

Measurements of the anatomical distribution of erythemal ultraviolet: a study comparing exposure distribution to the site incidence of solar keratoses, basal cell carcinoma and squamous cell carcinoma

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Authors' Accepted Manuscript Version of :
Downs, Nathan and Parisi, Alfio (2009) Measurements of the anatomical distribution of erythemal ultraviolet: a study comparing exposure distribution to the site incidence of solar keratoses, basal cell carcinoma and squamous cell carcinoma. *Photochemical and Photobiological Sciences*, 8 (8). pp. 1195-1201. ISSN 1474-905X
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Abstract

Measurements of anatomical UV exposure distribution were made using miniaturized polysulphone dosimeters over a four year period between 2005 and 2008 in Toowoomba, Australia (28°S, 152°E). Anatomical UV exposures were expressed relative to the horizontal plane ambient UV. The UV exposures were compared with existing data detailing the anatomical distribution of basal cell carcinoma (BCC), squamous cell carcinoma (SCC) and Solar keratoses (SK). Surface UV exposures to unprotected skin surfaces have been presented for each of the face, neck, arm, hand and leg assessing a total of 1453 body sites (2491 measurements). Measured exposures are presented for the human facial region to a resolution of 5 mm. The median anatomical UV, expressed relative to the horizontal plane ambient UV for each of the face, neck, forearm, hand and leg regions of the body varied from 26%, 23%, 13%, 30% and 12% respectively in the 0°-30° SZA range; 39%, 36%, 17%, 35% and 23% in the 30°-50° SZA range; and 48%, 59%, 41%, 42% and 47% in the 50°-80° SZA range. Detailed positions of UV exposure measured over the face, neck, arm, hand and leg were more closely related to NMSC incidence data for the face and upper limbs. Further analysis with existing facial BCC and SK density data did not however show a direct relationship with the measured UV exposures highlighting the importance of other factors influencing the causation and localisation of facial NMSC.

Keywords: Ultraviolet, erythema, non-melanoma skin cancer, polysulphone dosimetry.

Introduction

Non melanoma skin cancer (NMSC) is the most common type of cancer observed in fair skinned populations¹. Of the types of NMSC, basal cell carcinoma (BCC) occurs more frequently, originating in the basal cell layer of the epidermis varying in depth from between 40 µm for the head, 50 µm for the arms and legs and 150 µm for the dorsal sides of the hand². Squamous cell carcinoma (SCC), affecting the stratified squamous epithelium occur frequently to exposed areas of human skin. The incidence of SCC and BCC increases with age^{3,4} and is strongly correlated in fair skinned populations living in low latitudes. Exposure to ultraviolet (UV) radiation plays a causative role in the gene mutation of skin carcinomas⁵, penetrating the dermal layer over the UVA waveband, reaching subcutaneous tissue⁶ and affecting the epidermal layer in both the UVA and UVB wavebands. The ambient UV incident upon skin surfaces of the human body is strongly dependent on geographical latitude, having a significantly greater intensity in lower latitudes due to higher solar elevation. Low geographical latitude and the predominately northern European ethnocentric origin of the modern Australian population contribute to Australia having the largest incidence rates of NMSC in the world, displaying a distinct latitudinal gradient⁷.

Like NMSC, actinic or solar keratoses (SK) are also commonly observed in fair skinned populations that are exposed to high ambient levels of UV radiation such as those which occur in Australia^{8,9}. These cutaneous lesions have been noted to be more prevalent on sun exposed regions of the body compared to BCC and SCC leading to SK being noted as potentially better markers of sunlight exposure than the presence of skin cancers⁸. In addition to SK forming in frequently sun exposed regions of the body, SCC have been linked to the presence of pre-existing SK lesions¹⁰ leading to their being recognised as either pre-cursors to, or representative of the developmental stages of SCC¹¹. In this research, the published facial distribution of SK¹² incidence and BCC¹³ incidence was compared to measured facial site UV exposure data in the 0°-30°, 30°-50° and 50°-80° solar zenith angle (SZA) ranges. This extends the work of previous research which has published NMSC site incidence data over broader regions of the body and face.

In 1979, Diffey¹³ published measurements of UV exposure made at 40 facial locations on a large fiberglass headform. These results were shown in comparison to detailed published BCC facial site incidence data¹⁴. Unlike the study of Diffey¹³ which utilised a mannequin headform, studies of sun exposure measured to individuals have not been able to accurately link measured exposures to the development of skin cancers due to the limited number of body sites that can be assessed on living human subjects and the extended latency period

between an exposure event and the development of a cancer. Furthermore, whilst the distribution of NMSC to the human body has been extensively documented including studies conducted by Peal and Scott¹⁵, Krickler et al.¹⁶ and Raasch¹⁷, detailed NMSC site distributions are often limited to broad regions of the body making direct comparisons between body surface exposure and NMSC site incidence difficult.

The pattern in UV exposure received by specific body sites, being dependent upon SZA is critical toward understanding frequency of incidence and anatomical distribution of NMSC present in worldwide populations. The current study provides results on the UV exposure distribution received by surfaces of the human body with variation in SZA to a spatial resolution of between 5 mm and 20 mm to the face, neck, forearm, hand and leg. This research extends previously detailed measurements of exposure recorded on the face over three SZA ranges¹⁸, where preliminary results were provided for a number of facial sites. These earlier results for UV exposures over the human facial topography are extended in this paper to provide detailed measurements of facial and body surface UV exposures made under low and high cloud cover conditions. Measurements of UV surface exposures are further compared with facial and body site NMSC and SK incidence data.

Methods

Exposure Ratio

Measurements of ultraviolet exposure were made using miniaturized polysulphone dosimeters. The miniaturized dosimeters used in this research were chosen to be small and flexible enough to be attached in large numbers to the complex surface topography of a life sized mannequin model. Each miniaturized dosimeter was made using a flexible card frame measuring approximately 10 mm by 15 mm with a clear circular aperture of 6 mm over which polysulphone film of an approximate thickness of 40 μm was adhered. Pre- and post-exposure measurements of polysulphone film absorbance were made at 330 nm using a spectrophotometer (model 1601, Shimadzu Co., Kyoto, Japan) and subsequent exposures were expressed relative to the horizontal plane exposure measured in proximity to the mannequin. Here, the exposure measured at any site and expressed relative to the horizontal plane exposure is given by:

$$ER = \frac{E_{site}}{E_{hor}} \quad (1)$$

where ER is the exposure ratio of the UV exposure measured at any given body site, E_{site} , and expressed relative to the horizontal plane exposure, E_{hor} . Both E_{site} and E_{hor} are the erythemal UV exposures measured with the dosimeters for the exposure periods listed in Table 1 within the SZA ranges 0° - 30° , 30° - 50° and 50° - 80° . For the SZA range 0° - 30° , measurements were made between November and March near solar noon, and varied for the SZA ranges 30° - 50° and 50° - 80° depending on the calculated SZA position for the months April to October. The ER was chosen as a valuable method of representing exposure to body surfaces relative to the horizontal plane ambient as measurements from several experiments could be combined with reasonable certainty. The erythemally effective exposures, E were calculated using the representation¹⁹:

$$E = K(9\Delta A^3 + \Delta A^2 + \Delta A) \quad (2)$$

For which, ΔA is the change in polysulphone film absorbance measured at 330 nm and K is a constant that is eliminated in the ratio, ER . The estimated uncertainty of the miniaturized dosimeters due to variation in ΔA was determined for this research to be $\pm 7\%$ (1σ). Uncertainty in the measured exposure ratio, ER is therefore taken to be in the order of 14% for all measurements quoted here.

Measurement sites

Measurements of ER were taken at up to 1453 body sites on the mannequin face (709 sites), neck (98 sites), forearm (166 sites), hand (247 sites) and leg (233 sites). Sites on each of the five body parts were organized into horizontal and vertical contours. Contours on the face and hand were separated by 5 mm, 10 mm on the arm and neck, and 20 mm on the leg. Vertical and horizontal contours were drawn onto each body part. The intersection of each vertical and horizontal contour was also marked on the mannequin models and used as a viable dosimeter location. Two mannequin models were used to measure the UV exposure to each of the body parts. These included a headform which was used to represent facial and neck ER distribution, and a whole body mannequin which was used to represent arm, hand, and leg ER. ER data measured at each contour intersection site was plotted onto three dimensional contour representations of each body part. This technique, used previously¹⁸, colours the three dimensional contour wireframe model of each mannequin body part depending on the ER of each individual body part subsite which represent individual measured mannequin contour intersections or viable dosimeter locations. The data presented as a colour wireframe mesh has also been provided in tabular form in the supplementary material and was organized into tables for each of the face, neck, arm, hand and leg, listing actual measurements of UV

exposure relative to the horizontal plane ambient UV. Data presented in tables represent all of the ER data collected in the 2005 to 2008 measurement period. Where no data is listed no measurements have yet been taken for that subsite location. A Total of 2491 ER subsite measurements were taken in the 2005 to 2008 measurement period. ER measurement dates, SZA range, body part and cloud coverage for each exposure period are listed in Table 1. Exposure times were limited to the SZA ranges given in the table for each experiment. Typical exposure periods were 2 hours in duration.

Table 1. Date, SZA ranges and cloud cover experienced during mannequin body measurements conducted in the period 2005 through to 2008.

| Mannequin Measurement Location | | | | | | | | | | | | | | |
|--------------------------------|------------|-----------------|-----------|------------|-----------------|-----------|------------|-----------------|-----------|------------|-----------------|-----------|------------|-----------------|
| Face | | | Neck | | | Arm | | | Hand | | | Leg | | |
| Date | SZA (°) | cloud (okta) | Date | SZA (°) | cloud (okta) | Date | SZA (°) | cloud (okta) | Date | SZA (°) | cloud (okta) | Date | SZA (°) | cloud (okta) |
| 18 Feb 06 | 0-30 | 4 | 14 Nov 07 | 0-30 | 1-3 | 13 Dec 07 | 0-30 | 5-7 | 21 Nov 07 | 0-30 | 2-3 | 13 Nov 07 | 0-30 | 2 |
| 12 Mar 07 | 0-30 | 1 | 25 Jan 08 | 0-30 | 2-5 | 01 Feb 08 | 0-30 | 3-5 | 01 Feb 08 | 0-30 | 3-5 | 01 Feb 08 | 0-30 | 3-5 |
| 21 Feb 08 | 0-30 | 2-4 | 18 Dec 07 | 30-50 | 7-8 | 30 Apr 07 | 30-50 | 0 | 02 Apr 08 | 30-50 | 1-2 | 04 Mar 08 | 30-50 | 3-2 |
| 25 Jan 08 | 0-30 | 2-5 | 27 Aug 07 | 50-80 | 1 | 02 Apr 08 | 30-50 | 1-2 | 28 Aug 07 | 50-80 | 4-5 | 06 Aug 07 | 50-80 | 0 |
| 14 Nov 07 | 0-30 | 1-3 | | | | 18 Jul 07 | 50-80 | 0 | | | | 02 Aug 08 | 50-80 | 0 |
| 16 Sep 05 | 30-50 | 0 | | | | 12 Jul 07 | 50-80 | 0 | | | | | | |
| 5 Oct 06 | 30-50 | 3 | | | | | | | | | | | | |
| 16 Oct 07 | 30-50 | 0 | | | | | | | | | | | | |
| 16 Oct 07 | 50-80 | 0 | | | | | | | | | | | | |
| 27 May 05 | 50-80 | 0 | | | | | | | | | | | | |
| 27 Aug 07 | 50-80 | 0 | | | | | | | | | | | | |

For the ER data presented in the supplementary tables, each column was taken to represent a vertical contour on each mannequin body part including vertical contours that passed from the forehead through to the front of the neck for the face model; the base of the skull to the lower back of the neck for the neck model; the shoulder to the wrist for the arm model, the wrist to the finger tips for the hand model, and the upper thigh to the ankle for the leg model. Horizontal contours were represented as rows in each body part table and extended from the centre of the face toward the ear for the face model; from the centre of the back of the neck to the side of the neck for the neck model; and complete connected bands for the arm, hand and leg models whereby the first horizontal contour represents a band located at the shoulder for the arm; a complete band around the wrist for the hand model and a complete thigh band for the leg model. Where more than one measurement has been recorded at a specific body part subsite, mean ER is listed for that site location for the supplementary tables presented in this research. ER measurements presented in the tables are the collected ER measured within each SZA range and may therefore have been measured on different days under different atmospheric conditions (Table 1). Uncertainties in ER were minimized by representing body site exposure relative to the horizontal plane ambient UV. The data has been shown

collectively for the four year measurement period to minimize the number of exposure tables that need to be presented in this work. Supplementary figures of the ER for each body part in the SZA ranges 0° - 30° , 30° - 50° and 50° - 80° were constructed from tabular representations of mean body site ER recorded in the 2005 to 2008 measurement period.

Both mannequins used in this study were placed on a rotating platform that completed approximately two revolutions per minute. The rotating platform and mannequins were placed in open environments which were located at least 30 m from the nearest buildings inside the grounds of the University of Southern Queensland Toowoomba campus (28° S, 152° E). Measurements of the ER were made over a four year period between 2005 and 2008. The measurement intervals were taken under low cloud cover conditions where possible during periods when the SZA varied from 0° - 30° , 30° - 50° and 50° - 80° .

Incidence data

For this research, NMSC incidence data from two Australian studies were compared to the median ER measured to the face, neck, arm, hand and leg mannequin models. Both of these studies detailed BCC and SCC incidence rates based on either clinical or histological diagnosis of either NMSC in their respective study populations. Body site incidence data for both BCC and SCC were detailed for the face, neck, leg and upper limbs where the upper limb groups included lesions diagnosed to the arms and hands together. Both study groups presented NMSC incidence data collected in similar latitudes to the measured UV exposure distributions presented in this research.

