A summary of key messages to be included in public information resources for the primary prevention of skin cancer.

Authored by the British Association of Dermatologists, January 2009
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Introduction

Ultraviolet Radiation and the skin:

Ultraviolet radiation (UVR) exerts a number of important biological effects on the skin, influencing the immune system and vitamin D metabolism as well as causing DNA damage, photoaging, cancer, and pigmentary changes through biologically complex mechanisms. In addition, there are psychological effects, with many people reporting enhanced well-being after sun exposure, and social influences, with 20th and 21st century fashion dictating that a suntan is attractive and a sign of increased socio-economic status. That UVR exposure is directly linked to skin cancer is indisputable, but because of the differences in relationships of the differing tumours, as well as the complexity of the messages relating to sun exposure, it has been difficult to provide a simple, coherent and safe message that influences public opinion effectively.

The sun emits UV radiation (UVR). Long wavelength UVA [400-320nm] makes up 90 percent of radiation reaching the surface of the earth, short wavelength UVB [320-290nm] approximately 10 percent, while very short wave length UVC [290-200nm] is all reflected away by the earth's atmosphere. Penetration of UVR into the skin is wavelength dependent – long wavelength UVA penetrates deeply into the skin, reaching the basal layer of the epidermis and even dermal fibroblasts (Marrot and Meunier, 2008). UVB penetration through skin is more limited, but the increased energy of these wavelengths produces greater biological effects for shorter periods of exposure. (Ibrahim and Brown, 2008; Latonen and Laiho, 2005).

The immediate effects of UVR exposure are skin darkening, UVR induced erythema (sunburn) which may be followed by epidermal shedding, and cutaneous immunosuppression. Since the targets of UVR include nucleic acids, proteins, lipids, and other macromolecules, the biological consequences for deoxyribonucleic acid (DNA) structure are particularly striking, resulting in 'signature' mutations which are commonly found in cutaneous malignancies in humans. These DNA abnormalities are often repaired, but increasing numbers of abnormalities due to increasing UVR exposure may overwhelm the repair mechanisms. The increase in cutaneous malignancy in patients with DNA repair abnormalities indicates the importance of repair in normal skin. UVA is 10,000 times less mutagenic than UVB, but is present in natural UV radiation, i.e. sunlight, in much greater quantity (Pillai *et al.*, 2005). As a consequence, whilst UVA has historically been implicated in skin ageing, it has now been linked, along with UVB, in the development of skin cancers in animals and in immunosuppression in humans. Although the main source of UVA exposure is from sunlight, use of UVA emitting lamps in sunbeds for recreational tanning has raised additional concerns about artificial sources of human exposure (Gallagher and Lee, 2006).

UV radiation is a human carcinogen, and acts as both a promoter and inducer of skin cancer (Albert and Ostheimer, 2003). DNA and ribonucleic acid (RNA) contain strongly absorbing chromophores for UVB, and the consequences of UVR absorption are both DNA damage and immunosuppression, through an effect on T cells trafficking through the skin. Thus UVR exposure produces the appropriate

cellular and sub-cellular changes to promote the induction of skin cancer (Ibrahim and Brown, 2008; Blum *et al.*, 1941; Findlay, 1928; Hall, 1950; Levine *et al.*, 2005).

There are epidemiological data, as well as scientific information, regarding the increased risk UVR imposes on the development of skin cancer.

The World Health Organization has estimated that in the year 2000, up to 71,000 deaths worldwide were attributable to excessive UVR exposure (WHO, 2006). In the UK, more than 70,000 new cases of skin cancer are diagnosed annually, making it the most common cancer. Of these, 9,000 are melanoma. There are over 2,300 deaths from skin cancer annually in the UK, of which 1,800 are from melanoma and 500 from non-melanoma skin cancer. For women under 40, the rate of basal cell carcinoma (BCC) appears to have tripled over a period of just 30 years in the UK, while that of SCC quadrupled (Marks *et al.*, 1988), although it cannot be discounted that some of this increase may be attributable to better registration of skin cancers.

UVR exposure represents one of the most avoidable causes of cancer risk and mortality in humans. Whereas genetic and other factors undoubtedly contribute importantly to skin cancer risk, the role of ultraviolet is incontrovertible. As a consequence, it is likely that the majority of skin cancers are avoidable.

Although several associations have been established for skin cancer risk, such as skin phototype, immune suppression, viral infection, and genetic background, nonetheless solar UVR is broadly accepted to be the main initiator and promoter of skin cancer (Gallagher and Lee, 2006). Whilst most accept that the evidence for the role of UVR in the aetiology of both non-melanoma skin cancer and cutaneous malignant melanoma is overwhelming, there are a few authors who reject this claim (Shuster, 2008).

Objectives of the paper:

The British Association of Dermatologists was commissioned by NICE to produce a summary of key messages that should be included in public information resources for the primary prevention of skin cancer. The British Association of Dermatologists is the professional body representing dermatologists in the UK. The association contains well established expert groups, including a *Therapy and Guidelines Committee*, responsible for the development of national guidelines, patient information and responding to NICE initiatives; a *Skin Cancer Committee*, responsible for service organisation in skin cancer care, and a *Communications Committee*, responsible for delivering appropriate messages to a wide range of audiences. The members of the British Association of Dermatologists are at the centre of both research into and treatment of skin cancer. Consultant Dermatologists are the experts in the prevention and detection of the disease. The association also has a wide range of interactions with primary care and patient groups.

The objectives of this paper are as follows:

To produce a summary of relevant, accurate and up to date key skin cancer primary prevention messages that should be included in information resources targeted at the general public. Where possible the paper should also provide relevant key messages for specific population groups (for example, children or those at higher than average risk of developing skin cancer). The paper provides a broad framework of key messages and its supporting evidence. It is not, however, the remit of this paper to adapt these messages for delivery to the specific target audiences, media/format or objectives of an intervention.

