	Ibadan, Nigeria	New cases at the eye clinic	9%; 65% of patients outdoor workers; 40% had recurrence post-op
59	Imo State, Nigeria	New patients at eye clinic	11.5%
60	Anambra State, Nigeria	3 rural villages, adults 18–49 y	8.2%
61	Enugu State, Nigeria,	Cement factory, coal mine, saw mill & iron/steel workers	27.7% (pinguecula and pterygium)
62	Benin City, Nigeria	Commercial motorcyclists	25.7% of eyes
63	Ibadan, Nigeria	University drivers	5.6% (age 31–64 y)
64	Kano, Nigeria	Red eye presenting to eye clinic	11% due to inflamed pterygium
65	Nigeria	Elderly patients presenting at primary care (60+ y)	6.4%.
66	Osun State, Nigeria	Welders	17.5% (mean age 38 y).
67	Lagos, Nigeria	Presentations with conjunctival masses	89.5%
68	Lagos, Nigeria	Seropositive HIV/AIDS patients >15 y	19.0%
69	Kigali, Rwanda	Eye outpatients	4.4%
70	Harare, Zimbabwe	Patients with conjunctival tumours	53% ocular surface squamous neoplasia, 42% pterygium, 5% other

Table 6 Cataract-induced vision loss in African countries, focusing on prevalence (listed alphabetically according to name of country)