Detailed facial site UV exposures measured in this study were further compared to histologically confirmed BCC incidences recorded by Brodtkin¹⁴ as detailed by the exposure comparison of Diffey et al.¹³. This data set, excluding superficial type BCC were diagnosed in the Oncology Section of the Skin and Cancer Unit, University Hospital, New York, and may therefore differ in BCC distribution observed in an Australian population for which the ambient UV environment is likely to be different to that which subjects diagnosed in the Brodtkin et al.¹⁴ study were exposed. This data set was however sufficiently detailed to make a comparison to the current UV distribution exposure sets allowing for a comparison of 39 facial locations illustrated in the study conducted by Diffey et al.¹³. The facial SK incidence data compared in this study was sourced from published naevi and SK facial distributions¹². Published SK data detailed in the Nguyen et al.¹² study data was comprised of 79 adult participants taking part in a field trial located in the Nambour region of Southern Queensland²⁰. These participants were diagnosed by a medically qualified investigator as

having at least one SK located on the head or neck. The Nambour region is located within approximately 200 km of the Toowoomba measurement site.

Results

Patterns in facial exposure

The face is not regularly protected by clothing as are other regions of the body that are exposed to the ultraviolet environment. Correspondingly, non melanoma skin cancers are highly prevalent on the face followed by other regions of the body that receive high solar UV exposures including the arms, hands and legs^{15,16,17}. Within the human facial region, the nose, ears and cheeks receive the highest proportions of ambient UV^{13,21}. Of these facial regions, the nose often receives the greatest proportion of ambient UV over a large SZA range^{22,23,18}. Supplementary tables 1(a), 1(b) and 1(c) list the erythemally effective ER measured to the face under low cloud cover conditions for SZA ranges of 0°-30°, 30°-50° and 50°-80° respectively. The tables are organized into 18 vertical and 49 horizontal contours. A clear increase of the exposure relative to the horizontal plane toward the lower proximities and outer extremities of the face is evident in the data for lower solar elevations (larger SZA).

Patterns in body surface exposure

Table 2 represents the variation in measured ER for each of the body parts studied in this research. The minimum, maximum, median and first and third interquartile ranges are listed in the table. The highest measured exposure relative to the horizontal plane UV was received by the face at the vertex in each SZA range. Of each of the face, neck, arm, hand and leg body parts studied in the 0°-30° SZA range, the dorsum of the hand received the highest exposure relative to the horizontal plane UV, followed by the face, the back of the neck, the forearm and legs.

Table 2. Exposure ratio statistics, expressed as a percentage of the horizontal plane ambient UV and listed for the face, back of the neck, forearm, hand and leg in the SZA ranges 0°-30°, 30°-50° and 50°-80°.

| | Face | | |
|--------------------|---------|---------|---------|
| | 0°-30° | 30°-50° | 50°-80° |
| Range | 1-100% | 6-100% | 0-100% |
| IQR | 15-47% | 24-58% | 33-70% |
| Median | 26% | 39% | 48% |
| Total measurements | 391 | 154 | 229 |
| | Neck | | |
| | 0°-30° | 30°-50° | 50°-80° |
| Range | 4-67% | 13-69% | 19-86% |
| IQR | 16-33% | 30-44% | 49-67% |
| Median | 23% | 36% | 59% |
| Total measurements | 170 | 44 | 23 |
| | Forearm | | |
| | 0°-30° | 30°-50° | 50°-80° |
| Range | 3-61% | 0-55% | 2-88% |
| IQR | 5-29% | 7-35% | 21-57% |
| Median | 13% | 17% | 41% |
| Total measurements | 140 | 175 | 109 |
| | Hand | | |
| | 0°-30° | 30°-50° | 50°-80° |
| Range | 1-76% | 1-76% | 0-84% |
| IQR | 8-51% | 12-57% | 10-61% |
| Median | 30% | 35% | 42% |
| Total measurements | 264 | 119 | 82 |
| | Leg | | |
| | 0°-30° | 30°-50° | 50°-80° |
| Range | 1-39% | 4-52% | 12-82% |
| IQR | 9-16% | 15-33% | 37-57% |
| Median | 12% | 23% | 47% |
| Total measurements | 248 | 231 | 112 |

Exposures measured within the 0°-30° SZA range received the strongest UV irradiance. This is due to high solar elevation and reduced atmospheric absorption caused by incident sunlight moving through a shorter atmospheric path than occurs at greater SZA. The measured pattern of exposure would commonly be observed in sub-tropical to low latitudes during the summer months either side of midday. At greater SZA ranges, the face and neck receive the highest ER for the 30°-50° and 50°-80° SZA ranges with the hand and leg receiving higher exposures than the forearm. This is due to UV radiation incident in the greater SZA ranges having a more significant influence on vertically orientated body surfaces.

Exposures to all body parts measured in this study showed an increase in ER with increasing SZA range. Apart from the ER measured in the 0°-30° SZA range for the back of the neck, all body parts showed a further increase in the interquartile range of exposures. These findings

indicate that the UV exposure received over the body surface increases relative to the horizontal plane exposure and affects a larger surface area of the body with increasing SZA.

While there is a clear spreading in the received exposure over a larger area with increasing SZA, exposures measured in the high SZA ranges were received during periods of the day that receive a lower UV irradiance. The lower ER measured at sites in the 0°-30° SZA range receive a significant level of the ambient UV due to the higher UV irradiances at these smaller SZA. The measured ranges of exposure listed in Table 2 therefore provide an indication of the proportions of each body part at risk of receiving high levels of solar UV radiation. For populations located in sub-tropical to low latitudes that experience high solar elevations, and subsequently all of the SZA ranges studied in this research, the areas of the body surface that receive the highest UV exposure are those highlighted in the 0°-30° SZA range. The areas of the body that receive the highest UV exposure based on a comparison between all studied SZA range distributions are therefore the vertex, the nose, the cheeks, the top of the ear, the dorsa of the forearms and hand, the lower back of the neck located near the shoulder, and the calf muscle region of the leg.

Comparison of measured exposure with sites of NMSC incidence

The anatomical distribution for histologically confirmed incidences of BCC and SCC measured in Australian populations of sub-tropical and tropical latitude were compared to the ER data measured in the 0°-30°, 30°-50° and 50°-80° SZA range. The localisation of BCC and SCC data were measured from electoral roll populations residing in Geraldton, Western Australia¹⁶ and Townsville, Queensland¹⁷. These two regional Australian cities are located in latitudes of 29°S and 19°S respectively and are therefore subject to the SZA ranges studied in this research. The incidence of both BCC and SCC to the face and upper limbs were reported in these two studies to be higher than the confirmed incidences to the neck and legs, regions of the body that are better protected by clothing than the face and upper limbs, particularly in warm climates, where often the forearms are not protected.

Generally, BCC incidence reported by Kricker et al.¹⁶ and Raasch et al.¹⁷ was most strongly correlated to UV exposures measured in this research to the face, followed by the upper limbs. Both of these studies further reported the greatest incidence of BCC to the legs followed by the neck, however exposures measured in this research were higher to the neck region followed by measurements made to the legs of the mannequin. The examined incidences of SCC which were recorded in similar latitudes to the measured pattern of exposure show a higher correlation with ER than the respective BCC incidence where the facial incidence of this cancer was greater than the incidence to the upper limbs in the

Geraldton¹⁶ study and lower in the Townsville¹⁷ study. Here the facial incidence of SCC was measured in Geraldton¹⁶ to be 58% and 57% (men and women respectively) and 19% in Townsville¹⁷ and the incidence to the upper limbs was measured at 9% and 14% (men and women) in Geraldton¹⁶ and 49% in Townsville¹⁷ essentially demonstrating that approximately half of the observed SCCs occurred to frequently exposed regions of the body. The patterns in solar UV exposure affecting unprotected skin surfaces measured in this research may therefore be found to be in better agreement with future studies relating the anatomical distribution of SCC than BCC. A more detailed analysis of measured ER and subsite incidence rates is however needed to determine associations between exposure and whole body incidence of NMSC.

Comparisons with facial BCC and SK site incidence to UV exposure

Comparison between the facial distribution of UV exposure and the localisation of BCC incidence has been reported previously¹³. The facial distribution of BCC incidence has been detailed by Brodtkin et al.¹⁴, Scrivener et al.²⁴ and more recently by Richmond-Sinclair et al.²⁵ in an Australian setting. These studies show high rates of BCC incidence to the nose. Comparisons between the distribution of facial exposure and BCC incidence provide a valuable insight into the causal nature of UV exposure and the aetiology of BCC as the face is not often protected by clothing and receives a high proportion of the ambient UV. The correlation between facial BCC tumour density¹⁴ and UV exposure examined by Diffey et al.¹³ did not show a strong relationship. This was partly due to differences in latitude between the two locations in which the data sets were collected. The facial UV exposure data recorded in the current study within each of the 0°-30°, 30°-50° and 50°-80° SZA ranges is presented in figure 1. Comparisons made between the research of Diffey et al.¹³ and the current facial exposure measurements show similarities that highlight the difficulty in establishing a relationship between UV exposure and BCC tumour density. The data presented shows a steady increase in BCC tumour density with increasing UV exposure ratio, however consistent discontinuities in the comparison weaken the relationship with significantly higher tumour densities occurring for example, under the nose, an area of the face that does not receive a high proportion of the ambient UV.

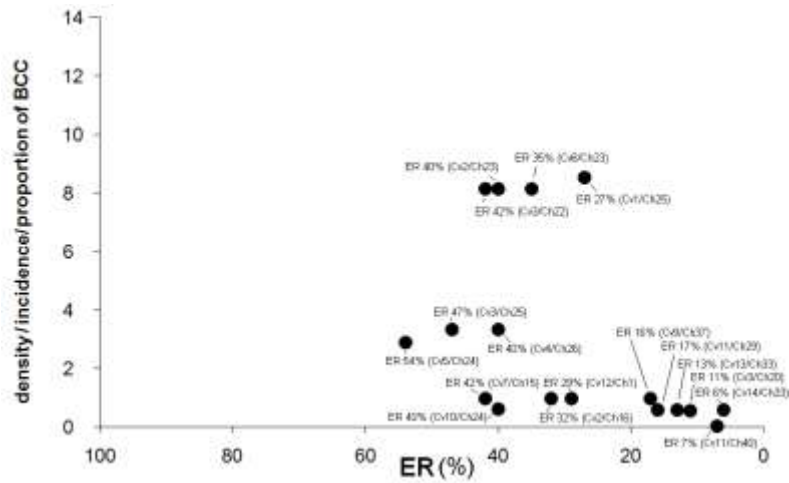


Figure 1(a) Facial BCC tumour incidence¹⁴ and UV exposure in the SZA 0°-30°.

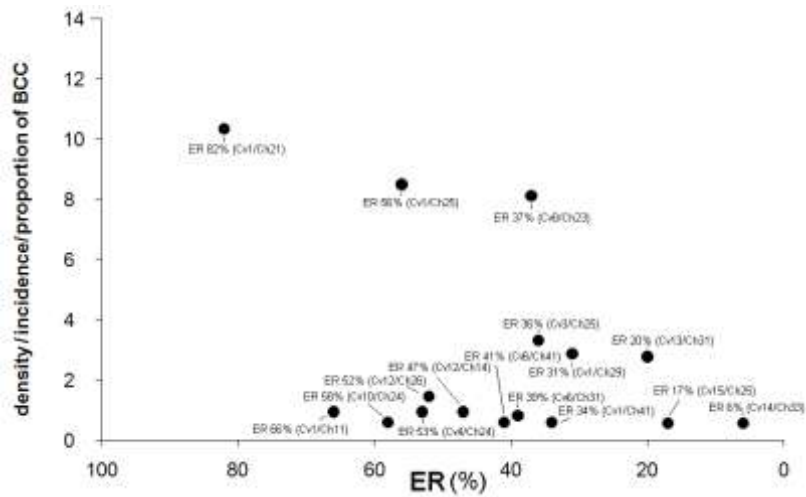


Figure 1(b) Facial BCC tumour incidence¹⁴ and UV exposure in the SZA 30°-50°.

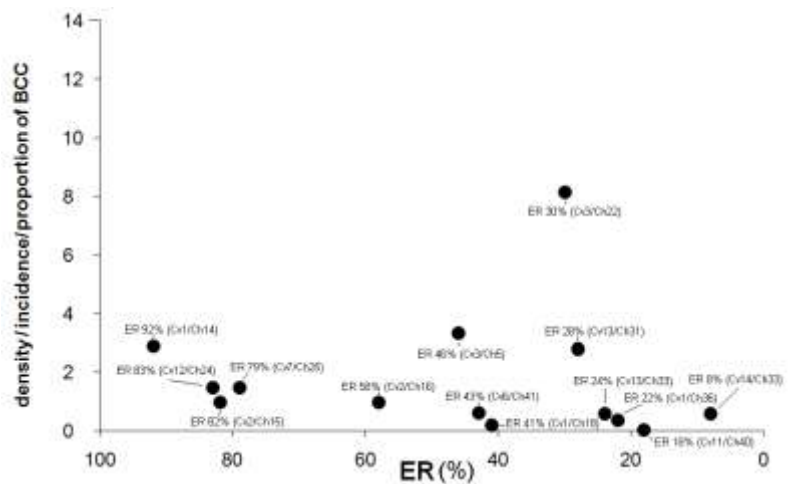


Figure 1(c) Facial BCC tumour incidence¹⁴ and UV exposure in the SZA 50°-80°.