The skin cancer primary prevention messages may be adapted and presented via one or more of the following formats:

- One to one group based verbal advice (with or without the use of information resources)
- Mass media campaigns
- Leaflets and other printed information, including posters, and teaching resources
- New media: the internet (including social network sites), e-media and text messaging
- Consequently, the key skin cancer prevention messages covered by the expert paper need to be amendable to being included in any of the above information resources and formats

The expert paper should provide a range of key messages relevant to the general public in the UK (the NICE scope document has not excluded any population groups). The expert paper should also identify relevant key messages for specific population groups (for example, children) including those at a higher than average risk of developing skin cancer and/or for specific age groups (please see appendix B in NICE scope document for further information).

The paper will review the relationship between UVR and skin cancer, and recommend appropriate and deliverable messages for information resources in the UK.

The messages are applicable to sun exposure both in the UK and abroad.

Section 1 of the paper outlines a number of key factors and discussion points that influence the development of the recommendations included in section 2. The relationship between skin cancer and UVR is subject to a number of variables and controversies, and it is therefore important that these are outlined to provide the context for the recommendations that follow. These points include the differing causes of the main types of skin cancer, variables affecting sun exposure levels, the influence of skin type and the possible health benefits of sun exposure, which all impact on the level of detail and specificity available in the recommendations.

Methods:

A broad based electronic literature search was performed. Databases searched include MEDLINE (Ovid), PubMed, EMBASE (DialogDatastar) in addition to the internet sites of the World Health Organisation, Office for National Statistics, Cancer Research UK. We included Meta-Analyses, Randomised Controlled Trials, Case-Control Studies and Review Articles, and searched on relevant terms (e.g. skin cancer prevention, vitamin D) alone and in combination. The identified publications were reviewed independently by three reviewers, who selected studies and publications based on relevance, quality and consistency. High quality review articles and meta-analyses were selected for inclusion above single papers.
An editorial panel was formed to evaluate the relative importance of the publications based on consistency, source and relevance, and the key messages identified. The paper was then drafted, reviewed by the editorial panel and subsequently sent for peer review by three independent experts in the field.

Stages:

1. The literature search was conducted by an Information Scientist
2. The literature review was then sent to certain members of the editorial panel for evaluation and key messages identified from the research.
3. The key messages were then written by the lead authors, based on the review of evidence on all issues pertaining to skin cancer epidemiology, incidence, public prevention campaigns, health messages, primary prevention methods, including issues for discussion.
4. The draft document was circulated to the full editorial panel for review.
5. The draft document was subsequently peer reviewed by three independent experts in public health and skin cancer.
6. Additions and amendments from the three independent experts were incorporated into the final paper prior to submission to NICE.

Please see appendix A for further details on the search methods, data analysis, criteria for considering studies for this review and results.

Section 1: Background and context

Unlike other health campaigns where the negative health impact is incontrovertible and no or limited health benefits are evident, for example the anti-smoking messages, the skin cancer and sun safety health messages are subject to a range of variables and discussion points.

Studies suggest that the public perception of skin cancer severity is low (Lowe *et al.*, 1993; Glanz *et al.*, 1999). Factors including the time lag between sun exposure and skin cancer development, a belief that skin cancers can be easily ‘removed’, and the fashion for tanned skin, may influence people’s attitudes toward self protection against skin cancer. Any information resource must correct these assumptions - malignant melanoma causes more than 2,300 deaths per year in the UK and non-melanoma skin cancers are associated with lower mortality but significant morbidity and often extensive scarring.

UVR damages the skin and is linked to skin cancer and skin ageing. The simple solution would be to advise the public against sun exposure. However, UVR from the sun also carries a number of health benefits; primarily that UVR causes the production of vitamin D in the body, which is known to be essential for some functions, e.g. calcium homeostasis, and to be beneficial for many others. The preferred option is therefore to advise against 'excess' sun exposure, such as would cause sunburn or heavy tanning, as this allows people to benefit from limited sun exposure but minimizes the most harmful effects of the sun, and will reduce cumulative sun exposure at the same time.

However, the message itself is not easily definable, as a number of variables, such as the geographical location, time of day, weather conditions and the individual's skin colour, all contribute to the net effect of the sun on the skin.

It is therefore difficult to quantify how much sun it takes to damage the skin, how much sun it takes to obtain an individual's optimum vitamin D level, or furthermore to combine the two and define a safe level of sun exposure that allows a person to obtain the recommended level of vitamin D without suffering skin damage.

For these reasons, a set of broad guidelines based on the range of available evidence but allowing for a 'common sense' approach and taking into account these variables and need for balance is the only viable option, and this paper sets out to provide such recommendations.

1. Melanoma and non-melanoma skin cancers

While UVR is responsible both for melanoma and non-melanoma skin cancers, the different types of skin cancer are attributable to different types of exposure.

Malignant melanoma:

Melanoma incidence has most strongly and consistently been associated with reported ''intermittent sun exposure'' mostly accrued through recreational activities (Gallagher and Lee, 2006; Walter *et al.*, 1999, Gandini *et al.*, 2005), although there is some evidence for a dual aetiology with episodic high intensity sun exposure acting on a background of high cumulative UVR levels. Although melanoma accounts for only five percent of total cutaneous malignancy, it is responsible for approximately 75 to 80 percent of skin cancer-related deaths (Ibrahim and Brown, 2008).

Malignant melanoma (MM) occurs among all adequately studied racial and ethnic groups but is rare in populations with heavily pigmented skin. Its incidence is much lower compared to non-melanoma skin cancer (NMSC) but has been rising in fair-skinned populations throughout the world for several decades (Armstrong and Kricker, 1994). The annual increase varies between populations but in general has been estimated to be between three and seven percent, with mortality rates increasing less quickly. These estimates suggest a doubling of incidence rates every 10 to 20 years.

The frequency of its occurrence is closely associated with skin type, and also depends on the geographical zone. Incidence among dark skinned ethnic groups is one per 100,000 per year or less,

but exceeds 50 per 100,000 per year among light-skinned people in those areas with the highest rates. The figures for light-skinned people in Northern Europe are lower, but still very significant.