Reference	Study year (when stated)	Location	Age (y years)	Prevalence of bilateral blindness (<3/60 in better eye)	Main cause
80	1991	Mmankgodi, Botswana	60+ y	11%	Cataract (34%)
81	NS	Botswana	50+ y	3.7%	Cataract (46.9%)
82	NS	Two rural provinces, Burundi	50+ y	1.1%.	Cataract (55%)
83	NS	Limbe urban area, Cameroon	40+ y	1.1%	Posterior segment disease (29%), cataract (21%)
84	2005	Muyuka, South West Cameroon	40+ y	1.6%	Cataract (62.1%)
85	1992	North Province Cameroon	6+ y	1.2%	Cataract
86	1998	Cape Verde Islands	All	0.8% all ages; 11.4% >70 y	Cataract (57.7%)
87	1994	Bossangoa, Central African Republic	All	2.2% all ages; 11.4%	Onchocerciasis (73.1%)
				50+ y	Cataract (16.4%)
88	2007–8	Upper Egypt	≥40 y	9.3%.	Cataract (60%)
89	2008	Eritrea	50+ y	7.5%	Cataract (55.1%)
90	NS	Ethiopia	All	1.6%	Cataract (49.9%)
91	1989	Hamar tribe, Ethiopia	All	1.9% all ages; for 40+ y, <1% of men, 13% of women	Cataract
92	NS	Gurage Zone, Central Ethiopia	40+ y	7.9%	Cataract (46.1%)
93	2006	Gurage Zone, Central Ethiopia	40+ y	3.5%.	Cataract (59.0%)
94	1994–5	Jimma Zone, SW Ethiopia	All	0.85%	Cataract (56.8%)
95	1996	Gambia	All	0.43% all ages; 4.08% 50+ y	Cataract (48%)
96	2006–8	Tema, Ghana	40+ y	1.2%	Cataract (44.2%)
97	NS	Turkana tribe, NW Kenya	All	1.1%	Cataract in >45 y
98	2005	Nakuru District, Kenya	50+ y	2.0%	Cataract (42.0%)
99	NS	Rural areas, Kenya	All	0.7% all ages; 6.5% men, 9.4% women 60+ y	Cataract (36%)
100	2010	4 regions, Libya	50+ y	3.15%	Cataract (29%)
101	2011	Atsinanana region, Madagascar	50+ y	1.96%	Cataract (64%)
102	2009–10	Southern Malawi	50+ y	3.3%	Cataract (48.2%)
103	1990	Rural Segou region, Mali	All	1.7%	Cataract (54%)
104	1995	Dambatta, Kano State, Nigeria		1.14%	Cataract (54%)
105	2005–7	Nigeria	≥40 y	4.2%	Cataract (43%)
106	2002	Ife-Ijesha, Osun State, Nigeria	60+ y	5.6%	Cataract (42.3%)
107	2002	Rural south-west Nigeria	All	1.0% (mainly in the 50+ age group)	Cataract (44.4%)
108	NS	Egbedore, Osun State, Nigeria	All	1.18%	Cataract (47.4%)
109	1991	Akinalu-Ashipa, Osun State, Nigeria	All	0.9%	Cataract (48.1%)
110	NS	Anambra State, Nigeria	All	0.33% all ages; 2.62% 50+ y	Cataract (70.6%)
111	NS	SW Nigeria	60+ y	28.6%	Cataract (32.3%)
112	NS	Egbedore, Osun State, Nigeria	50+ y	6.3%	Cataract (56.0%)
113	2005	Egbedore, Osun State, Nigeria	50+ y	Cataract-related blindness: 2.0%	
114	2006–7	Akinyele, SW Nigeria	50+ y	Cataract blindness 2.0%	
115	2005	Sokoto State, Nigeria	All	1.9%	Cataract (51.6%)
116	2007	Plateau State, Nigeria	50+ y	Cataract blindness 2.1%	
117	NS	Atakunmosa West, Nigeria	5–120 y	1.1%	Cataract (57.2%)
118	NS	Ozoro, Delta State, Nigeria	40+ y	6.3%	Cataract (60%)
119	2004	Kaduna State, Nigeria	All	0.6%	Cataract (37.8%)
120	2005–7	National Blindness Survey, Nigeria	40+ y	4.2%	Cataract (43%)
121	2006	Western Rwanda	50+ y	1.8%	Cataract (65%)
122	2010	Cape Town, South Africa	50+ y	1.4%	Cataract (27%)
123	NS	Ingwavuma, KwaZulu-Natal, South Africa	All	1.0%	Cataract (59.0%)
124	2006	South Africa	60+ y women, 65+ y men	Cataract blindness 15.6%	
125	2005	Mankien, Southern Sudan	5+ y	4.1%	Cataract (41.2%)
126	2007	Kilimanjaro region, Tanzania	50+ y	2.4%	Cataract (52.4%)
127	1986	Central Tanzania	7+ y	1.26%	Cataract (22%)
128	2002	Southern Togo	All	2.47%	Cataract (44.4%)
129	1999	Sudanese refugees in Uganda	All	21%	Cataract (42%)
130	NS	SW Uganda	13+ y	1.6%4%	Glaucoma (38.5%) Cataract (23.1%)
131	1996	Mbandaka, Iboko and Lukolela, SW Equator, Zaire		20%	Cataract (54%)
132	2010	Southern Zambia	50+ y	2.2%	Cataract (47.2%)
133	1990–2010	North Africa and Middle East countries	All	2.1% (1990) 1.1% (2010)	Cataract 29.2% (1990) 23.4% (2010)

NS not stated.

Table 7 Sun exposure and photoprotection practices in African countries (listed alphabetically according to name of country)