The relationship between facial UV exposure and the distribution of SK, possible markers for the later development of SCC⁸, were examined with respect to measured facial ER. Figure 2 compares the facial distribution of SK incidence measured in Nambour (Latitude 27° S)¹² with the facial ER data measured here for each of the 0°-30°, 30°-50° and 50°-80° SZA ranges. Comparisons between this data set show that SK incidence increases with facial UV exposure. The greatest incidence of observed SK for the Nambour study¹² was found on the cheek, followed by the ears and the nose. Each of these regions of the face receive a consistently high UV exposure across each of the 0°-30°, 30°-50° and 50°-80° SZA ranges. However, as is evident in figure 2, it is difficult to establish a clear relationship between UV exposure distribution and the incidence of SK.

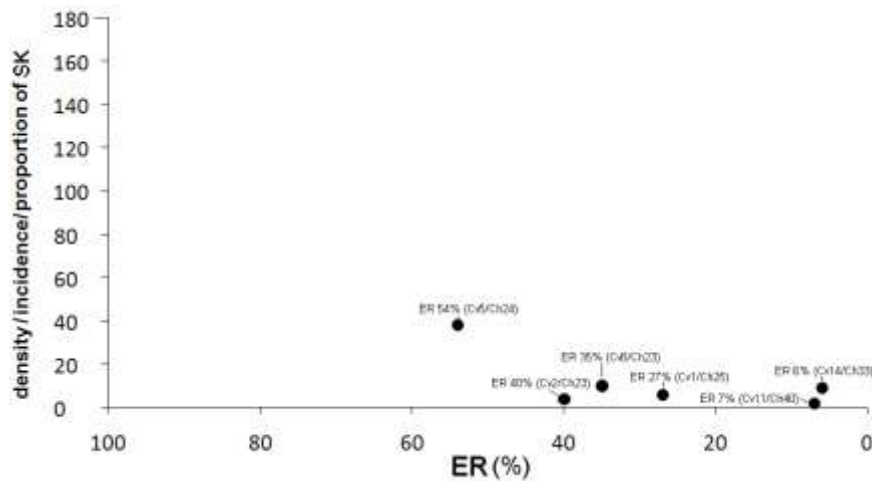


Figure 2(a) Facial SK incidence¹² and UV exposure in the SZA 0°-30°.

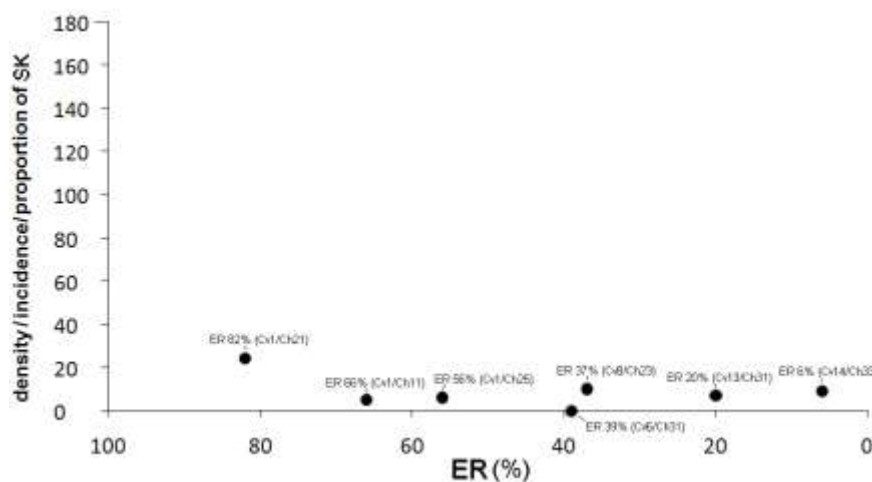


Figure 2(b) Facial SK incidence¹² and UV exposure in the SZA 30°-50°.

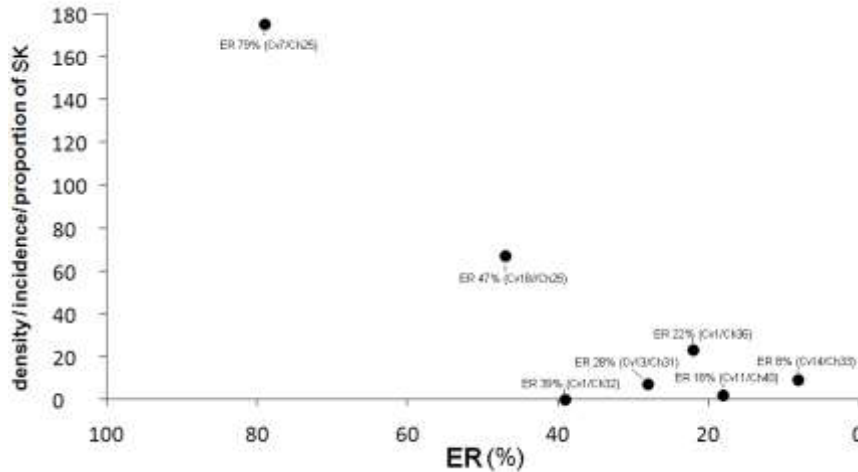


Figure 2(c) Facial SK incidence¹² and UV exposure in the SZA 50°-80°.

Discussion

This research has presented detailed subsite information for facial exposures in the 0°-30°, 30°-50° and 50°-80° SZA ranges. Measurements of exposure were consistently high over the scalp region of the facial mannequin model in each SZA range. Periorbital exposures tended to be low across all SZA ranges although greater exposures were observed over the upper cheek region with increasing SZA. Summary statistics were given for neck, arm, hand and leg body models. It was determined that higher exposure occurred on body parts orientated more closely toward the horizontal plane. These included the lower back of the neck toward the shoulder region, the lower anterior of the forearm, the dorsa of the hand and the upper anterior calf muscle region of the leg. Each of these subsites received a higher proportion of the ambient UV with increasing SZA.

The incidence of SCC in men and women is lower than BCC^{7,16,17}. The proportion of SCC is greater to the exposed surfaces of the upper limbs than BCC^{17,26}. This, in part is due to the higher incidence rate of BCC localised on the body trunk, an area of the body not readily exposed to solar UV, decreasing the relative proportion of BCC incidence to frequently exposed body surfaces. Patterns in BCC incidence supported by the hypothesis that intermittent exposures affect areas of the body not readily exposed to solar UV, may account for BCC anatomical distributions that develop later in life as a result of earlier severe episodes of sunburn. Chronic exposure to solar UV is more likely to establish a pattern in exposure similar to that which has been measured in this research as it can reasonably be concluded

that chronic exposure to solar UV will affect unprotected skin surfaces of the body that receive a higher solar UV exposure.

Nevertheless, the aetiological factors that influence the development of NMSC cannot be directly related to the measured anatomical distribution of UV exposure alone. The relevance of this particular point must be emphasised in relation to the currently presented erythematous UV exposure distributions which were measured using upright mannequin subjects. The current research cannot therefore account for situations including sunbathing or indeed all of the exposure situations likely to be experienced within an individual's lifetime. Additional factors including variation in skin thickness above the basal layer, the presence of hair, clothing, and personal outdoor lifestyle patterns will influence NMSC incidence rates and are difficult to quantify with respect to comparisons made using mannequin subjects.

Existing data present in the literature detailing the measured distribution of solar UV exposure to human subjects is limited by the total number of body sites that can be measured. An approach that integrates detailed measurements of UV exposure distribution, such as the body exposure sets provided here may improve interpolated estimates of whole body exposure measured using human subjects which in turn may improve correlations made with the anatomical distribution of NMSC incidence data. The measured patterns in UV exposure presented in this research can be applied to a variety of SZA ranges providing a detailed data set of UV exposures that may assist in future studies assessing the anatomical distribution of melanoma and NMSC incidence.

Conclusions

Measurements of body surface UV exposure patterns have been presented with respect to changing SZA. These measurements improve upon previously available data which is often limited to fewer isolated body sites. The presented collection of measured UV exposure data is of further importance in detailing the solar exposures that affect human skin surfaces which are influenced by shading caused by the body itself and surface orientation with respect to the diffuse skylight and the direct solar beam. A total of 2491 measurements of ER to the face, neck, forearm, hand and leg have confirmed that exposures received by the face and back of the neck are greater than exposures received by both the upper and lower limbs. Of each of the studied body parts, the anatomical distribution of BCC and SCC is greatest to the face and upper limbs, particularly the dorsum of the hand and forearm^{15,16,17,26}. Incidence rates of both

types of NMSC are particularly high at the nose^{14,15} and correlate with the facial ER measurements taken in this research across all SZA ranges.

Acknowledgements

The authors would like to offer their sincere thanks to Professor Bruce Armstrong, School of Public Health, University of Sydney and Dr Georgina Long, Sydney Melanoma Unit, for their assistance in this research. One of the authors, Nathan Downs, received funding through an Australian postgraduate award scholarship.

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Supplementary Information: Tables

Sup Table 1(a). Facial site exposure ratio measured between 2005 and 2008 and expressed as a percentage for the SZA range 0°-30°. ER ranges in the table show high exposed areas in red (ER: 75-100), mid exposed areas in blue (ER:25-74) and low exposed areas uncloured (ER: 0-25).

| | Cv1 | Cv2 | Cv3 | Cv4 | Cv5 | Cv6 | Cv7 | Cv8 | Cv9 | Cv10 | Cv11 | Cv12 | Cv13 | Cv14 | Cv15 | Cv16 | Cv17 | Cv18 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|
| Ch1 | 100 | 100 | 82 | 85 | 77 | 96 | | | | | | | | | | | | |
| Ch2 | 67 | 100 | 84 | 95 | 95 | | 85 | 58 | | | | | | | | | | |
| Ch3 | | 100 | 80 | 77 | 85 | | 64 | | 70 | 86 | | | | | | | | |
| Ch4 | 87 | 80 | 84 | | 76 | | 88 | 68 | 71 | 81 | 72 | | | | | | | |
| Ch5 | | 78 | 74 | | 89 | | | | 46 | 94 | 74 | 69 | | | | | | |
| Ch6 | | 70 | 53 | | 56 | | 79 | | | 41 | | 79 | 65 | | | | | |
| Ch7 | | | | | 49 | | | 56 | 49 | 67 | 28 | | 40 | 55 | | | | |
| Ch8 | | 38 | 58 | | | | | | | | | | 46 | 53 | | | | |
| Ch9 | | | | | 58 | | 45 | | | 62 | 42 | | | 48 | 42 | | | |
| Ch10 | | 51 | 52 | | 50 | | | | | | | | | | 47 | | | |
| Ch11 | | | | | 88 | | | 84 | 54 | 45 | | | | 36 | 29 | | | |
| Ch12 | | 30 | 45 | | | | 49 | | | | | | | 45 | | 36 | | |
| Ch13 | | | | | 50 | | | | | 45 | 29 | 33 | 29 | 27 | 29 | 26 | | |
| Ch14 | | 56 | 34 | | | | | | 54 | 69 | | | | | 46 | 40 | | |
| Ch15 | | | | | 51 | | 42 | | 69 | 60 | | 29 | | | 22 | 17 | | |
| Ch16 | | 32 | 27 | | | | | | 43 | | | 48 | | 25 | | 22 | | |
| Ch17 | | | | | | | | | 4 | | | 23 | 35 | | 13 | 23 | | |
| Ch18 | | 17 | 6 | | 4 | | | | | 7 | | 14 | | 22 | 29 | 18 | | |
| Ch19 | | | | | 8 | | 10 | | | | | | | 27 | 17 | 22 | | |
| Ch20 | 59 | 23 | 11 | | 8 | | | | | 16 | 9 | 9 | 15 | 26 | | | | |
| Ch21 | | | | | 7 | | | 15 | | | | | | 25 | 19 | 19 | | |
| Ch22 | 70 | 55 | 42 | | 7 | | | | | 21 | 8 | 8 | | 25 | 14 | | 65 | |
| Ch23 | 59 | 40 | 32 | | 17 | | | 35 | 31 | 40 | 21 | 29 | 25 | 18 | 31 | 75 | | |
| Ch24 | | 55 | 34 | | | 31 | | 34 | 40 | | | | | 17 | 21 | | | |
| Ch25 | 27 | 19 | 47 | | 44 | | | 48 | | | 47 | 34 | 22 | | | | | 31 |
| Ch26 | | | | 40 | | | | | | 29 | | | | 26 | 20 | 7 | 13 | 25 |
| Ch27 | | 5 | 8 | | 30 | | | 35 | | | 29 | 18 | 24 | 14 | 28 | | | 9 |
| Ch28 | | | | | 25 | | | | | 24 | | | | 16 | 12 | 20 | 26 | |
| Ch29 | | 12 | 19 | | | | | 27 | | | 17 | 9 | 14 | 15 | | | 8 | |
| Ch30 | 28 | | 37 | | 38 | | 36 | | 19 | 15 | 14 | 12 | 17 | 15 | | 20 | | |
| Ch31 | | 40 | 46 | | | | | 26 | | | 10 | 9 | | 15 | | 17 | | |
| Ch32 | | | | | 33 | | | | | 20 | | 13 | | 8 | | 10 | | |
| Ch33 | | 5 | 8 | | | | | 21 | | | 14 | 12 | 13 | 6 | | | | |
| Ch34 | | | | | 26 | | | | | 19 | | | | | | | | |
| Ch35 | | 25 | 28 | | | | | 14 | | | 18 | 15 | 15 | | | | | |
| Ch36 | | | | | 16 | 12 | | | | 21 | | | | | | | | |
| Ch37 | | 7 | 7 | | | | | 26 | 16 | | 19 | 14 | | | | | | |
| Ch38 | | | | | 19 | | 27 | 19 | | | | | | | | | | |
| Ch39 | | 33 | 29 | | | | | | | | 12 | 13 | | | | | | |
| Ch40 | | | | | 38 | | | 19 | | 15 | 7 | | | | | | | |
| Ch41 | | 21 | 16 | | | | | | 11 | 5 | | | 19 | | | | | |
| Ch42 | | | | | 6 | 10 | 8 | 7 | 3 | 11 | | | | | | | | |
| Ch43 | | 4 | 5 | | | 4 | 3 | 8 | | | | | 25 | | | | | |
| Ch44 | 1 | 1 | 1 | | 3 | | 5 | | | | | 23 | | | | | | |
| Ch45 | | | 3 | 2 | | | | | | | | | 28 | | | | | |
| Ch46 | | | | | 7 | | 9 | 15 | | 18 | | | | | | | | |
| Ch47 | | | 7 | | | | | | | | | | 29 | | | | | |
| Ch48 | | | | | 13 | | 14 | | | | 17 | | | | | | | |
| Ch49 | | | 9 | | 11 | | | 18 | | | | | 29 | | | | | |