Non-melanoma skin cancer:

Non-melanoma skin cancers (NMSCs) comprising basal cell carcinomas (BCCs) and squamous cell carcinomas (SCCs) are the commonest malignancies diagnosed in fair-skinned populations worldwide, especially in those with blue eyes, a fair complexion, skin type I and II (sunburn easily, suntan poorly, freckle with sun exposure), and red or blond hair. Their incidence is rising dramatically (Diepgen and Mahler, 2002). The most accurate UK data for NMSC comes from a study in Northern Ireland where between 1993 and 2002, the age-adjusted incidence rates for BCC increased from 88 to 104 per 100,000 in men, and fell from 75 to 71 per 100,000 in women, while the age-adjusted incidence rates for SCC increased from 41 to 48 per 100,000 in men but remained steady at 22 per 100,000 in women. These levels are confirmed in other UK studies (Brewster *et al.*, 2007), and are still likely to be under-estimates because of poor reporting.

Over 80 percent of NMSCs occur on areas of the body that are frequently exposed to sunlight, and tumours may be multiple.

Whilst BCC and SCC are often grouped together, the role of UVR may be different in the two tumour types. Intensive UVR exposure in childhood and adolescence, particularly in those who burn easily, is associated with the development of BCC. For SCC, chronic UVR exposure in the earlier decades is more important (Leiter and Garbe 2008.)

Incidence also increases with age; according to Holme *et al.* (2000), in 1998 the incidence of BCC in individuals over 75 years old was approximately five times higher than that of individuals between 50 and 55 years old, and for SCC approximately 35 times higher. In addition, immunosuppression increases the risk of SCC (Ismail *et al.*, 2006). In renal transplant patients, the cumulative incidence of developing skin cancer, calculated by life table analysis, increased progressively from seven percent after one year of immunosuppression to 45 percent after 11 years and to 70 percent after 20 years. Other aetiological factors, whilst clearly related (e.g. chemical carcinogens, ionizing radiation), are of more limited significance.

2. Variables affecting sun exposure levels

Many factors influence the intensity of UVR reaching the earth's surface. These include:

- Environmental factors such as ozone levels, cloud cover and height, environmental pollutants, and ground surfaces
- Shade reduces UVA exposure by 50 percent (Schaefer *et al.*, 1998). UVA, in particular, is amplified in the presence of reflective surfaces such as snow, sand and water (which reflect 30 percent to 80 percent, 15 percent to 30 percent, and <5 percent of UVR respectively) (Rai and Srinivas, 2007)

- Temporal relationships of UVR exposure also exist: maximal solar irradiation occurs around noon, and in the summer months

- Geography also functions to alter UVR exposure. Decreasing latitudes and increasing altitudes increase ultraviolet (UV) irradiation, for example a one kilometer increase in altitude increases UVR by 10 to 25 percent (Matts, 2006)

While these variables influence UVR levels, the most significant element is the skin type of the individual being exposed to UVR in each of these locations / situations.

3. The influence of skin type

While recognizing that not all individuals can be categorized into a specific skin type, dermatologists use a scale of I to VI to describe skin type with regard to the effects of UVR. An individual's skin type cannot be changed and does not vary according to how tanned the person is – it is genetically determined. This system allows for a common sense approach to self protection.

There is an increased risk of NMSC in white populations, especially those with blue eyes, a fair complexion, skin type I and II, and red or blond hair (type I skin). NMSC is uncommon in black populations, Asians, and Hispanics. There is a higher incidence of BCC in albino blacks than in normally pigmented black populations. In contrast to white populations, sunlight does not appear to be an important aetiological factor for SCC or melanoma in black populations because lesions occur on non-sun-exposed regions of the body.

Type I: pale skin, burn very easily and rarely tan. They generally have light coloured or red hair and freckles.

Type II: usually burn but may gradually tan. They are likely to have light hair, and blue or brown eyes. Some may have dark hair but still have fair skin.

Type III: burn with long exposure to the sun but generally tan quite easily. They usually have a light olive skin with dark hair and brown or green eyes.

Type IV: burn with very lengthy exposures but always tan easily as well. They usually have brown eyes and dark hair.

Type V: have a naturally brown skin, with brown eyes and dark hair. They burn only with excessive exposure to the sun and their skin further darkens easily.

Type VI: have black skin with dark brown eyes and black hair. They burn only with extreme exposure to the sun and their skin further darkens very easily.

On unprotected skin, sunburns from UVB occur from amounts of sun exposure that vary with skin type, but can be as short as 10 minutes in skin type I in the UK. However, most incident sunlight is composed of UVA (320-400nm), which is much less erythemogenic. In fact, 1,000 times more UVA is required to cause sunburn when compared with UVB (Kullavanijaya and Lim, 2005). Tanning is the more common result of UVA exposure, explaining its prominent role in the tanning industry. The lack of

visible erythema after sunbed use can be deceptive because many of UVB's harmful effects are shared by UVA. However, in one recent study up to 58 percent of users reported burns from indoor tanning (Cokkinides *et al.*, 2009).

People with a large number of moles, or with a family history of melanoma, are also at greater risk (see Section 2(1) on 'Risk'.)