Reference	Study years	Location	Study population	Main findings
8	2012	All nine provinces, South Africa	707 schoolchildren from 24 government primary schools	56% reported sunburn last summer; 50% ever wore a hat; 66% ever used sunscreen
136	2010–2011	Tizi-Ouzou, Algeria	435 children, aged 5–15 years	Majority spent >60 min outside per day at end of both summer and winter
137	2008–2009	Cairo, Egypt	75 girls, aged 14–17 years	Mean daily sun exposure 22 min; mean body surface exposed <20%
138	2007	Rabat, Morocco	411 adults (84% female), mean age 40 years	38% low levels of knowledge of sun exposure risks and sun protection options; 50% used sunscreens; sunscreen cost noted as prohibitive
139	2008	Rabat, Morocco	2896 adults stratified by origin (urban/rural) and gender	52% regularly exposed to the sun for >2 hours during peak UVR times; 16% of them used no photoprotection; women, rural residents and workers used more photoprotection than their counterparts
140	1990	Cape Town, South Africa	231 White adult beachgoers at 3 Cape Peninsula beaches	Half (more females) used sunscreen ≥ SPF15; 90% cited skin cancer as a potential consequence of excess sun exposure
141	2002	Durban, South Africa	30 children and adolescents, aged 4–14 years	Children received an average of 4.6% of the total daily ambient solar UVR each day; boys received higher sun exposure than girls
142	Not stated	Limpopo, South Africa	90 children with OCA (mean age 11.8 years) attending a special needs school for the visually impaired	Children with OCA had at least one hat; girls sought shade more than boys; 38% used sunscreen
143	Not stated	Limpopo, South Africa	38 children with OCA, mean age 13 years	Sun protection practices used: 71% sunscreen, 100% hats, 21% sunglasses, 73% long skirts/trousers and 34% stayed indoors
144	1997	Kilimanjaro region, Tanzania	94 individuals with OCA attending outreach clinics, median age 16 years	50% had read about skin cancer risk, 63% knew skin cancers were related to sun exposure and 78% knew that skin cancer was preventable; 96% applied sunscreen daily
145	Not stated	13 locations in northern Tanzania	164 individuals with OCA, 52% <16 years	Risk factors for sun damage: 50% spent >6 hours per day in the sun, 62% had no hat, 80% wore short sleeves
146	2005–2006	Tunis, Tunisia	197 patients with melasma, aged 19–60 years, 95% women	Sun exposure reported as a triggering factor for melasma by 51% women and an aggravating factor by 84%

OCA oculocutaneous albinism.

depending on design, quality and ease of use.[148] The shade should be effective at preventing exposure to both direct and diffuse solar UVR[149] and additionally in Africa should provide temperature control for heat relief. Umbrellas are a handheld form of shade, and are used in many African countries. Depending on diameter, fabric colour and type, and holding position, an umbrella may block up to 90% of solar UVR exposure of the head.[150] Given the cost of an umbrella, this is unlikely to be a feasible option for many Black people in Africa.

Hats and clothing

Clothing can provide protection against solar UVR exposure depending on the extent of coverage, textile colour, weave, porosity and weight.[151] In some African countries, traditional female dress requires full body coverage (with the face covered/uncovered). Headgear, such as veils, kufi (brimless, rounded cap worn by men in Western Africa) and mokorotlo (traditional Basothu hat), differs between cultures and tribes. Wearing a broad-brimmed hat (brim > 10 cm) or a hat with flaps over the ears and neck is an effective way to reduce head and neck exposure. Nevertheless, uptake of such hats is challenged by fashion, culture, cost, and temperature-related factors. In northern Tanzania, many individuals with OCA do not wear hats and most wear short-sleeved shirts.[145] A Moroccan survey found that 70% of adults were regularly exposed to the sun during midday hours, with 66% wearing no hat and 16% using no photoprotection.[139]

As agriculture is an important economic activity in Africa, the health risks of farm workers due to chronic exposure to high solar UVR merit consideration, but have not been documented. While most African countries have occupational health and safety legislation for the protection of staff, specific mention of the hazards of solar UVR is unlikely. In addition whether African outdoor workers would wear sun protective clothing and hats is unknown.

Sunglasses

Sunglasses can provide excellent eye protection from both direct and diffuse/reflected UVR, but are costly and may not be culturally acceptable by some African populations. How commonly eye protection is used in Africa has not been systematically investigated. Among Moroccans, sunglasses as a photoprotection option was used by only 19% of the study population.[138]

Sunscreen

Topically applied sunscreens are used widely for photoprotection, particularly in fair-skinned individuals, in developed countries. They are highly effective in decreasing the risk of sunburn, particularly if combined with wearing protective clothing and seeking shade. In addition, there is emerging evidence that regular sunscreen use lowers skin cancer risk and photoageing.[152] Sunscreens with high SPFs, 50+, are now available.[153] These may be useful in environments where the UVI is high or extreme, circumstances that are frequent throughout Africa. It is particularly important that African people with fair skin adopt adequate sun protection strategies. A 1990 survey of fair-skinned South Africans found that only 5% used sunscreen with SPF 15 or higher at the beach.[140] In some African countries, such as South Africa, individuals with OCA are provided with sunscreen by the government free of charge. In addition to supply, detailed information and advice on the use of such sunscreens are required.[142,144]