Sup Table 1(b). Facial site exposure ratio measured between 2005 and 2008 and expressed as a percentage for the SZA range 30°-50°. ER ranges in the table show high exposed areas in red (ER: 75-100), mid exposed areas in blue (ER:25-74) and low exposed areas uncoloured (ER: 0-25).

| | Cv1 | Cv2 | Cv3 | Cv4 | Cv5 | Cv6 | Cv7 | Cv8 | Cv9 | Cv10 | Cv11 | Cv12 | Cv13 | Cv14 | Cv15 | Cv16 | Cv17 | Cv18 |
|------|-----|-----|----------|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|
| Ch1 | 100 | | 69 97 | | | | | 70 | | | | | | | | | | |
| Ch2 | | | | | | | 100 | | | | | | | | | | | |
| Ch3 | | | 69 | | | | | 63 | | | | | | | | | | |
| Ch4 | | | | | | | 100 | | | | | | | | | | | |
| Ch5 | 71 | 66 | | 70 | | 70 | | 64 | | 75 | 66 | 75 | 57 | | | | | |
| Ch6 | | | 61 | | | | 90 | | | | | | | | | | | |
| Ch7 | 65 | | | | | | | | | | | | 56 | 88 | | | | |
| Ch8 | | | 45 | | | | 79 | 55 | | | | | | | | | | |
| Ch9 | 62 | | | | | | | | | | | | | 70 | 46 | | | |
| Ch10 | | | | | | | 58 | | | | | | 10 | | | | | |
| Ch11 | 66 | | | | | | | 60 | | | | | | 53 | 46 | | | |
| Ch12 | | | | | | | 77 | | | | | | | | | | | |
| Ch13 | 69 | | | | | | | | | | | | 32 | 51 | | | | |
| Ch14 | | 16 | | 48 | | 54 | 82 | 57 | | 59 | | 47 | 33 | 29 | 33 | 32 | | |
| Ch15 | 66 | | | | | | | 49 | | | | | | 40 | | | | |
| Ch16 | | | | | | | 12 | | | | | | 37 | | 32 | | | |
| Ch17 | 35 | | | | | | | | | | | | | 42 | | | | |
| Ch18 | | | | | | | 13 | 9 | | | | | | | | | | |
| Ch19 | 38 | | | | | | | | | | | | 26 | 48 | | | | |
| Ch20 | | | | | | | 21 | 16 | | | | | | | | | | |
| Ch21 | 82 | | 27 | | | | | | | | | | | 42 | | | | |
| Ch22 | | | | | | | 33 | | | | | | 44 | | | | | |
| Ch23 | 98 | | 46 | | | | | 37 | | | | | | 60 | | | | |
| Ch24 | | 47 | | 53 | | 57 | 83 | 58 | | 58 | | 52 | 43 | 36 | 28 | | 20 | 24 |
| Ch25 | 56 | | 36 | | | | | 49 | | | | | 38 | 47 | 17 | | | |
| Ch26 | | | | | | | 51 | | | | | | | | | | | |
| Ch27 | 9 | | | | | | | | | | | | | 32 | 31 | | | |
| Ch28 | | | 16 | | | | 39 | 34 | | | | | | | | | | |
| Ch29 | 31 | | | | | | | | | | | | 22 | 32 | | | | |
| Ch30 | | | | | | | 54 | | | | | | | | 30 | | | |
| Ch31 | 67 | 44 | 35 | 45 | | 39 | | 30 | | 19 | | 18 | 20 | 25 | | 20 | | |
| Ch32 | | | | | | | 40 | | | | | | 21 | | | | | |
| Ch33 | 12 | | 8 | | | | | | | | | | | 6 | | | | |
| Ch34 | | | | | | | 31 | 24 | | | | | 15 | | | | | |
| Ch35 | 50 | | 37 | | | | | | | | | | | | | | | |
| Ch36 | | | | | | | 26 | | | | | | 18 | | | | | |
| Ch37 | 11 | | | | | | | 19 | | | | | | | | | | |
| Ch38 | | | 18 | | | | 42 | | | | | | | | | | | |
| Ch39 | 54 | | | | | | | 21 | | | | | | | | | | |
| Ch40 | | | 35 | | | | 38 | | | | | | | | | | | |
| Ch41 | 34 | 16 | | 16 | | 41 | | 14 | | | | | | | | | | |
| Ch42 | | | 17 | | | | | 8 | | | | | | | | | | |
| Ch43 | 8 | | | | | | | | | | | | | | | | | |
| Ch44 | | | | | | | 13 | 11 | | | | | | | | | | |
| Ch45 | | | | | | | | | | | | | | | | | | |
| Ch46 | 8 | | | | | | 24 | 21 | | | | | | | | | | |
| Ch47 | | | | | | | | | | | | | | | | | | |
| Ch48 | 12 | | | | | | 25 | | | | | | | | | | | |
| Ch49 | | | | | | | | 26 | | | | | | | | | | |

Sup Table 1(c). Facial site exposure ratio measured between 2005 and 2008 and expressed as a percentage for the SZA range 50°-80°. ER ranges in the table show high exposed areas in red (ER: 75-100), mid exposed areas in blue (ER:25-74) and low exposed areas uncoloured (ER: 0-25).

| | Cv1 | Cv2 | Cv3 | Cv4 | Cv5 | Cv6 | Cv7 | Cv8 | Cv9 | Cv10 | Cv11 | Cv12 | Cv13 | Cv14 | Cv15 | Cv16 | Cv17 | Cv18 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|
| Ch1 | 100 | 100 | 81 | 83 | 100 | | 73 | 74 | | | | | | | | | | |
| Ch2 | 100 | 96 | | 100 | | | | | 100 | | | | | | | | | |
| Ch3 | | | | | | | 100 | | 79 | | | | | | | | | |
| Ch4 | 100 | 94 | | | | | | | | | 63 | 77 | | | | | | |
| Ch5 | | | | | | | 84 | | 92 | | | 88 | 97 | | | | | |
| Ch6 | 78 | 73 | | | | | | | | | | | | 83 | | | | |
| Ch7 | | | | | | | 80 | | 94 | | | | 72 | 72 | | | | |
| Ch8 | 94 | 73 | | | | | | | | | 66 | | 78 | 63 | | | | |
| Ch9 | | | | | | | 90 | | 86 | | | | | | | | | |
| Ch10 | 88 | 78 | | | | | | 39 | | | | | 62 | 100 | 66 | | | |
| Ch11 | | | | | | | 75 | | 79 | | 74 | | | | | | 68 | |
| Ch12 | 88 | 65 | | | | | | 55 | | | | | | 61 | | | | |
| Ch13 | | | | | | | 83 | | 66 | | 60 | | 56 | | | | 61 | |
| Ch14 | 92 | 77 | | | | | | 54 | | | | | 52 | 53 | 53 | | | |
| Ch15 | | | | | | | 82 | | 77 | | | | | | | | | 54 |
| Ch16 | 56 | 58 | | | | | | 18 | | | | 53 | 45 | 34 | | | | 57 |
| Ch17 | | | | | | | 11 | | 28 | | | | | 43 | | | | 26 |
| Ch18 | 41 | 29 | | | | | | | | | | | 45 | 94 | 31 | | | |
| Ch19 | | | | | | | 34 | | 39 | 18 | | | 54 | | | | | 36 |
| Ch20 | 67 | 61 | | | | | | | | | | | 11 | 43 | | | | |
| Ch21 | | | | | | | 42 | 25 | 39 | | | | | | | 23 | | 52 |
| Ch22 | 100 | 53 | 30 | | | | | | | | | | | | | | | |
| Ch23 | | | | | | | 59 | | | | | | | 49 | 49 | | | 65 |
| Ch24 | 33 | 75 | | | | | | 83 | 64 | | | | | | | | | |
| Ch25 | | | 46 | | | | 79 | 51 | 64 | | 82 | | 83 | 52 | 44 | | 31 | |
| Ch26 | 25 | 26 | | | | | | | 73 | | | | | | 47 | | | 16 |
| Ch27 | | | | | | | 56 | 37 | | | | | 51 | | 49 | | | 37 |
| Ch28 | 21 | 15 | | | | | | | | | 47 | 23 | | 51 | | | | |
| Ch29 | | | | | | | 52 | | 51 | | | | 22 | | 34 | | 25 | |
| Ch30 | 65 | 63 | | | | | | 40 | | | 33 | | | 30 | | | | |
| Ch31 | | | | | | | 59 | | | | | | 28 | 27 | | 37 | | |
| Ch32 | 39 | 39 | | | | | | 56 | 44 | | 33 | 33 | | 34 | | | | |
| Ch33 | | | | | | | 45 | | | | | | 24 | 8 | | | | |
| Ch34 | 64 | 72 | | | | | | | | | 22 | | | | | | | |
| Ch35 | | | | | | | 39 | 39 | 30 | | | 38 | 41 | | | | | |
| Ch36 | 22 | | | | | | | | | | 45 | | | | | | | |
| Ch37 | | 15 | | | | | 41 | 37 | | | | | | | | | | |
| Ch38 | 36 | | | | | | | | 35 | | 36 | 29 | | | | | | |
| Ch39 | | 66 | | | | 45 | 63 | | | | | 23 | | | | | | |
| Ch40 | 62 | | | | | | | 24 | | | 18 | 44 | | | | | | |
| Ch41 | | 33 | | | | 43 | 25 | | 22 | | | 38 | | | | | | |
| Ch42 | 29 | | | | | | | | | | | | | | | | | |
| Ch43 | | 10 | | | | | 8 | | 28 | 43 | | 36 | | | | | | |
| Ch44 | 7 | 0 | | | | | | | | | | | | | | | | |
| Ch45 | 1 | 1 | | | | | 14 | | 40 | 35 | | 27 | | | | | | |
| Ch46 | | | | | | | | | | | | | | | | | | |
| Ch47 | 13 | | | | | | 15 | | | 46 | | 58 | | | | | | |
| Ch48 | | | | | | | | | 52 | | | | | | | | | |
| Ch49 | 28 | 16 | | | | | 35 | | | 33 | | 43 | | | | | | |

Sup Table 2(a). Site exposure ratio measured to the back of the neck and expressed as a percentage for the SZA range 0°-30° and cloud cover less than 4 oktas measured between 2005 and 2008. ER ranges in the table show high exposed areas in red (ER: 75-100), mid exposed areas in blue (ER:25-74) and low exposed areas uncloured (ER: 0-25).

| | Cv1 | Cv2 | Cv3 | Cv4 | Cv5 | Cv6 | Cv7 | Cv8 | Cv9 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ch1 | 6 | | 6 | 17 | 7 | 16 | 8 | | |
| Ch2 | 10 | | 9 | | 12 | | 12 | | |
| Ch3 | 13 | | 14 | | 14 | | 12 | | |
| Ch4 | 14 | | 18 | | 17 | | 15 | | |
| Ch5 | 20 | | 15 | 20 | 20 | 24 | 19 | | |
| Ch6 | 19 | | 17 | | 21 | 23 | 19 | | |
| Ch7 | 20 | | 18 | | 17 | 26 | 23 | | |
| Ch8 | 21 | | 22 | | 23 | 34 | 27 | | |
| Ch9 | 17 | | 22 | 28 | 21 | 18 | 32 | | |
| Ch10 | 20 | | 22 | | 29 | | 32 | 50 | |
| Ch11 | 23 | | 23 | | 32 | | 37 | 52 | 50 |
| Ch12 | 19 | | 20 | | 26 | | 30 | 38 | 48 |
| Ch13 | 24 | | 28 | | 20 | 39 | 34 | 36 | 40 |

Sup Table 2(b). Site exposure ratio measured to the back of the neck and expressed as a percentage for the SZA range 30°-50° and cloud cover greater than 4 oktas measured between 2005 and 2008. ER ranges in the table show high exposed areas in red (ER: 75-100), mid exposed areas in blue (ER:25-74) and low exposed areas uncloured (ER: 0-25).