4. Vitamin D and photoprotection

Evidence relating to sun safety cannot be interpreted in isolation from the increasing, but sometimes contradictory, volume of evidence surrounding the risks to health from vitamin D deficiency and its link to sun avoidance.

i) Physiology of Vitamin D

Vitamin D is produced in the skin in response to UVR. Solar radiation is the major (90 to 100 percent) source of vitamin D in humans, and vitamin D status reflects sun exposure over the preceding month or so. There is seasonal variation in UVR, and vitamin D levels reflect changes in outdoor behaviour as well as UVR levels. Pre-vitamin D and vitamin D are photolabile, and the synthetic function fades after 5 to 10 minutes of sun exposure. As a consequence, production of vitamin D due to UV exposure is limited, no matter how long someone is exposed to sunlight. Hence it is simply not possible to synthesize large stocks of vitamin D by prolonged exposure to the sun (Webb *et al.*, 1989, Dahl, 2004). Plasma levels of above 30 microgram/l of 25 hydroxyvitamin D are required for normal physiological function (Feskanich *et al.*, 2004). This includes calcium homeostasis and normal bone health. In northern latitudes, and in winter, many individuals are vitamin D deficient by these definitions. Some groups are more susceptible to vitamin D deficiency and these include breast fed babies, the elderly, persons with limited sun exposure, and those with malabsorption syndromes, obesity or dark skin.

ii) Health benefits of vitamin D and health risks from vitamin D deficiency

Higher vitamin D levels may have health benefits, and so it has been suggested that additional UVR exposure or vitamin D supplements may be necessary, for example, supplements of 25 micrograms (µg) (1,000 IU) in those under one year, 50 µg in children up to 13, and 50 µg (2000 IU) in adults, including during pregnancy and lactation (Cranney, 2007). It is clear that high vitamin D levels benefit bone health. A recent evidence-based review of research concluded that supplements of both vitamin D3 (at around 20 micrograms/day) and calcium (500-1200 micrograms/day) decreased the risk of falls, fractures, and bone loss in elderly individuals aged 62 to 85 years (Cranney, 2007). They may also reduce the risk of internal malignancy (Giovannucci, 2005; Freedman *et al.*, 2007; Skinner, 2008; Lu *et al.*, 2008; Stolzenberg-Solomon, 2009; Ahn *et al.*, 2008; Khazai *et al.*, 2008). However, a WHO IARC working group paper concluded that there was insufficient evidence to support conclusively the relationship between vitamin D levels and colo-rectal and breast cancer, and none to support a relationship to prostatic cancer. Two studies of dietary supplementation with 10 and 21 micrograms of

vitamin D failed to influence the incidence of colo-rectal or breast cancer, but supplementation with up to 20 micrograms of vitamin D reduced all cause mortality in the over 50 age group. It is possible, but unproven, that high vitamin D levels may reduce disease progression in established malignancy. Controversially, very high levels of vitamin D are associated with increased mortality from cardiovascular disease (IARC Reports, 2008). Other adverse health issues associated with low vitamin D levels include multiple sclerosis, hypertension, diabetes, autoimmune disorders and osteoporosis (Moan *et al.*, 2008; Diffey, 2006). Whilst there are suggestions of benefit from high vitamin D levels, these health benefits are as yet unproven. The 2008 IARC report concluded that for the time being, the definition of vitamin D deficiency should relate to the prevention of rickets, osteomalacia or muscular pain as opposed to internal malignancies. However, this is an emerging area of research which may support the role of vitamin D in disease prevention in future studies.

iii) The arguments

a) It has been suggested that the potential benefits of exposure to sunlight may outweigh the widely publicized adverse effects on the incidence of skin cancer (Ness *et al.*, 1999). As indicated above, the evidence for benefit of UVR exposure acting through vitamin D is contradictory, whilst the evidence for UVR exposure as a cause of skin cancer is incontrovertible.

b) Some have argued that there is little evidence that sun avoidance measures prevent melanoma (Shuster, 2008) and that there is no reduction in the incidence of melanoma with sunscreen use. Almost all authorities accept that there is a direct link between UVR exposure and melanoma (Menzies, 2008). There are convincing data that sunscreen use has little influence on vitamin D status (Marks, 1995).

c) At the same time, it has been suggested that advice aimed at reducing the frequency of episodes of sunburn may have the net effect of reducing vitamin D levels. As indicated above, this is unlikely to be a significant factor because of the very short period of time in the sun needed for maximum vitamin D synthesis.

iv) Vitamin D Recommended Daily Allowance (RDA)

The minimal requirement for vitamin D is dependent on many factors such as latitude, personal lifestyle (including smoking and body mass index) skin type and the season. It is thus not possible to give a precise figure of dietary supplementation to avoid vitamin D deficiency but the range of vitamin D intakes required to ensure maintenance of wintertime vitamin D status of 20 to 40 year old adults, considering a variety of sun exposure preferences, is between 7.2 and 41.1 micrograms/day. Government guidelines say people between the ages of 51 and 70 should get 400 International Units (IU) (10 micrograms) of vitamin D daily, and those ages 71 and older, 600 IU. In adult patients at high risk, daily vitamin D3 intake should be 800–1000 IU or 50,000 IU vitamin D3 per month (Kullavanijaya and Lim 2005).

v) The need for balance

There are clear and robust data linking skin cancer and UVR. The data regarding the health benefits of vitamin D are emerging, but are still unclear. Sun safety messages must therefore be tailored to take into account this growing area of research, and should influence but not replace sun safety messages.

People should not be advised to forsake photoprotection for cutaneous vitamin D supplementation. Oral supplementation of vitamin D, through diet or dietary supplements is an additional means of achieving adequate vitamin D levels.

Section 2: Recommendations

1. Risk

i) Skin types

"Skin types I and II are at the greatest risk of developing skin cancer. These skin types sunburn rapidly and therefore should avoid sun exposure and should protect the skin with clothing. Skin types III and IV should protect themselves in strong sunshine, and during prolonged exposure. Types V and VI need only protect themselves during prolonged UVR exposure.
Sunburn causes skin cancer and should be avoided by all individuals, regardless of age or skin type."

The recommendations outlined in this paper regarding methods of sun protection (e.g. clothing, shade and sunscreen) should be used in conjunction with the skin type guide. For example, the use of clothing and sunscreen as outlined below applies to skin types I and II at all times in the sun, and to skin types V and VI during periods of prolonged or intense sun exposure.

ii) Children

"Protect children in the sun using shade, clothing and sunscreen with SPF 50+. Keep babies out of direct sunlight."