While the purchase of sunscreens per capita in Europe, North America, Latin America and Asia is known,[153] such data are not available for African countries. Commercial sunscreens are unlikely to be in common use in Africa because sunburn occurs less frequently in pigmented skin than in white skin, the cost of sunscreens may be beyond the means of the majority, sunscreens are not widely available, and/or there is little public health guidance to promote their use.

Some rural tribes in southern Africa have traditional methods for skin protection which may fulfil a similar function to sunscreen. These come in the form of clays, found locally and rich in the mineral kaolinite, which are applied to the face. Two such clays were shown recently to have SPFs around 3 with broad spectrum protection.[154] These may provide cost-effective, easily obtainable and culturally-acceptable alternatives to conventional sunscreens in Africa.

Information for the general public

The WHO INTERSUN programme provides information and practical advice on the health effects of solar UVR exposure. It recommends use of the UVI, providing estimates of predicted levels of solar UVR, to guide sun exposure, and suggests that personal photoprotection is used when the UVI is 3 or greater. However the UVI is not well known or understood, even in countries where awareness campaigns have been extensive,[155] and its effectiveness in influencing behaviour has not been assessed. Furthermore, a simple message using the UVI to provide recommendations on the amount of time that can be spent outdoors safely is not appropriate for African countries in which the population is highly heterogeneous, comprising a wide range of ethnic groups, skin types and photosensitivities. A very recent survey found that people with deeply pigmented skin, particularly in South Africa, were less familiar with the term "sunburn" than population groups with less pigmented skin; when it was explained as a change in skin colour associated with pain or tenderness, many agreed that they had in fact experienced sunburn.[156] Special attention is warranted to protect children, those with compromised immunity and people with OCA from over-exposure to the sun, and to encourage changes in lifestyle that promote safe sun behaviour throughout life. Only two African Cancer Associations, Namibia and South Africa, mention on their websites that they run skin cancer prevention and sun awareness programmes. In parallel, Vision 2020 strives to reduce the burden of eye disease and blindness in Africa.[157] Beyond the health benefits of such campaigns, they are likely to strengthen national economies by reducing the financial burden to health care systems caused by eye and skin cancer therapies. In the USA, for every dollar invested in the SunWise programme, 2–4 dollars in medical care costs and productivity is saved.[158]

Future research

Few reports were found on the prevalence and incidence of diseases associated with exposure to solar UVR in African countries in comparison with studies in many other parts of the world, despite the potential for high-dose exposure to solar UVR. In addition such investigations frequently comprised a small number of participants, and only a minority involved work carried out in the last 10 years. Thus there is a pressing need to collect data on a large, preferably country-wide scale, regarding the frequency of SCC, BCC, CM and cataract in populations of varying skin colours living in different locations throughout Africa. Only then can an estimate of the disease burden be made and any trends in incidence determined. It is particularly important to monitor any changes in CM incidence and mortality data in the fair skinned population living in South Africa. Over time, it is likely that changes in personal sun exposure will occur, for example, due to migration from rural to urban areas potentially leading to a reduction in solar UVR overall and possibly more intense "recreational" intermittent exposure, or wearing less clothing potentially leading to greater exposure to solar UVR with increased risk of sunburn. Legislation and policy changes are required to ensure appropriate shade is incorporated into the design of buildings in Africa, especially for health clinics and school playgrounds. Knowledge about sunglasses, improvements in the acceptability of wearing them and their provision at low cost would contribute significantly to the reduction of eye disease and blindness in Africa. Finally the impact of public health messages regarding "safe" sun exposure needs to be monitored, together with an estimate of the cost-effectiveness of such programmes in Africa.

Conflict of interest statement

The authors declare no conflicts of interest.

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