| | Cv1 | Cv2 | Cv3 | Cv4 | Cv5 | Cv6 | Cv7 | Cv8 | Cv9 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ch1 | | 14 | | 13 | | 13 | | | |
| Ch2 | | 21 | | 21 | | 16 | | | |
| Ch3 | | 24 | | 23 | | 23 | | | |
| Ch4 | | 32 | | 30 | | 27 | | | |
| Ch5 | | 38 | | 35 | | 32 | | | |
| Ch6 | | 33 | | 37 | | 35 | | | |
| Ch7 | | 56 | | 33 | | 35 | | | |
| Ch8 | | 35 | | 32 | | 47 | | | |
| Ch9 | | 37 | | 38 | | 44 | | | |
| Ch10 | | 33 | | 44 | | 44 | | 62 | |
| Ch11 | | 40 | | 30 | | 40 | | 49 | 53 |
| Ch12 | | 43 | | 69 | | 42 | | 59 | |
| Ch13 | | 38 | | 42 | | 44 | | 48 | |

Sup Table 2(c). Site exposure ratio measured to the back of the neck and expressed as a percentage for the SZA range 50°-80° and cloud cover less than 4 oktas measured between 2005 and 2008. ER ranges in the table show high exposed areas in red (ER: 75-100), mid exposed areas in blue (ER:25-74) and low exposed areas uncloured (ER: 0-25).

| | Cv1 | Cv2 | Cv3 | Cv4 | Cv5 | Cv6 | Cv7 | Cv8 | Cv9 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ch1 | 19 | | | | | | | | |
| Ch2 | | | | | | | | | |
| Ch3 | 43 | | | | | | | | |
| Ch4 | | | | | | | | | |
| Ch5 | 49 | | | | 47 | | 48 | | |
| Ch6 | | | 49 | | | | | | |
| Ch7 | 59 | | | | 62 | | 57 | | |
| Ch8 | | | 48 | | | | | | |
| Ch9 | 58 | | | | 66 | | 69 | | |
| Ch10 | | | 56 | | | | | | |
| Ch11 | 45 | | | | 63 | | 77 | | 86 |
| Ch12 | | | 60 | | | | | | |
| Ch13 | 62 | | | | 68 | | 68 | | 73 |

Sup Table 3(a). Site exposure ratio measured to the arm and expressed as a percentage for the SZA range 0°-30° and cloud cover less than 4 oktas measured between 2005 and 2008. ER ranges in the table show high exposed areas in red (ER: 75-100), mid exposed areas in blue (ER:25-74) and low exposed areas uncoloured (ER: 0-25). Contours located on the anterior of the arm recorded the highest exposures.

| | Cv1 | Cv2 | Cv3 | Cv4 | Cv5 | Cv6 | Cv7 | Cv8 | Cv9 | Cv10 | Cv11 | Cv12 | Cv13 | Cv14 | Cv15 | Cv20 | Cv21 | Cv22 | Cv23 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|
| Ch1 | | | | | | | | | | | | | | | | | | | |
| Ch2 | | | | | | | | | | | | | | | | | | | |
| Ch3 | | | | | | | | | | | | | | | | | | | |
| Ch4 | | | | | | | | | | | | | | | | | | | |
| Ch5 | | | | | | | | | | | | | | | | | | | |
| Ch6 | | | | | | | | | | | | | | | | | | | |
| Ch7 | | | | | | | | | | | | | | | | | | | |
| Ch8 | | | | | | | | | | | | | | | | | | | |
| Ch9 | | | | | | | | | | | | | | | | | | | |
| Ch10 | | | | | | | | | | | | | | | | | | | |
| Ch11 | | | | | | | | | | | | | | | | | | | |
| Ch12 | | | | | | | | | | | | | | | | | | | |
| Ch13 | | | | | | | | | | | | | | | | | | 5 | 9 |
| Ch14 | 18 | 9 | 6 | 7 | 21 | 5 | 20 | 15 | | 8 | | | | | | | | 8 | 13 |
| Ch15 | 25 | 43 | 43 | 31 | 54 | 23 | 35 | 31 | 13 | 17 | 13 | | | | | 3 | 4 | 9 | 10 |
| Ch16 | 13 | 23 | 38 | 39 | 61 | 49 | 37 | 32 | 20 | 23 | 17 | | | | 3 | | 3 | 6 | 7 |
| Ch17 | 12 | 19 | 29 | 30 | 54 | 60 | 40 | | 27 | 21 | 19 | 8 | 4 | 3 | | | | | 7 |
| Ch18 | 8 | 13 | 19 | 27 | 38 | 36 | 44 | 42 | 23 | 22 | 13 | 13 | | | 3 | | | 5 | 6 |
| Ch19 | 6 | 10 | 19 | 29 | 31 | 40 | 43 | 36 | 25 | 23 | | 11 | 8 | 5 | | | 3 | 5 | |
| Ch20 | 5 | 9 | 13 | 23 | 30 | 41 | 39 | | | | | 10 | 6 | 4 | 4 | | | | |
| Ch21 | | | | 18 | 29 | 43 | | | 40 | | | | 6 | 3 | 4 | | | | |
| Ch22 | | | | | | 35 | | | | | | | 5 | 4 | 4 | | | | |
| Ch23 | | | | | | 27 | | | | | | | 5 | | 6 | | | | |
| Ch24 | | | | | | | | | | | | | 7 | 3 | 4 | | | | |
| Ch25 | | | | | | | | | | | | | | | 3 | | | | |
| Ch26 | | | | | | | | | | | | | | 4 | | | | | |
| Ch27 | | | | | | | | | | | | 8 | | | 3 | | | | |
| Ch28 | | | | | | | | | | | | | | 4 | | | | | |

Sup Table 3(b). Site exposure ratio measured to the arm and expressed as a percentage for the SZA range 30°-50° and cloud cover less than 4 oktas measured between 2005 and 2008. ER ranges in the table show high exposed areas in red (ER: 75-100), mid exposed areas in blue (ER:25-74) and low exposed areas uncoloured (ER: 0-25). Measurements made underneath the shirt covering the shoulder had an ER of 0. Contours located on the anterior of the arm recorded the highest exposures.

| | Cv1 | Cv2 | Cv3 | Cv4 | Cv5 | Cv6 | Cv7 | Cv8 | Cv9 | Cv10 | Cv11 | Cv12 | Cv13 | Cv14 | Cv15 | Cv20 | Cv21 | Cv22 | Cv23 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|
| Ch1 | | | | | | | | | | | | | | | | | | | |
| Ch2 | | | | | 0 | | | | | | | | | | | | | | |
| Ch3 | | | | | | | 0 | | 0 | | | | | | | | | | |
| Ch4 | | | | | | | | | | | | 0 | | | | | | | |
| Ch5 | | | | | 0 | | 0 | | | | | | | | | | | | |
| Ch6 | 0 | | | | | | | | | 0 | | | | | 0 | | | | |
| Ch7 | | | | | 0 | | | | | | | | | | | | | | |
| Ch8 | | | | | | | | | | 0 | | 0 | | | | 0 | | 0 | |
| Ch9 | 0 | | 0 | | 0 | | 0 | | | | | | | | | | | | |
| Ch10 | | | | | | | 0 | 0 | | | | | 0 | | | | | | 0 |
| Ch11 | 0 | | 0 | | 0 | | | | | | | 0 | | | | 0 | | | |
| Ch12 | | | | | | | 9 | | 1 | | | | | | | | | 3 | 1 |
| Ch13 | 10 | 0 | 1 | 1 | 7 | | 14 | 8 | 7 | 4 | | | 0 | | | | 8 | 13 | |
| Ch14 | 18 | 1 | 20 | 8 | 38 | 5 | 13 | 24 | 11 | 6 | 5 | 0 | | | | 6 | | 14 | |
| Ch15 | 22 | 28 | 30 | 44 | 49 | 31 | 39 | 40 | 25 | 25 | 17 | 5 | | 2 | 3 | 0 | 7 | 15 | 10 |
| Ch16 | 18 | 25 | 29 | 51 | 46 | 47 | 45 | 46 | 29 | 28 | 25 | 9 | 5 | | 4 | | | 8 | 9 |
| Ch17 | 17 | 23 | 19 | 40 | 43 | 33 | 49 | 43 | 36 | 32 | 20 | | | 3 | 4 | | 6 | 6 | 8 |
| Ch18 | 7 | 17 | 33 | 41 | 45 | 45 | 37 | 35 | 34 | 22 | 17 | 22 | 11 | | | | | 2 | 8 |
| Ch19 | 8 | 20 | 29 | 33 | 48 | 49 | 37 | 55 | 41 | 28 | | 16 | 13 | 7 | 3 | | 6 | 7 | |
| Ch20 | 4 | | 20 | 24 | 42 | 42 | 45 | | 17 | | | 14 | 10 | 5 | | | | | |
| Ch21 | | | | 23 | 39 | 47 | 19 | | 38 | | | | 9 | 5 | 6 | | | | |
| Ch22 | | | | | | 39 | | | | | | | 7 | 3 | | | | | |
| Ch23 | | | | | | 30 | | | | | | | | | | | | | |
| Ch24 | | | | | | | | | | | | | | | 7 | | | | |
| Ch25 | | | | | | | | | | | | | | 6 | | | | | |
| Ch26 | | | | | | | | | | | | 11 | 4 | | | | | | |
| Ch27 | | | | | | | | | | | | | 11 | 4 | 5 | | | | |
| Ch28 | | | | | | | | | | | | | 15 | | | | | | |

Sup Table 3(c). Site exposure ratio measured to the arm and expressed as a percentage for the SZA range 50°-80° and cloud cover less than 4 oktas measured between 2005 and 2008. ER ranges in the table show high exposed areas in red (ER: 75-100), mid exposed areas in blue (ER:25-74) and low exposed areas uncoloured (ER: 0-25). Contours located on the anterior of the arm recorded the highest exposures.

| | Cv1 | Cv2 | Cv3 | Cv4 | Cv5 | Cv6 | Cv7 | Cv8 | Cv9 | Cv10 | Cv11 | Cv12 | Cv13 | Cv14 | Cv15 | Cv20 | Cv21 | Cv22 | Cv23 | |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|----|
| Ch1 | | | | | | | | | | | | | | | | | | | | |
| Ch2 | | | | | | | | | | | | | | | | | | | | |
| Ch3 | | | | | | | | | | | | | | | | | | | | |
| Ch4 | | | | | | | | | | | | | | | | | | | | |
| Ch5 | | | | | | | | | | | | | | | | | | | | |
| Ch6 | | | | | | | | | | | | | | | | | | | | |
| Ch7 | | | | | | | | | | | | | | | | | | | | |
| Ch8 | | | | | | | | | | | | | | | | | | | | |
| Ch9 | | | | | | | | | | | | | | | | | | | | |
| Ch10 | | | | | | | | | | | | | | | | | | | | |
| Ch11 | | | | | | | | | | | | | | | 2 | | | | | |
| Ch12 | | | | | | | | 11 | | | | | | | | | | | | 20 |
| Ch13 | | | | | | 6 | | | | 25 | | | | | 4 | | | | | 24 |
| Ch14 | 27 | 20 | 39 | 31 | | | 66 | 64 | 43 | | 46 | | 13 | | | | | | | 23 |
| Ch15 | 32 | 27 | | | | 61 | | 71 | | 49 | 65 | | | | 13 | 12 | | 14 | | |
| Ch16 | | 41 | 47 | 62 | 67 | | | 87 | 76 | 66 | 49 | | 23 | | | | | | | |
| Ch17 | 19 | 26 | | 55 | 51 | 58 | 72 | 61 | 63 | 54 | | 24 | | 16 | | | | | 11 | 19 |
| Ch18 | 19 | 23 | 41 | 55 | 54 | | 71 | 69 | | 60 | 49 | 41 | 37 | | 13 | | | | | |
| Ch19 | 12 | 14 | 32 | 47 | 52 | 60 | 63 | 82 | 57 | 44 | | 43 | | | 26 | | | | | |
| Ch20 | 11 | 22 | | 36 | | 55 | 58 | 56 | 66 | | | 48 | 29 | | 18 | | | | | |
| Ch21 | | | | 29 | 43 | 54 | 65 | | | | | | 30 | | | | | | | |
| Ch22 | | | | | | | | | | | | | 19 | | 12 | | | | | |
| Ch23 | | | | | | 45 | | | | | | | | | | | | | | |
| Ch24 | | | | | | | | | | | | | | | 12 | | | | | |
| Ch25 | | | | | | | | | | | | | 29 | | | | | | | |
| Ch26 | | | | | | | | | | | | | | | 20 | | | | | |
| Ch27 | | | | | | | | | | | | | | | | | | | | |
| Ch28 | | | | | | | | | | | | | 46 | | 21 | | | | | |

Sup Table 4(a). Site exposure ratio measured to the hand and expressed as a percentage for the SZA range 0°-30° and cloud cover less than 4 oktas measured between 2005 and 2008. ER ranges in the table show high exposed areas in red (ER: 75-100), mid exposed areas in blue (ER:25-74) and low exposed areas uncloured (ER: 0-25). The dorsa of the hand received the highest exposures. For this research the mannequin hand was tilted from the arm's longitudinal axis increasing the UV radiation received due to the increased proportion of the hand oriented toward a horizontal plane.

