Investigating work-related neoplasia associated with solar radiation

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Introduction

In 2008, the World Health Organisation reported that one in three diagnosed cancers was skin cancer [1]. More than 15 years earlier, in 1992, the International Agency for Research on Cancer had classified ultraviolet (UV) radiation as a group 1 carcinogen and stated that ‘solar radiation causes cutaneous malignant melanoma and non-melanotic skin cancer’ [2]. Although solar (mainly UV) radiation encountered during leisure activities and holidays is very important in causing skin cancer, other exposures should also be taken into account when investigating skin cancer diagnoses. Both solar and non-solar exposures resulting from occupation and work-related tasks have been reported as skin carcinogens [3]. Solar radiation comprises UV radiation (UVA and UVB) and visible light, but as it is difficult to separate the effects of these different components in epidemiological studies the effects of all three are usually treated as a whole [4]. Non-solar causes of work-related skin neoplasia include ionizing radiation, arsenic, polycyclic aromatic hydrocarbons and welding burns [3].

In order to identify associations between causal agents (i.e. exposures) and work-related ill-health, there are within the UK well-established surveillance schemes based on a model developed within the Surveillance of...
Work-related and Occupational Respiratory Disease project, which has operated since 1989 [5]. A similar surveillance scheme for occupational skin disease, as reported by clinical specialists in dermatology, is EPIDERM, which has operated since 1993, and forms part of The Health and Occupation Research (THOR) network [6,7]. Between February 1993 and January 1999 reports originating from dermatologists showed that 13% (1608 of 12 574 estimated cases) were skin cancers and that the vast majority (96%) of these cited sunlight or UV radiation as the suspected causal agent. In comparison, analysis of occupational physicians’ reporting to THOR (from May 1994 to January 1999) showed that skin neoplasia was seldom reported because it is largely diagnosed in elderly men rather than those in the current working population. Additionally, more than three quarters of those with skin cancer diagnoses reported to the surveillance schemes were working in agriculture, construction or the armed forces [6]. Analysis of more recent EPIDERM data (2002–05 inclusive) showed a slightly higher proportion (18%) of estimated cases of skin neoplasia, and again very few reports (<1%) originating from occupational physicians [8]. Data contained in case reports to EPIDERM may provide further important details about work-related exposure to suspected agents, such as when exposures took place in relation to dates of diagnosis. Analysis of these data can therefore add important information to current evidence concerning work-related skin neoplasia.

Methods

This study analysed incident case reports of work-related skin disease originating from clinical specialists in dermatology who report to EPIDERM. EPIDERM’s methodology for reporting and analysing case reports has previously been described in detail [6]. In summary, dermatologists are asked to report new cases of work-related skin disease seen in their clinical practice within an allocated reporting period. Data collected for each case include demographic information, diagnosis, employment (job and industrial sector) and suspected agent(s). Additionally, from 2006 onwards, EPIDERM reporters were asked to provide symptom onset data for case reports.

Case reports of skin neoplasia reported between 1996 and 2012 (inclusive) were identified from the EPIDERM database, and subdivided by diagnosis, namely keratosis, basal cell carcinoma (BCC), squamous cell carcinoma (SCC), melanoma and unspecified neoplasia. A minority of cases had been assigned more than one diagnosis by reporters (e.g. keratosis and BCC) and these were excluded from further analysis. Where the suspected causal agent associated with a case was cited as ‘sun/sunlight/ultraviolet light’ (subsequently described as sunlight in this study) any information relating to exposure was extracted. Exposure-related information included the following:

- date first exposed, e.g. stable lad from 1950 to 1965,
- duration of exposure, e.g. retired window cleaner with 50 years of sun exposure and
- where the exposure took place, e.g. sunlight North Africa 1943–45.

Where exposure information was less specific (e.g. ‘postman all his life’), the school leaving age and retirement age applicable to the case were used to estimate exposure (i.e. the date of first exposure and duration). Cases were analysed by diagnosis, employment, exposure and (for cases reported after 2005) symptom onset using IBM SPSS statistics 20.

Multicentre Research Ethics Committee approval has been given for THOR.