In a recent study, an intensive UVR exposure in childhood and adolescence was found to be causative for the development of BCC whereas for SCC, chronic UVR exposure in the earlier decades was accused (Leiter and Garbe, 2008). BCC was associated with frequent severe sunburns and freckling in childhood. In addition, there was an inverse association with cumulative recreational lifetime exposure. These studies suggest that childhood sun exposure patterns in susceptible individuals may play a major role in accounting for risk of BCC. Regular use of sunscreens during the first 18 years of life has been predicted to reduce the lifetime risk of non-melanoma skin cancers by 78 percent (Stern *et al.*, 1986).

Sunburns, in particular burns which occur in childhood, are believed to be a primary cause of melanoma (Armstrong, 1988) but a recent meta-analysis has shown that sunburns increase the risk of melanoma, no matter at what age they occur (Dennis *et al.*, 2008).

Studies suggest that people generally do not apply sufficient quantities of sunscreen to obtain the indicated SPF, as outlined in the section 4(i) below. The recommended SPF 50 takes into account these behavioural factors that lead to a reduced level of protection. If applied adequately, then SPF 30 should be sufficient for children.

Babies should be kept out of direct sunlight not just to protect against skin damage but also to prevent overheating, as babies are unable to regulate their body temperature through sweating to the same extent as adults.

iii) Outdoor workers

"If you work outdoors, protect exposed skin during the summer with regular application of high protection sunscreen. If possible, wear a hat that shades your face, neck and ears. Try to spend time in the shade during breaks, and if possible limit your time in the sun in the middle of the day (11am to 3pm)."

Some professions require individuals to spend higher than average periods of time outdoors and thus increase their cumulative sun exposure as well as their risk of sunburn. Outdoor workers, in particular those with pale skin types, should therefore be categorised as a high risk group. In the US, knowledge and prevention practices for skin cancer have been found to be variable (Glanz *et al.*, 2007).

Outdoor workers should use high protection sunscreens during the summer months, and these should be reapplied every two hours. Water resistant products are advisable if sweating or contact with water is likely. Workers should be encouraged to spend time in the shade during breaks, especially around solar noon when the sun is at its strongest. Where possible, the use of clothing and headgear that protect the skin are advised.

Employers should incorporate sun safety messages into health and safety training, and take measures to protect their staff including, where possible, the adaption of uniforms to include clothing and headgear that will limit UV exposure.

Studies have shown that employees working under mandatory sun protection policy have reduced levels of sun damage than those working under voluntary sun protection policy (Woolley *et al.*, 2008)

iii) Immunosuppressed patients

"If you have had a transplant you will be given immunosuppressive drugs to prevent you rejecting the transplanted organ. These work by dampening down your immune (defence) system. However, these treatments also increase the risk of skin cancer and some benign tumours and infections. Likewise, if you are an HIV patient, you are also at higher risk of developing skin cancer. Learn how to recognize the early signs of skin cancer. Examine your skin regularly for signs of cancer and get an annual check from your doctor or transplant nurse. Protect yourself from the sun – use SPF 30+, clothing and shade."

People with a damaged immune system (e.g. after an organ transplant or taking immunosuppressive drugs and, to a lesser degree, as a result of an HIV infection) are at a higher risk of developing skin

cancer. Immunosuppression increases the risk of SCC. In renal transplant patients, the cumulative incidence of developing skin cancer, calculated by life table analysis, increased progressively from seven percent after one year of immunosuppression to 45 percent after 11 years and to 70 percent after 20 years (Ismail *et al.*, 2006).

iv) Number of moles

"If you have a lot of moles (more than 50), you will need to take extra care to check your skin monthly for any changes. Protect your skin from sun damage using clothing, shade and sunscreen."

People with many (more than 50) ordinary moles (Silva Idos *et al.*, 2009; Gandini *et al.*, 2005), or with a very large dark hairy birthmark, have a higher than average chance of getting a melanoma. Some people have many unusual (atypical) moles (known as 'dysplastic naevi'). They tend to be larger than ordinary moles, to be present in large numbers, and to have irregular edges or colour patterns. The tendency to have these 'dysplastic naevi' can run in families and carries an increased risk of getting a melanoma. Moles are different to freckles but if you are in doubt, check with your GP.

v) Family history

"If you have a family history of skin cancer, you should take extra care to protect your skin from the sun, and should regularly check your skin for changes that may indicate skin cancer."

Approximately two percent of melanoma patients have a family history of the disease (MacKie, 1998). People who have already had one melanoma have approximately a five percent risk of getting another one (Slingluff *et al.*, 1993) Rarely melanoma can be familial and this increased susceptibility may occur as a result of the inheritance of mutations at the CDKN2A locus or in the CDK4 gene. For these families, gene testing and genetic counselling may be appropriate (Newton-Bishop and Gruis, 2007).

High risk groups as outlined above should always protect their skin from the sun, and obtain vitamin D from the diet or supplements. Clothing and shade should be the primary sun protection methods for these groups.

2. When to protect the skin*

"Spend time in the shade between 11am and 3pm when it's sunny.
Protect the skin both in the UK and abroad when it's sunny, and on winter sports holidays."

Solar noon is the point at which the sun is at its highest in the sky at a particular location and this is when the sun's UVR is at its most intense This does not always coincide precisely with 12pm or what we call 'noon' according to the clock. Because time zones and daylight saving time separates solar noon from the ascribed noontime (Ting, 2003), a convenient rule of thumb is that if your shadow is longer than you are tall, there is relatively less danger from UVR (Palm and O'Donoghue, 2007). This principle can be applied anywhere in the world.

In the UK, UVR levels are at their highest in the middle of the day, between 11am and 3pm.

In line with the need to balance sun safety messages with the aforementioned vitamin D issues, it is no longer appropriate to suggest that people stay out of the sun entirely. Therefore the messages “stay indoors” or “stay in the shade” between 11am and 3pm are better replaced with “spend time in the shade between 11am and 3pm when it’s sunny”.