| | Cv1 | Cv2 | Cv3 | Cv4 | Cv5 | Cv6 | Cv7 | Cv8 | Cv9 | C10 | C11 | C12 | C13 | C14 | C15 | C16 | C17 | C18 | C19 | C20 | C21 | C22 | C23 | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|
| Ch1 | | | | | | | | | | | | | | | | | 4 | | | 4 | | | | |
| Ch2 | | | | | 22 | | | | | | | | | | | | | | 4 | | | | | |
| Ch3 | | | | | | 42 | | | | | | | | | 8 | | 3 | | | | | 13 | | |
| Ch4 | | | | 11 | 31 | 45 | | | | | | | | | 6 | | | 3 | | | | | | |
| Ch5 | | | | 37 | 49 | 48 | 37 | 35 | 30 | 27 | | | | | 7 | | | 3 | | | | 14 | | |
| Ch6 | | | | 65 | 65 | | 35 | 34 | 24 | 15 | | | | | 5 | | | | | | | | | |
| Ch7 | | | | 52 | 76 | | 62 | 44 | 26 | | | | | | 2 | | | | | | | | | |
| Ch8 | | | | 20 | 69 | | 52 | 46 | 30 | 11 | | | | | 2 | | | | | | | 3 | | |
| Ch9 | | 16 | | 76 | 73 | | 73 | 50 | 42 | 34 | | | | | | | | | | | | | 5 | |
| C10 | 29 | | 57 | 66 | 75 | | 72 | 48 | 52 | 53 | 6 | 2 | 5 | | | | 1 | | | | 2 | | 3 | 10 |
| C11 | 42 | 69 | 51 | 57 | 75 | | 71 | 61 | 56 | 53 | | | | | 1 | | | | | | 2 | 1 | | 6 |
| C12 | | 31 | 63 | 47 | 65 | | 63 | 56 | | 38 | | | | | | | | 2 | | | | | 1 | 6 |
| C13 | 32 | 29 | 10 | 42 | | 33 | 70 | 40 | | 23 | | | | | 3 | | | 2 | | | | | | 3 |
| C14 | 26 | 22 | | 37 | 67 | 9 | 62 | 61 | 8 | | | | | 2 | | | 5 | | 8 | | | | | |
| C15 | | 17 | | 30 | 65 | | 10 | | | | | | | | 5 | | | | | | | | | |
| C16 | | | | 41 | 54 | 3 | 58 | 29 | 28 | | | | | | | | | 8 | 3 | | | | | |
| C17 | | | | 37 | 17 | | 41 | 14 | | | | | | | | | | | | | | | | |
| C18 | | | | 46 | | | 11 | 7 | | | | | | | | | | | | | | | | |
| C19 | | | | 41 | | | 11 | 9 | | | | | | | | | | | | | | | | |
| C20 | | | | | | | 9 | | | | | | | | | | | | | | | | | |

Sup Table 4(b). Site exposure ratio measured to the hand and expressed as a percentage for the SZA range 30°-50° and cloud cover less than 4 oktas measured between 2005 and 2008. ER ranges in the table show high exposed areas in red (ER: 75-100), mid exposed areas in blue (ER:25-74) and low exposed areas uncloured (ER: 0-25). The dorsa of the hand received the highest exposures. For this research the mannequin hand was tilted from the arm's longitudinal axis increasing the UV radiation received due to the increased proportion of the hand oriented toward a horizontal plane.

| | Cv1 | Cv2 | Cv3 | Cv4 | Cv5 | Cv6 | Cv7 | Cv8 | Cv9 | C10 | C11 | C12 | C13 | C14 | C15 | C16 | C17 | C18 | C19 | C20 | C21 | C22 | C23 | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|
| Ch1 | | | | | | | | | | | | | | | | | | 6 | | | | | 15 | |
| Ch2 | | | | | 31 | | | | | | | | | | 12 | | | 6 | | | | | | |
| Ch3 | | | | | | | | | | | | | | | | | | 5 | | | 12 | 20 | | |
| Ch4 | | | | 21 | 46 | 57 | | | | | | | | | 10 | 5 | | | | | | | 22 | |
| Ch5 | | | | 50 | | | 45 | 42 | 44 | 33 | | | | | | | | 5 | | | | | | |
| Ch6 | | | | 61 | 62 | 70 | 53 | 45 | | 18 | | | | | | | | | 6 | | | | | |
| Ch7 | | | | 64 | 74 | | 56 | 32 | | | | | | | 5 | 4 | | | | | 6 | | | |
| Ch8 | | | | 35 | | | 61 | 55 | 53 | 41 | 25 | 10 | | 20 | | | | 2 | | | | | | |
| Ch9 | | 34 | | 52 | 76 | 70 | 70 | 58 | 58 | 34 | | | 3 | 7 | 2 | | | 1 | | | | | 10 | |
| C10 | 47 | | 61 | 67 | 66 | | 58 | 52 | | | | | | | | | | | | | 3 | | 3 | 20 |
| C11 | | 66 | | | | | 71 | 51 | 53 | 58 | | | | | 3 | | | 3 | | | | | | 13 |
| C12 | 39 | 64 | 67 | 53 | 70 | 60 | 46 | 53 | 56 | | | | 4 | | | | | | | | 11 | 5 | | 9 |
| C13 | 69 | 31 | 10 | | | 37 | | 51 | 32 | 33 | | | | | | | | | | | | | | |
| C14 | 47 | | | 52 | 72 | | 60 | 10 | | | | | | | | | | | | | | | | |
| C15 | | 16 | | 48 | 68 | | 60 | | 60 | | | | | | 4 | | | 17 | | | | | | |
| C16 | | | | | 60 | 15 | 61 | 11 | | | | | | | | | | | | | | | | |
| C17 | | | | 51 | 31 | | 45 | | 20 | | | | | | | | | | | | | | | |
| C18 | | | | 60 | | | 24 | | | | | | | | | | | | | | | | | |
| C19 | | | | 57 | | | 15 | 14 | | | | | | | | | | | | | | | | |
| C20 | | | | | | | 15 | | | | | | | | | | | | | | | | | |

Sup Table 4(c). Site exposure ratio measured to the hand and expressed as a percentage for the SZA range 50°-80° and cloud cover greater than 4 oktas measured between 2005 and 2008. ER ranges in the table show high exposed areas in red (ER: 75-100), mid exposed areas in blue (ER:25-74) and low exposed areas uncoloured (ER: 0-25). The dorsa of the hand received the highest exposures. For this research the mannequin hand was tilted from the arm's longitudinal axis increasing the UV radiation received due to the increased proportion of the hand oriented toward a horizontal plane.

| | Cv1 | Cv2 | Cv3 | Cv4 | Cv5 | Cv6 | Cv7 | Cv8 | Cv9 | C10 | C11 | C12 | C13 | C14 | C15 | C16 | C17 | C18 | C19 | C20 | C21 | C22 | C23 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ch1 | | | | | | | | | | | | | | | | | | | | | | | |
| Ch2 | | | | | | | | | | | | | | | | | | | 3 | | | | |
| Ch3 | | | | | 60 | | | | | | | | | | | 3 | | | | | | | |
| Ch4 | | | | | | 60 | | | | | | | | | 17 | | | 7 | | | 39 | | |
| Ch5 | | | | 58 | | 71 | | | 60 | | 41 | | | | | | | | | | | | |
| Ch6 | | | | | 57 | | | | 53 | | 27 | | | | | 7 | | 10 | | | | | |
| Ch7 | | | | | | | 71 | | | 45 | | | | | | | | | | | | 0 | |
| Ch8 | | | | 53 | 84 | | | | | 68 | 35 | 17 | | 17 | 0 | | 0 | 0 | | | | | |
| Ch9 | | | | | 75 | | 80 | | | 58 | | | 0 | | 0 | 0 | 0 | 0 | | 3 | | | |
| C10 | | | 58 | | 73 | | 42 | | 59 | | | | | | 0 | 0 | | 0 | | | | | 41 |
| C11 | | 67 | | | 60 | | 66 | | 56 | | | | 5 | | 2 | | | | | 6 | | | |
| C12 | | | 70 | 52 | 58 | | 78 | | 63 | | | | | | | | | | | | | | 20 |
| C13 | | | 10 | | 68 | | 62 | | 53 | | 34 | | | | | | | | | 20 | | | |
| C14 | 42 | 31 | | 40 | 72 | 7 | 77 | | | | | | | | 15 | | 12 | | | | | | |
| C15 | | | | | 60 | | 73 | | 60 | | | | | | | | | | | | | | |
| C16 | | | | 76 | 67 | 20 | | | | | | | | | | | | | | | | | |
| C17 | | | | | 34 | | 61 | | | | | | | | | | | 26 | | | | | |
| C18 | | | | 65 | | | | | | 8 | | | | | | | | | | | | | |
| C19 | | | | | | | 36 | | | | | | | | | | | | | | | | |
| C20 | | | | | | | | | | | | | | | | | | | | | | | |

Sup Table 5(a). Site exposure ratio measured to the leg and expressed as a percentage for the SZA range 0°-30° and cloud cover less than 4 oktas measured between 2005 and 2008. ER ranges in the table show high exposed areas in red (ER: 75-100), mid exposed areas in blue (ER:25-74) and low exposed areas uncloured (ER: 0-25). No exposures were measured to contours Cv0, Cv1 or Cv2 as these were protected by the mannequin's shorts which were worn during the measurement period.

| | Cv3 | Cv4 | Cv5 | Cv6 | Cv7 | Cv8 | Cv9 | Cv10 | Cv11 | Cv12 | Cv13 | Cv14 | Cv15 |
|------|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| Ch1 | | | | | | 7 | 6 | 9 | | | | | |
| Ch2 | | | | | | 6 | 6 | 22 | | | | | |
| Ch3 | | | | | 1 | 9 | 5 | | | | | | |
| Ch4 | | 0 | 0 | 1 | 3 | 10 | 5 | | 0 | 0 | 0 | 0 | 0 |
| Ch5 | 0 | 3 | 2 | 2 | 4 | 11 | | | 0 | 0 | 0 | 0 | 0 |
| Ch6 | 1 | 6 | 4 | 4 | 5 | 10 | | 0 | 0 | 0 | 0 | 0 | 0 |
| Ch7 | 6 | 8 | 8 | 6 | 8 | 9 | | 7 | 12 | 13 | 9 | 1 | |
| Ch8 | | 11 | 12 | 10 | 11 | 9 | | 10 | 13 | 16 | 13 | 7 | |
| Ch9 | | 13 | 15 | 14 | 15 | 10 | | 10 | 10 | 15 | 12 | 9 | |
| Ch10 | | 15 | 19 | 17 | 18 | 9 | | 8 | 8 | 11 | 11 | 19 | |
| Ch11 | | 14 | 19 | 19 | 19 | 10 | | 8 | 6 | 7 | 11 | 17 | |
| Ch12 | | 20 | 23 | 19 | 16 | 7 | | 7 | 6 | 6 | 13 | 15 | |
| Ch13 | | 23 | 20 | 21 | 16 | 12 | | 6 | 8 | 8 | 15 | 15 | |
| Ch14 | | 21 | 21 | 20 | 14 | 12 | | 7 | 7 | 9 | 16 | 13 | |
| Ch15 | | 20 | 20 | 19 | 14 | 14 | | 9 | 8 | 9 | 14 | 16 | |
| Ch16 | | 20 | 19 | 18 | 14 | 13 | | 9 | 8 | 9 | 13 | | |
| Ch17 | | | 16 | 16 | 14 | 16 | | 11 | 10 | 9 | 12 | | |
| Ch18 | | | 16 | 18 | 15 | 17 | | 9 | 9 | 9 | 12 | | |
| Ch19 | | | 15 | 15 | 15 | 24 | | 8 | 10 | 9 | 11 | | |
| Ch20 | | | 13 | 15 | 15 | | | 7 | 8 | 9 | 10 | | |
| Ch21 | | | 15 | 16 | 17 | | | 6 | 10 | 9 | 8 | | |
| Ch22 | | | | 16 | 17 | | | 7 | 9 | 10 | 11 | | |
| Ch23 | | | | 17 | 16 | | | 7 | 9 | 10 | 11 | | |
| Ch24 | | | | 18 | 17 | | | 6 | 10 | 9 | 12 | | |
| Ch25 | | | | 14 | 16 | | | 8 | 9 | 10 | 13 | | |
| Ch26 | | | | 14 | 19 | | | 8 | 10 | 11 | 14 | | |
| Ch27 | | | | | 24 | | | 8 | 11 | 10 | 13 | | |
| Ch28 | | | | | 16 | | | 7 | 11 | 11 | 12 | | |
| Ch29 | | | | | | | | 9 | 10 | 12 | | | |
| Ch30 | | | | | | | | 10 | 10 | 12 | | | |
| Ch31 | | | | | | | | 10 | 11 | 16 | | | |
| Ch32 | | | | | | | | 9 | 10 | 13 | | | |
| Ch33 | | | | | | | | | 10 | 12 | | | |

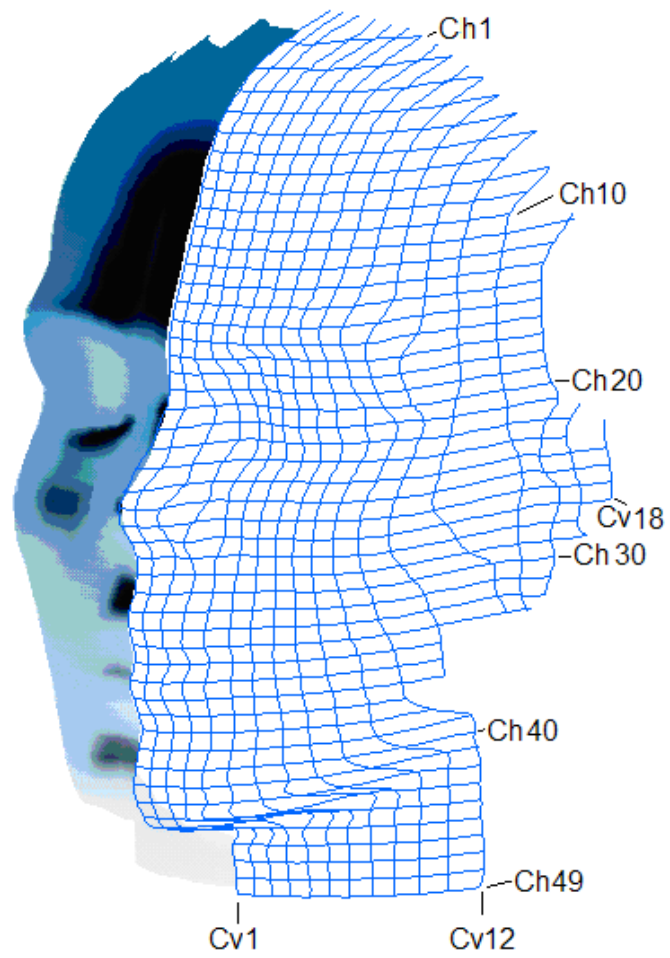
Sup Table 5(b). Site exposure ratio measured to the leg and expressed as a percentage for the SZA range 30°-50° and cloud cover less than 4 oktas measured between 2005 and 2008. ER ranges in the table show high exposed areas in red (ER: 75-100), mid exposed areas in blue (ER:25-74) and low exposed areas uncloured (ER: 0-25). No exposures were measured to contours Cv0, Cv1 or Cv2 as these were protected by the mannequin's shorts which were worn during the measurement period.