Results

Between 1996 and 2012, 1944 cases of skin neoplasia were reported to EPIDERM by 97 clinical specialists in dermatology. Only nine cases had been assigned more than one diagnosis and the 1935 cases with single diagnoses were: keratosis 722 (40%); BCC 819 (42%), SCC 172 (9%), melanoma 66 (3%) and unspecified neoplasia 106 (6%). The suspected causal agent was sunlight in nearly all of the case reports (1922/1935; 99%); for seven cases, a second suspected causal agent was also cited, including hydrocarbons, tar and Germall 115 (imidazolidinyl urea). For the 13 cases not associated with sunlight, six had no reported causal agent, and the remaining seven involved exposures to bipyridyl/paraquat, welding sparks/burns, sulphur and x-rays. Subsequent analyses involve the 1915 cases with a single skin neoplasia diagnosis, where sunlight was the only reported suspected causal agent. Analyses of these cases by age and gender are shown in Table 1.

Most case reports (1734/1915; 91%) of work-related skin neoplasia were in males and the majority (62%) were aged over 65 at the time of EPIDERM reporting. Individuals with a diagnosis of melanoma appeared to have the lowest median age at the time of reporting to EPIDERM; however, case numbers for females with melanoma were very low. Delays between symptom onset (for cases reported after 2005) and reporting to EPIDERM are shown in Table 2; these were longest for keratosis diagnoses (discounting groups where case numbers were very low, such as females with SCC/melanoma/unspecified skin neoplasia). In terms of employment, armed forces personnel were reported most frequently (694 cases; 36%), followed by agricultural/forestry workers (421; 22%) and construction trades (401; 21%). Information relating to exposure was available for 42% (804/1915) of the cases, including estimated year of first exposure, duration of exposure or both. Exposure estimates were most frequently available for armed forces personnel, as demonstrated in Figure 1,
which shows first exposure date for 792 cases in total, 690 (87%) of them from the armed forces.

For each case, the difference between age at estimated first exposure and age when the case was reported to EPIDERM was calculated. Additionally, where data were available, the time between estimated first exposure and symptom onset was calculated, as shown in Table 3. The minimum age for estimated first exposure ranged from 14 to 34. Excluding cases of unspecified neoplasia, the median length of time between exposure and diagnosis (or symptom onset where data were available) was shortest for melanoma and longest for SCC cases. Duration of exposure information was available for 682 cases; the median duration is shown for each diagnostic category (Table 4). Where clear additional information was available about geographical location of exposure, this was also analysed in terms of whether the exposure took place in the UK (n = 65) or elsewhere (n = 270). Irrespective of diagnostic category, the median exposure duration appeared longer for cases where exposures occurred in the UK. Also of note are the wide ranges of exposure duration for each diagnostic category, irrespective of geographical location (apart from the categories where case numbers were low).

For half the reported cases (347/682; 51%), the geographical location of the exposure to sunlight was unclear. For example, an ‘aircraft engineer in the armed forces’ could have been working in the UK or elsewhere, whereas other case reports described individuals as working both within and outside the UK (e.g. a soldier in the armed forces who was also a labourer in the building trade). For the 335 cases where information on geographical location of exposure to sunlight was available, 89% of cases exposed in the UK had a recorded duration of exposure of 8 years or more; in comparison with only 17% of cases where exposure was outside the UK, as shown in Table 5.
For the 99 cases with an exposure to sunlight of less than 2 years, the number of cases exposed in the UK was two (2%), outside the UK there were 37 (37%) cases, whereas in 60 cases (61%) the geographical location of exposure was unclear. In comparison, for cases where the duration of exposure was 8 years or more, 58 (46%) received their exposure in the UK, 45 (36%) outside the UK and for 23 (18%) the geographical location was unclear.

**Discussion**

This study found that more than half (62%) the case reports of skin neoplasia submitted to a UK-wide surveillance scheme for work-related skin disease were aged over 65 at the time of reporting. This reflects the findings of other researchers who have reported increasing numbers of skin cancers (non-melanoma, melanoma and also keratosis) with increasing age [9–12]. There is also some evidence that malignant melanoma tends to be diagnosed at a younger age than other skin malignancies [10], which is reflected in case reporting to EPIDERM. In this study, the median time between first exposure to sunlight and diagnosis ranged from 44 years for melanoma to 57 years for unspecified neoplasia. Also of note were the delays between symptom onset and case reporting to EPIDERM, which could result from referral patterns or triage systems current at the time of reporting, or from late presentation by patients to clinicians. Data collection for symptom onset commenced in EPIDERM in 2006, which was after the introduction of clinical guidelines aiming to help general practitioners decide when to refer patients presenting with possible cancer symptoms to specialists [13]. However, although considerable effort has been made to raise skin cancer awareness in the general public, our results may indicate a need for more input to encourage people to seek early advice about skin lesions from clinicians.
This study also highlighted a high proportion (91%) of male case reports, which accords with the preponderance of male employees in the occupational sectors most frequently reported (armed forces, agriculture/forestry and construction). Other studies investigating work-related ill-health according to industrial sector have also demonstrated an increased incidence of skin neoplasia in construction and agricultural workers when compared with other sectors; again these analyses were based on THOR reports [14,15].