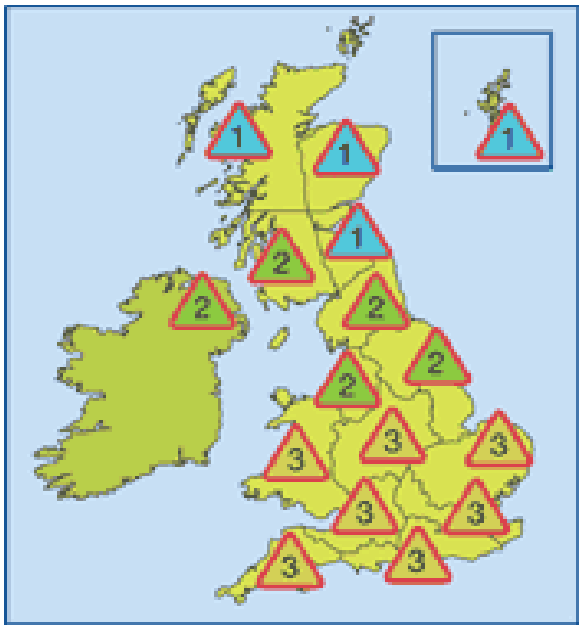
This takes into account the fact that it is only necessary when sunny, not year round, and allows people to spend short periods of time in the sun but not extended periods that may lead to sunburn or sun damage.

However, people with pale skin (types I and II) can sunburn in less than ten minutes in the UK, so in strong sunshine, deliberate sun exposure should be avoided between 11am and 3pm by these skin types. Others should be strongly cautioned against extended periods of outdoor activities at this time.

It is worth also noting that cloud cover reduces but does not eradicate UVR and it is therefore still possible for skin damage to occur even if clouds are present (Diffey *et al.*, 1988).

Both the climate and individuals’ minimal erythemal dose vary, and UV levels can be high enough to damage skin on sunny days in spring and autumn, not just in the summer months.

If in doubt, a UV forecast can provide guidance on the daily levels of UVR. The solar UV index was created by the World Health Organisation to show the level of the sun’s UV radiation that we are exposed to on a particular day. Weather forecasts using the UV index take into account the position of the sun in the sky, cloud cover and ozone levels. UV forecasts use a simple scale of 1 (very low risk) to 11+ (extreme risk), to show the possible danger to an individual’s skin and eyes from the sun, taking into account the different skin types. The solar UV index usually predicts the maximum amount of UV radiation for the day. This index does not exceed 8 in the UK (8 is rare; 7 may occur on exceptional days, mostly in the two weeks around the summer solstice). Indices of 9 and 10 are common in the Mediterranean area (Health Protection Agency, 2008).



Example of the Met Office's UK UV forecast. The Index numbers correspond with those in Table 1

Index	Fair, Burns	Fair, Tans	Brown	Black
1 2	Low	Low	Low	Low
3 4	Medium	Low	Low	Low
5	High	Medium	Low	Low
6	Very High	Medium	Medium	Low
7	Very High	High	Medium	Medium
8 9	Very High	High	Medium	Medium
10	Very High	High	High	Medium
11+	Extremely High	High	High	Medium

Table 1: The Solar UV Index, indicating the risk of damage to different skin types.

The amount of UV rays that reach the earth's surface increases by approximately five percent for every 1,000 feet above sea level. So for example, a mountain at 10,000 feet receives approximately 50 percent more UV exposure than an area at sea level. In addition, water is very efficient at reflecting (rather than absorbing) UV radiation. UV rays reflect off snow and ice in all directions, and can penetrate through clouds and fog. Depending on the age of the snow, around 50 to 90 percent of UV radiation is reflected, which puts areas such as the chin and nose tip at increased risk of sun damage. It is therefore important to recommend the use of sun protection methods (e.g. clothing, sunscreen and sunglasses) during skiing holidays.

3. Clothing*

"Protect the skin with clothing, including a broad-brimmed hat, long sleeved top, trousers, and UVR protective sunglasses. Choose close weave fabrics that don't allow the sun through."

This recommendation should be read in conjunction with the above advice on skin types and when to protect the skin.

Protective clothing should be the first line of defence against harmful UVR (Hatch and Osterwalder, 2006). In general, tightly woven, darker fabrics that fall away from the body protect better than clothing made from a loosely woven, light-coloured, slim-fitting textile (Morison, 2003). Denim, for example, has an ultraviolet protection factor (UPF) of 1,700 compared to cotton, which can have a UPF as low as 5, although this can vary greatly between different garments. Typically, the UPF is higher for materials that are darker in colour and those that have undergone fabric shrinkage after having been laundered (Kullavanijaya & Lim, 2005). The tightness of a fabric's weave is usually the most important factor in determining its UPF, however physical characteristics of fabrics such as thickness, weight and cloth cover have been shown to be only partly useful in explaining the UV protective abilities of fabrics and the processing history must also be considered. High UPF sun suits, similar in appearance to wetsuits covering the skin, offer a suitable method for protecting children when swimming and on the beach (Khazova *et al.*, 2007). Hats protect the scalp (Debuys *et al.*, 2000), while also providing some shade for the face and neck if wide brimmed (back flaps are valuable) (Bajdik *et al.*, 1998). Several ophthalmologic conditions are attributed to chronic UVR and visible light exposure including cataracts, keratitis, and age-related macular degeneration. Protective sunglasses should protect eyes against UVR and visible light and provide coverage over the lateral field of vision (Tuchinda *et al.*, 2006).[1]

4. Sunscreens – when to use, what types, and application*

This recommendation should be read in conjunction with the above advice on skin types and when to protect the skin.

i) UVA and UVB

"Choose a sunscreen labelled 'broad spectrum' which means it offers both UVA and UVB protection
Use a 'high protection' sunscreen of at least SPF 30 to protect against UVB.
Use a sunscreen with high UVA protection also, as shown in the UK by at least 4 stars and the circular UVA logo.
Choose a product labelled 'photostable'.
Sunscreens should not be used as an alternative to clothing and shade, rather they offer additional protection. No sunscreen can provide 100 percent protection."