| | Cv3 | Cv4 | Cv5 | Cv6 | Cv7 | Cv8 | Cv9 | Cv10 | Cv11 | Cv12 | Cv13 | Cv14 | Cv15 |
|------|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| Ch1 | | | | | | 17 | 13 | 18 | | | | | |
| Ch2 | | | | | 4 | 21 | 11 | 35 | | | | | |
| Ch3 | | 4 | 5 | 6 | 9 | 23 | 11 | | | | | | |
| Ch4 | 6 | 11 | 9 | 8 | 12 | 25 | 10 | | | | | | |
| Ch5 | 13 | 15 | 13 | 13 | 13 | 31 | | | 14 | 20 | 17 | | 9 |
| Ch6 | 21 | 22 | 18 | 15 | 20 | 25 | | | 16 | 22 | 25 | 37 | 19 |
| Ch7 | 25 | 28 | 29 | 21 | 25 | 21 | | | 17 | 22 | 28 | 38 | 30 |
| Ch8 | | 34 | 33 | 18 | 38 | 22 | | | 17 | 20 | 26 | 22 | 29 |
| Ch9 | | 37 | 34 | 29 | 43 | 23 | | | 14 | 17 | 25 | 44 | 30 |
| Ch10 | | 52 | 29 | 38 | 38 | 23 | | | 14 | 10 | 24 | 44 | 42 |
| Ch11 | | 43 | 45 | 31 | 42 | 22 | | | 11 | 12 | 22 | 42 | 45 |
| Ch12 | | 44 | 44 | 38 | 33 | 27 | | | 13 | 13 | 21 | 43 | 31 |
| Ch13 | | 37 | 47 | 36 | 33 | 28 | | | 10 | 13 | 21 | 48 | 35 |
| Ch14 | | 33 | 39 | 44 | 36 | 35 | | | 12 | 12 | 21 | 46 | 33 |
| Ch15 | | 39 | 32 | 28 | 33 | 30 | | | 18 | 15 | 21 | 40 | 33 |
| Ch16 | | 36 | 32 | 32 | 30 | 40 | | | 14 | 14 | 21 | 36 | |
| Ch17 | | | 27 | 31 | 34 | 35 | | | 14 | 14 | 21 | 35 | |
| Ch18 | | | 29 | 35 | 35 | 46 | | | 14 | 14 | 20 | 22 | |
| Ch19 | | | 34 | 31 | 45 | 41 | | | 13 | 14 | 15 | 26 | |
| Ch20 | | | 21 | 28 | 41 | | | | 12 | 13 | 16 | 27 | |
| Ch21 | | | 32 | 38 | 48 | | | | 11 | 15 | 16 | 26 | |
| Ch22 | | | | 38 | 39 | | | | 11 | 14 | 17 | 23 | |
| Ch23 | | | | 32 | 36 | | | | 14 | 16 | 18 | 29 | |
| Ch24 | | | | 26 | 36 | | | | 11 | 15 | 19 | 32 | |
| Ch25 | | | | 33 | 37 | | | | 13 | 15 | 24 | 29 | |
| Ch26 | | | | 26 | 39 | | | | 16 | 16 | 19 | 33 | |
| Ch27 | | | | | 43 | | | | 13 | 18 | 23 | 26 | |
| Ch28 | | | | | 44 | | | | 15 | 17 | 25 | 25 | |
| Ch29 | | | | | | | | | 15 | 18 | 23 | | |
| Ch30 | | | | | | | | | 16 | 19 | 23 | | |
| Ch31 | | | | | | | | | 14 | 21 | 22 | | |
| Ch32 | | | | | | | | | 15 | 19 | 28 | | |
| Ch33 | | | | | | | | | | 14 | 25 | | |

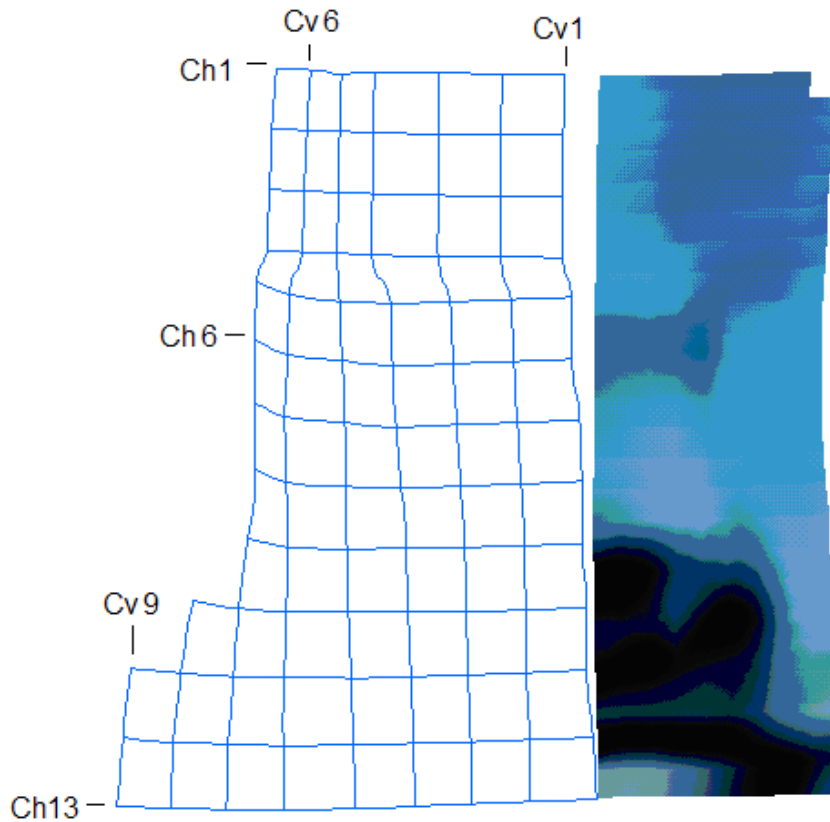
Sup Table 5(c). Site exposure ratio measured to the leg and expressed as a percentage for the SZA range 50°-80° and cloud cover less than 4 oktas measured between 2005 and 2008. ER ranges in the table show high exposed areas in red (ER: 75-100), mid exposed areas in blue (ER:25-74) and low exposed areas uncoloured (ER: 0-25). No exposures were measured to contours Cv0, Cv1 or Cv2 as these were protected by the mannequin's shorts which were worn during the measurement period.

| | Cv3 | Cv4 | Cv5 | Cv6 | Cv7 | Cv8 | Cv9 | Cv10 | Cv11 | Cv12 | Cv13 | Cv14 | Cv15 |
|------|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| Ch1 | | | | | | 33 | 24 | | | | | | |
| Ch2 | | | | | 12 | | | | | | | | |
| Ch3 | | | | | 19 | 36 | | | | | | | |
| Ch4 | | | | | 22 | | | | | | | | |
| Ch5 | | 35 | | 35 | | | | | | | 47 | | |
| Ch6 | 43 | | 42 | | 40 | | | | | | | | |
| Ch7 | 50 | | 38 | 36 | | | | | 32 | | 50 | 36 | 51 |
| Ch8 | | 45 | 15 | | 58 | | | | | | | | 38 |
| Ch9 | | 63 | 70 | 41 | | | | 34 | 37 | | 51 | 56 | |
| Ch10 | | 62 | 42 | 58 | 65 | | | | | | 37 | | 77 |
| Ch11 | | 64 | 62 | 65 | 55 | | | 24 | 25 | | | 40 | |
| Ch12 | | 71 | 70 | | 52 | | | | | | 31 | | 48 |
| Ch13 | | 62 | 75 | | 46 | | | 27 | 25 | | | | |
| Ch14 | | 60 | 53 | | 56 | | | | | | 35 | | 47 |
| Ch15 | | 43 | 59 | 59 | 40 | | | 39 | 25 | | | 61 | 52 |
| Ch16 | | 62 | 60 | | 45 | | | | | | 27 | | |
| Ch17 | | | 53 | | 44 | | | | | 27 | | 57 | |
| Ch18 | | | 56 | 59 | 51 | | | | | | 41 | | |
| Ch19 | | | 55 | | 57 | | | | | 33 | | 42 | |
| Ch20 | | | 46 | 51 | | | | | | | 45 | | |
| Ch21 | | | 49 | | 57 | | | | | 24 | | | |
| Ch22 | | | | 58 | | | | | | | 32 | | |
| Ch23 | | | | 54 | 60 | | | | | 33 | | 37 | |
| Ch24 | | | | 51 | | | | | | | 26 | | |
| Ch25 | | | | 52 | 58 | | | | | | | 53 | |
| Ch26 | | | | 51 | 53 | | | | | | 42 | | |
| Ch27 | | | | | 61 | | | | | | | 45 | |
| Ch28 | | | | | 50 | | | | | | 49 | | |
| Ch29 | | | | | | | | | | | | | |
| Ch30 | | | | | | | | | | | 41 | | |
| Ch31 | | | | | | | | | | | | | |
| Ch32 | | | | | | | | | | | 40 | | |
| Ch33 | | | | | | | | | | | | | |

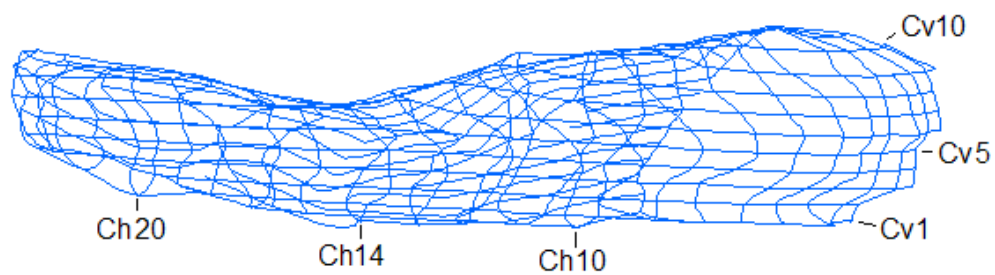
Supplementary Information: Figures



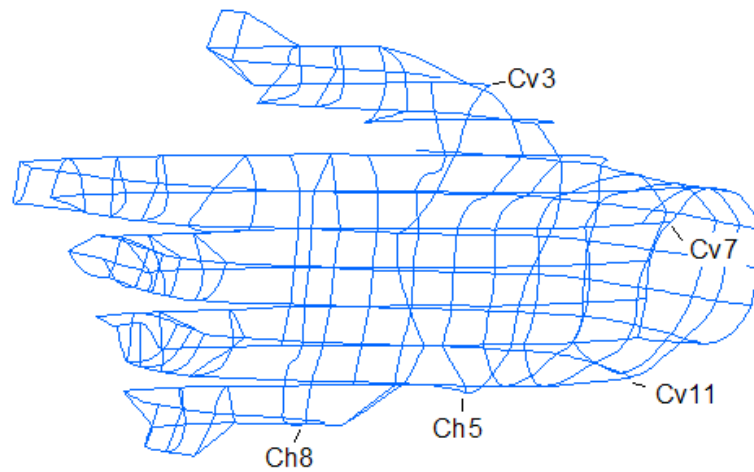
Sup Figure 1. Horizontal (Ch) and vertical (Cv) facial contour assignments.



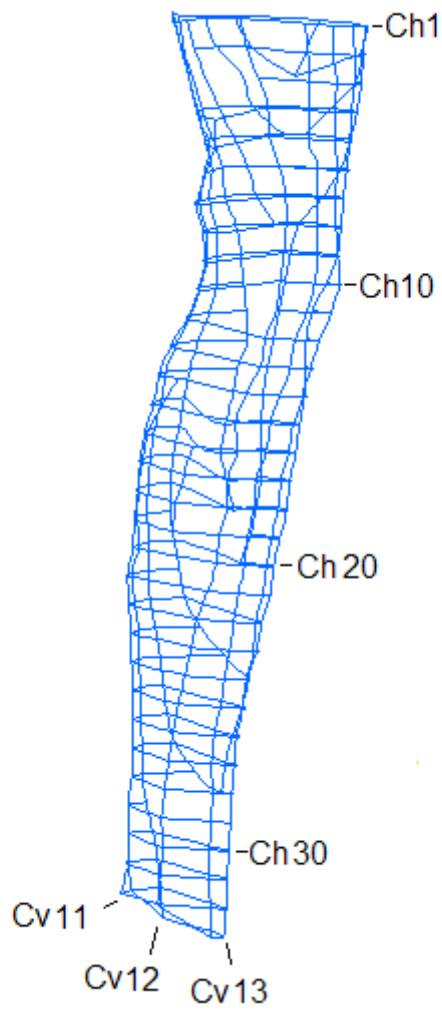
Sup Figure 2. Horizontal (Ch) and vertical (Cv) neck contour assignments.