It is also unsurprising that the suspected causal agent was sunlight in nearly all (99%) of the case reports in EPIDERM, as the main risk factor in skin cancer aetiology is exposure to UV radiation [2]. The degree of exposure to sunlight depends on a variety of factors including any protection used (e.g. clothing), with the highest intensity occurring on exposed parts of the body such as the face, hands and upper limbs. The clinical specialists in EPIDERM are not specifically requested to provide information on the location of skin lesions when they report a case, and scrutiny of the EPIDERM database showed that such information is provided very rarely, and mainly for reports of dermatographism in association with the use of personal protective equipment (gloves or protective footwear).

Patterns of solar radiation exposure associated with skin cancer have also come under scrutiny, with distinctions being made between total, occupational and non-occupational exposures. Meta-analyses of UK studies relating occupational exposure to solar radiation have showed an increased risk for BCC and SCC, but not for melanoma [16–18]. For keratosis, a study based in Australia showed an association with occupational exposure to solar radiation, however this was not demonstrated in a UK study [12,19]. Distinctions between occupational and non-occupational exposures are difficult to make, with clinicians (such as the reporters in this study) being reliant on details obtained from a patient’s history. The information obtained is therefore open to recall bias, and may be influenced by patients’ knowledge of the disease and perceptions about its cause; additionally, physicians’ questions and use of prompts are important. By contrast, it may be easier to separate occupational and non-occupational causes for other diagnoses reported to EPIDERM, such as contact dermatitis, especially if the suspected causal agent is only found in the work environment.

EPIDERM’s reporting methods specifically request or prompt certain data (on demographic information, diagnosis, employment [job and industrial sector] and suspected agents) but not information about first exposure or duration of exposure. In this study, information on work-related exposures to sunlight (first exposure, duration or both parameters) was available for 804 (42%) of the case reports. EPIDERM relies on case reporting based upon a clinical and occupational history, investigations and subsequent diagnosis, therefore disease attribution may be influenced by both patients and clinicians; this may be especially relevant for long latency diseases such as skin neoplasia. Patients’ age is particularly relevant, with most subjects in this study being retired and exposures many years prior to a diagnosis of skin neoplasia being considered as likely causes for their disease. Additionally, EPIDERM reporters with an interest in work-related dermatoses may be actively seeking occupational connections between exposure and disease. In this study, 95 clinicians reported the 1915 cases where sunlight was cited as the sole causal agent for skin neoplasia. By contrast, if there is no obvious benefit (e.g. potential compensation) to investigating a cause such as sunlight exposure or its occupational associations, under-reporting might occur. Beyond the doctor-patient interactions that might affect reporting of individual cases, surveillance schemes are often associated with under-reporting behaviour. Although EPIDERM participation rates are generally high, factors such as reporter fatigue, non-response and ‘no cases this month’ reports will influence the estimation of national disease rates [20]. These potential influences, both on under- and over-reporting, should be borne in mind when interpreting the findings presented here.

Where exposure information was available, a high proportion of case reports were associated with individuals who had served in the armed forces. This is unsurprising, as an individual is likely to have a good recollection of such employment, including national/war service, and associated geographical locations. In comparison although 43% of skin neoplasia case reports in EPIDERM were associated with construction or agricultural employment, specific details of such work (e.g. when the person was employed in these sectors) may be less memorable, especially for workers who have moved between jobs during their working lives. Additionally, although patients’ recall may partly explain the low proportion of reported cases working outside the armed forces sector, the methods used to obtain information by reporting physicians may also have a part to play, with skin neoplasia having a better-known connection to overseas work than to UK-based work. However, of the 95 clinicians reporting single diagnosis skin neoplasia cases associated with sunlight exposure, most (58/95; 61%) cited the UK as the location of exposure; with 37/95 (39%) citing non-UK locations. Although EPIDERM reporters are asked to return case reports of all categories of work-related skin disease, contact dermatitis is the diagnosis most frequently reported to the scheme [6,8], with at least 96% of EPIDERM reporters using patch testing in their clinical practice [21]. These findings are likely to reflect reporters’ areas of expertise, interest and day-to-day clinical case load. Consequently, occupational histories obtained in relation to diagnoses other than contact
dermatitis (e.g. neoplasia) may be less routine and therefore less detailed.