The role of photoprotection products against malignant melanoma is complex. A systematic review in 2003 failed to show that sunscreen use had any preventive effect (Dennis *et al.*, 2003). However, used appropriately, sunscreens have been shown to be extremely efficient against burning, DNA damage and immunosuppression of the skin. Further, the regular and careful use of sunscreens has been clearly shown to reduce the incidence of actinic keratoses and squamous cell carcinomas but not necessarily basal cell carcinomas (Darlington *et al.*, 2003; Green *et al.*, 1999).

Topically applied sunscreens protect by absorbing or reflecting radiation at the skin surface. UVR filters can be grouped into two broad categories: organic (previously called chemical) and inorganic (previously called physical) (Yaar and Gilchrest, 2007). Organic sunscreens absorb UVR, convert it into heat, and thus prevent photons from interacting with molecules in the skin. Organic sunscreens are usually 'invisible' and hence cosmetically appealing, but UVR absorption may activate them and they

may cause unwanted reactions. Although the first-generation organic sunscreens were unstable, several photostable organic UVR filters are now on the market.

High protection and SPF:

Sun Protection Factor, or SPF, is defined as the minimal perceptible erythema, or minimal erythema dose (MED) ratio between sunscreen-protected and unprotected skin: as UVB is approximately 1,000 times more erythemogenic as compared to UVA, the SPF is largely a measure of protection against UVB. Explaining what the SPF means is best accomplished through a clinical example. For instance, if a person normally experiences the onset of redness to unprotected skin after 10 minutes of sun exposure, sunscreen with SPF 8 would provide protection against perceptible sunburn for 80 minutes.

The SPF of a sunscreen is one of the most recognizable terms on a product bottle, and largely what the public uses to judge their protection from sunburn. However, changes to product labelling were introduced in the UK in 2007 in response to a new EU Recommendation (Commission Recommendation on the efficacy of sunscreen products and the claims made relating thereto, September 2006).

The SPFs are now also categorised as providing low to very high protection, and the corresponding level will be printed on the product label. The below table illustrates this:

Low protection	SPF 6 to 14	(i.e. SPF 6 and 10)
Medium protection	SPF 15 to 29	(i.e. SPF 15, 20 and 25)
High protection	SPF 30 to 50	(i.e. SPF 30 and 50)
Very high protection	SPF 50 +	(i.e. SPF 50+)

Therefore, any recommendation regarding UVB protection should refer both to the SPF and to its corresponding level of protection.

SPF 30:

Generally it has been advised that people should select sunscreens with SPF 30 or higher (Palm and O'Donoghue, 2007). This is because people generally do not apply sufficient quantities of the product. Importantly, the SPF is measured with a sunscreen application thickness of 2 mg/cm; in reality, subjects tend to apply much less of the product, often at an average thickness of just 0.5-1.0 mg/cm (Lautenschlager *et al.*, 2007; Stokes and Diffey, 1997). If a more uniform and appropriate application of sunscreens were employed, there would be no need for sun protection factors higher than 15 (Diffey, 2000). The recommended SPF 30 takes into account these behavioural factors that lead to a reduced level of protection[2]. If applied adequately, then SPF 15 is sufficient. For information on applying sunscreen, please see section (ii) on application, below.

UVA stars and circle:

In Europe the 'star system' is widely used to indicate a product's UVA protection. The stars indicate the percentage of UVA radiation absorbed by the sunscreen in comparison to UVB, in other words the ratio between the level of protection afforded by the UVB protection and the UVA protection. Five stars

(*****) indicates excellent protection against UVA equal to the SPF against burning, whereas one or more stars implies UVA protection equal to one or more fifths of the SPF against burning (Wahie *et al.*, 2007). If a customer opts for a low SPF, it may have a high level of stars, not because it is providing high UVA protection, but because the ratio between the UVA and UVB protection is about the same. That is why it is important to recommend a high SPF in conjunction with high UVA protection (e.g. high number of stars). According to the EU Recommendation, the UVA protection for each sunscreen should be at least one third of the labelled SPF. A product that achieves this requirement will be labelled with a UVA logo, the letters "UVA" printed in a circle.

Therefore, any recommendation regarding UVA protection should refer both to the UVA stars and the new UVA circle logo. Sunscreens that offer both UVA and UVB protection are called 'broad spectrum', and this should also be mentioned in guidance. 'Photostability' means that the filters do not break down in the sun.

ii) Application:

"Apply half an hour before going out in the sun, and half an hour after commencing sun exposure, to ensure adequate application and to avoid missed patches of skin. Don't forget your head, neck and ears.
Reapply sunscreen at least every two hours, and immediately after contact with water, even if the sunscreen is 'water resistant', and also after towel drying.
Apply sunscreen liberally."

The advice regarding sunscreen application refers to sun exposure above the five to 10 minute short bursts recommended to help maintain adequate vitamin D levels.

Reapplying sunscreen after initial application is an important step in effective sun safety. Individuals should apply a first coat of sunscreen before sun exposure. A second application approximately 20 to 30 minutes after initial application is estimated to prevent an additional 65 to 80 percent of UVR transmission (Lowe, 1990) and corrects areas of misapplication. Key exposed sites such as the neck, temples, and ears are often missed (Fry and Verne, 2003) so particular care should be taken to protect these areas.

Water resistance is defined as the ability of a sunscreen to retain its photoprotective properties following two 20 minute intervals (40 minutes total) of moderate activity in water immersion. Up to 85 percent of a product can be removed by towel drying, so reapplication should occur after swimming, sweating, or any other rigorous or abrasive activity.