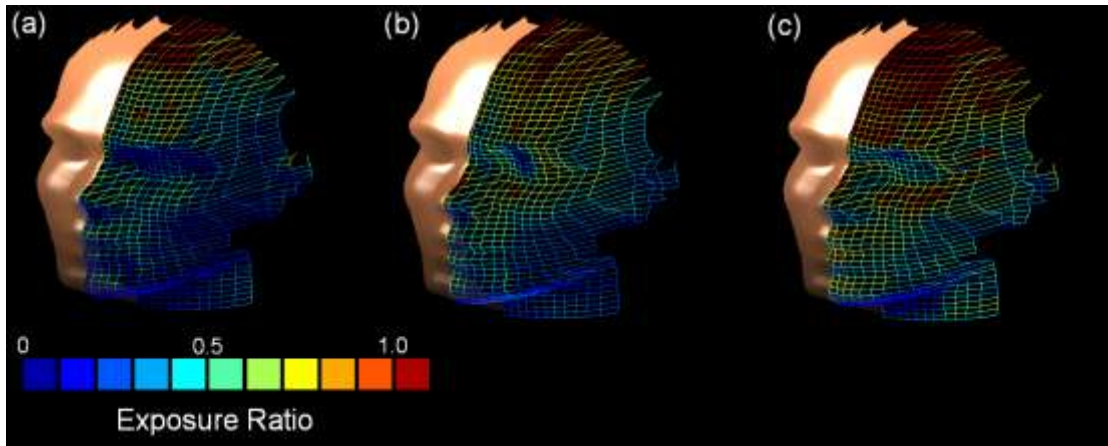
Sup Figure 3. View of three dimensional arm surface from behind the shoulder. Contours marked Cv1 through Cv23 are oriented along the arm's longitudinal axis. Anterior contours Cv1, Cv5 and Cv10 are shown. Contours marked Ch10, Ch14 and Ch20 are also shown on the diagram. These contours formed complete bands around the arm surface and were numbered from the shoulder (figure right) to the wrist (figure left). Vertical and horizontal contour assignments were given for the arm in its natural position when attached to the body mannequin such that banded contours are the horizontal contours in the wireframe.



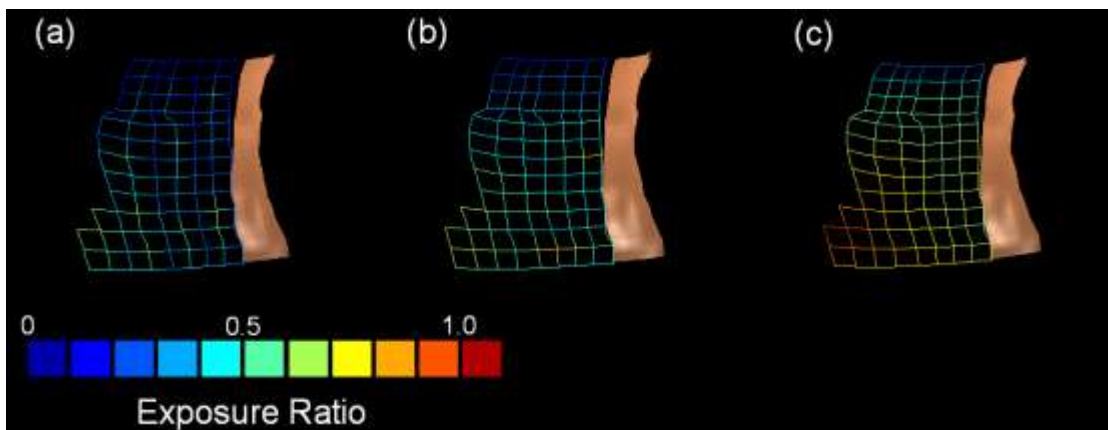
Sup Figure 4. Contours marked Cv1 through Cv23 represent the longitudinal contours extending from the wrist to the finger tips of the three dimensional hand surface. These contours start and end on the thumb. Contours banded about the hand surface and individual fingers start from the wrist and extend to the finger tip bands. Contours Ch5 and Ch8 are shown in the figure. Vertical and horizontal contour assignments were given for the hand in its natural position when attached to the body mannequin such that banded contours are the horizontal contours in the wireframe.



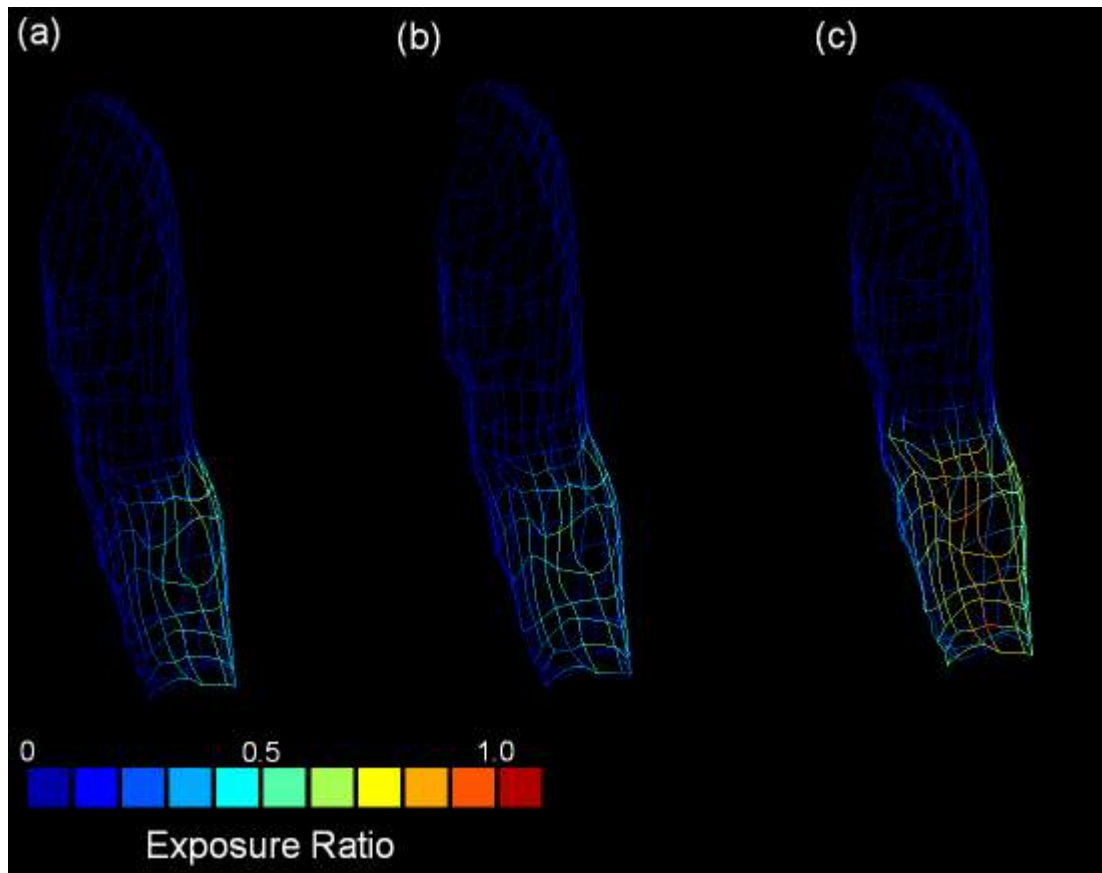
Sup Figure 5. Longitudinal leg contours extending from the upper thigh to the ankle start at Cv0 and end at Cv16. Contours Cv11 through Cv13 are shown in the figure for a forward facing view of the leg model showing the knee positioned to the upper right. Banded contours Ch1, Ch10, Ch20 and Ch30 show the thigh to ankle order in which these contours were labeled.



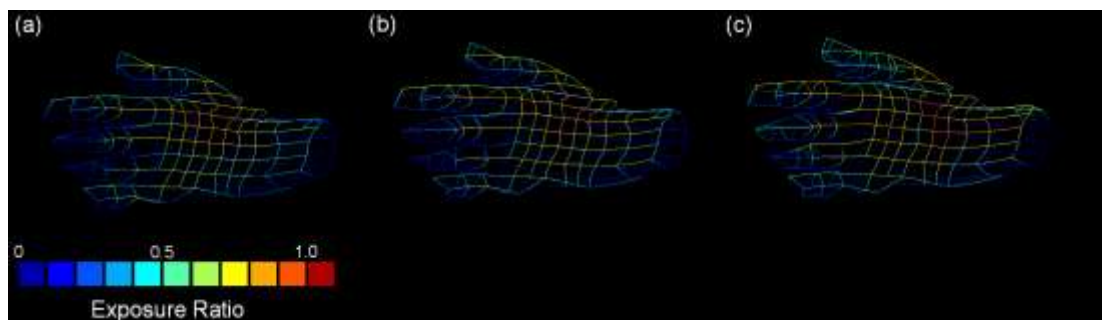
Sup Figure 6. Facial ER measured under low cloud cover conditions over the 2005 to 2008 period. (a) Facial ER measured in the SZA range 0° - 30° ; (b) Facial ER measured in the SZA range 30° - 50° ; (c) Facial ER measured in the SZA range 50° - 80° .



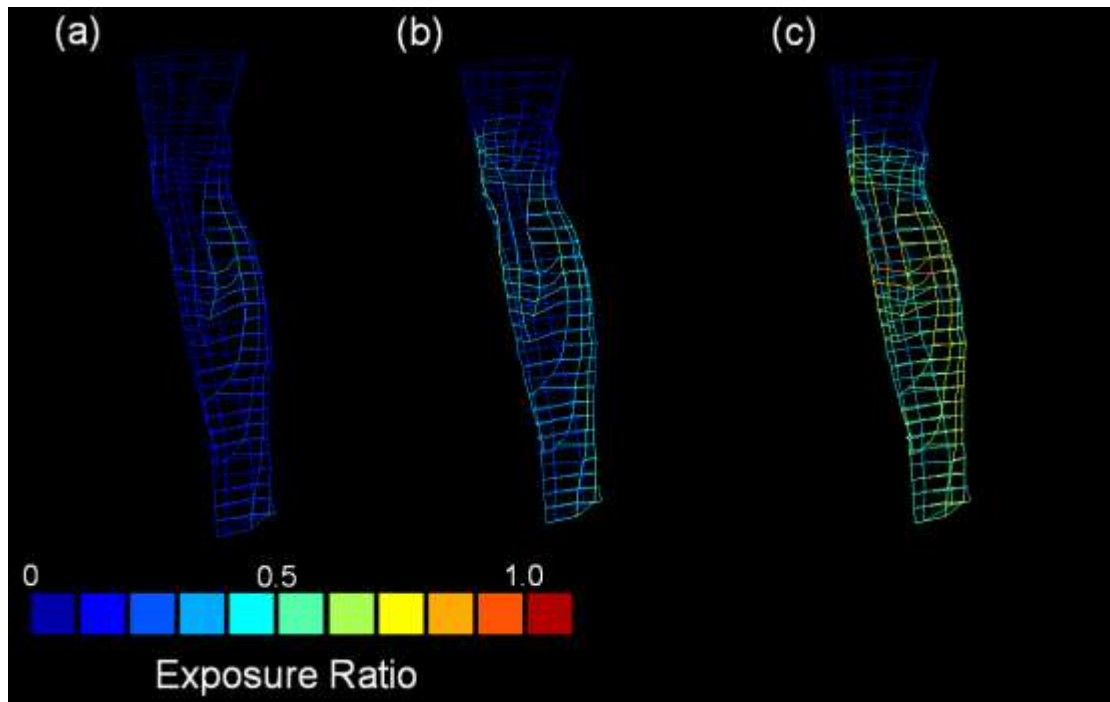
Sup Figure 7. ER measured to the back of the neck under low cloud cover conditions for SZA ranges 0° - 30° and 50° - 80° and high cloud cover conditions in the SZA range 30° - 50° measured over the 2005 to 2008 period. (a) Neck ER measured in the SZA range 0° - 30° ; (b) Neck ER measured in the SZA range 30° - 50° ; (c) Neck ER measured in the SZA range 50° - 80° . The greatest exposure was measured on the lower region of the neck toward the shoulder.



Sup Figure 8. ER measured to the arm under low cloud cover conditions over the 2005 to 2008 period. (a) Arm ER measured in the SZA range 0° - 30° ; (b) Arm ER measured in the SZA range 30° - 50° ; (c) Arm ER measured in the SZA range 50° - 80° . The anterior region of the lower forearm received the greatest exposure. The shoulder of the mannequin arm was protected by the sleeves of a polo style shirt.



Sup Figure 9. ER measured to the hand under low cloud cover conditions over the 2005 to 2008 period. (a) Hand ER measured in the SZA range 0° - 30° ; (b) Hand ER measured in the SZA range 30° - 50° ; (c) Hand ER measured in the SZA range 50° - 80° . The palm of the hand received negligible exposures.



Sup Figure 10. ER measured to the leg under low cloud cover conditions over the 2005 to 2008 period. (a) Leg ER measured in the SZA range 0° - 30° ; (b) Leg ER measured in the SZA range 30° - 50° ; (c) Leg ER measured in the SZA range 50° - 80° . The greatest exposure was measured over the upper anterior calf muscle region of the mannequin leg.