In terms of duration of exposure and geographical location, case reports for work-related exposures to sunlight indicated that individuals with UK exposures had a longer median duration of exposure than those with non-UK exposures, irrespective of neoplasia category. Of note is the wide range of exposure duration for each diagnostic category, but taking a single cut-off point (8 years) 89% of cases within the UK had a duration of exposure of 8 years or more, whereas 83% of cases exposed to sunlight outside the UK had a duration of under 8 years. These geographical differences are in keeping with other published work, with all types of skin malignancy appearing to have an inverse relationship with latitude, as the intensity of solar radiation is greater closer to the equator [18].

In summary, EPIDERM provides information on work-related skin neoplasia associated with exposure to sunlight, with the median interval between initial exposure and disease being shortest for melanoma and longest for SCC. In terms of geographical location and duration of exposure, there is a noticeable difference between UK exposure (median duration ranging from 39 to 51 years for specified diagnoses) and non-UK exposure (median duration ranging from 2.5 to 6.5 years). Occupations at risk include armed forces personnel, agriculture/forestry workers and those working in construction trades, albeit with mainly historical exposures to sunlight. Such information may be especially relevant when considering facilities and support networks available to patients, including the Veterans Agency war pensions scheme, which allows compensation for melanomatous and non-melanomatous skin cancers in association with exposure to UV light [22–25]. There may well be a continuing problem in workers exposed more recently to sunlight, which has yet to emerge in terms of skin cancer incidence because of the long latency of these conditions. It is therefore important to continue to emphasize avoidance of UV exposure wherever possible and also for employers to provide, and for outdoor workers to use skin protection, especially among those working abroad.

Key points

- In a UK-wide surveillance scheme for work-related skin disease, the suspected causal agent was sunlight for most (>99%) skin neoplasia case reports.
- The median time between exposure to sunlight and symptom onset was over 40 years for all skin neoplasia diagnostic categories.
- Irrespective of diagnostic category, the median duration of exposure to sunlight appeared longer where exposures occurred in the UK rather than outside the UK.

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Conflicts of interest

None declared.

References


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**Billy Liddell**

On my 12th birthday, my father took me (at my request) to watch Liverpool play Arsenal. It was 1950 and my childhood hero was playing on the left wing, his favourite position. He didn’t score a goal that day, but I recall the excitement every time he got the ball. I never saw him play again, transferring my interests to rugby, but a tear came to my eye when I heard of his death in 2001.

Billy Liddell’s father was a Scots coalminer from near Dunfermline who, like so many in that trade, had no option but to go down the pit on leaving school and so made sure his sons didn’t suffer the same fate. When his eldest son, who had shown a precocious aptitude both for football and mathematics, was spotted by Matt Busby as someone who might join him at Liverpool FC, his father insisted that the contract should enable young Billy to continue his accountancy studies. So Billy Liddell pursued both careers simultaneously and it was just as well, for his father died of pneumoconiosis in his 50s leaving his wife with four other children. On £3 a match as a footballer, Billy’s accountancy career allowed him enough to bring them down to Liverpool and ensure their futures. He became one of the two most famous footballers of his generation and he and Stanley Matthews were the only ones who represented Great Britain against the Rest of Europe in both those international matches of that decade.

Billy Liddell was a prolific goal scorer, even putting some balls in the net directly from corner kicks. He was respected by his opponents and was the most modest and gentlemanly of men, a Justice of the Peace, a Sunday School teacher and a non-smoker and teetotaler. He had a long career with Liverpool and Scotland and later became bursar of Liverpool University. He fell ill with Parkinson’s disease in the 1990s and died in 2001 aged 79. In his obituary, he is said to have suffered latterly from Alzheimer’s disease.

Men of my generation will remember the leather football we played with and how heavy it became on wet winter days. Bill Shankly, describing Billy Liddell’s scoring ability, said that his headers were like blasts from a gun. On one occasion, he scored with his head from well outside the penalty area. Two decades after I watched him play I found myself seeing patients with neurological damage from professional boxing at the Liverpool Stadium, not far from Anfield. We now know that repeated head trauma can result in both Parkinson’s and Alzheimer’s disease and, as in the case of Mohammed Ali, you don’t need to be knocked senseless. We also know that smoking, whatever its ills, is protective against Parkinson’s. Sadly, both father and son seem likely to have died from occupational disease.

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