The average adult should apply approximately 35 ml for full-body application – for lotions, the amount equivalent to a full shot glass (Wulf *et al.*, 1997). Patients should be reminded to use sunscreen liberally and evenly, rubbing in after application in order to avoid skip areas (Neale *et al.* 2002, Barr 2005). The overall message in terms of sunscreen use is "more is better."[3] However, expense may provide a barrier to sunscreen use and liberal application (Youl *et al.*, 2009; Nicol *et al.*, 2007).[4]

Topical sunscreens are an adjunct to sun-protective clothing.

5. Indoor tanning devices

"Sunbeds do not provide a safe alternative to sunbathing and should not be used to get a tan."

There is accumulating evidence that sunbed usage is directly related to development of all skin cancers. Artificial tanning devices such as sunbeds and sunlamps are an increasing source of ultraviolet radiation exposure. The UVR intensity of currently used tanning appliances may be 10 to 15 times that of the midday sun, leading to potential exposure to very high UVR doses (Gerber et al, 2002).

A review by the International Agency for Research on Cancer (IARC) Working Group found that first exposure to sunbeds before 35 years of age increase the risk of malignant melanoma by 75 percent (International Agency for Research on Cancer Working Group, 2007). Additionally there was no evidence of a protective effect from the use of sunbeds against damage to the skin from subsequent sun exposure. There are predictable problems with methodology of epidemiological studies of this type (recall bias and quantification of the total sunbed exposure) but this is an authoritative report. It concluded that young adults should be discouraged from using indoor tanning equipment and restricted access to sun beds by minors should be strongly considered (International Agency for Research on Cancer Working Group 2006). The contribution of sunbeds to malignant melanoma mortality has been estimated at 100 deaths per year in the UK (Diffey, 2003).

The available recommendations for safe use are widely ignored, and it is inappropriate to consider widespread public education without action in this area. Compulsory regulation of the industry is required.

Sources of further information

Further information and advice regarding skin cancer prevention is available from a number of organisations, including the following (presented alphabetically):

British Association of Dermatologists
www.bad.org.uk/sunawareness
Disease information, skin cancer prevention, skin cancer detection, indoor tanning, vitamin D

Cancerbackup / Macmillan Cancer Support
http://www.cancerbackup.org.uk/Cancertype/Skin
Disease information, skin cancer prevention

Cancer Research UK
http://info.cancerresearchuk.org/healthyliving/sunsmart/
Disease information, skin cancer prevention, epidemiology and mortality data, skin cancer detection, indoor tanning

NHS Choices
http://www.nhs.uk/conditions/Malignant-melanoma/Pages/Introduction.aspx?url=Pages/what-is-it.aspx
Disease information, skin cancer prevention

Footnotes

* The recommendations outlined in this paper regarding methods of sun protection (e.g. clothing, shade and sunscreen) should be used in conjunction with this skin type guide. For example, the use of clothing and sunscreen as outlined applies to skin types I and II at all times in the sun, and to skin types V and VI during periods of prolonged or intense sun exposure.

** The remit of this paper is to provide recommendations specific to the prevention of skin cancer. However, the authors recognize that skin cancer prevention measures may impact on other health issues relating to vitamin D and that this is an important issue that needs to be addressed.

[1]The Royal College of Ophthalmologists provides information and recommendations about types of sunglasses to protect the eye health.

[2] The authors acknowledge that some organisations recommend use of SPF 15 rather than SPF 30. However, it was deemed necessary to take into consideration the research outlined regarding the application of sunscreen products and the subsequent impact on the SPF provided.

[3] Advances in the design of sunscreen products has led to the availability of a range of different formulas, including lotions, sprays and gels, many of which are designed to be 'invisible' on the surface of the skin. In light of this level of variation, it is not possible to give a definitive quantity for application that is relevant to all products. Individual manufacturers can provide further details specific to the application of their particular sunscreens.

[4] A recent All Party Parliamentary Group on Skin report, as well as a number of individual organizations, have called for the removal of VAT from sunscreen products, as it is felt that sunscreens should be categorized as essential products.

[5] Cancer Research UK and the British Association of Dermatologists are calling for compulsory regulation of the sunbed industry. Guidelines primarily aimed at employers or self-employed people who operate UV tanning equipment (e.g. sunlamps, sunbeds, tanning booths), but also advice for their customers is provided by the Health and Safety Executive: 'Reducing health risks from the use of UV tanning equipment'.

Glossary

Actinic keratoses	a premalignant condition of thick, scaly, or crusty patches of skin
Basal cell carcinomas (BCCs)	a type of skin cancer which rarely metastasises
Calcium homeostasis	mechanism by which the body maintains adequate calcium levels
Chromophores	molecules responsible for colour in skin, hair and eyes
Cutaneous immunosuppression	reduction of the immune system in the skin
Cutaneous malignancy	cancer of the skin
DNA	nucleic acid that contains the genetic instructions used in the development and functioning of all known organisms
Epidermal shedding	shedding of the superficial layer of skin
Erythema	skin redness
Erythemogenic	causing of skin redness
IU	international units
Minimal erythema dose (MED)	lowest does of ultraviolet light which will cause redness in a particular individual
Photoaging	aging of the skin by means of damage from ultraviolet light
Photolabile	tendency to degrade in the presence of ultraviolet light
Photoprotective properties	ability to protect from ultraviolet light
RNA	a single-stranded nucleotide molecule containing ribose. RNA is transcribed from DNA by enzymes called RNA polymerases and is central to the synthesis of proteins.
Serum 25OHD	a metabolic product of vitamin D
Squamous cell carcinomas	a skin cancer arising from the keratinocytes of the superficial skin.
T cells	a group of white blood cells known as lymphocytes which supply cell mediated immunity
UV induced erythema	skin redness induced by ultraviolet light
UVR	ultraviolet radiation, emitted by the sun

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A summary of key messages to be included in public information resources for the primary prevention of skin cancer.

Authored by the British Association of Dermatologists, January 2009
for the National Institute for Health and Clinical Excellence (NICE)

Appendix A - Methods

A broad based electronic literature search was performed (see Table 1 below). An editorial panel was formed to evaluate the relative importance of the publications based on consistency, source and relevance, and the key messages identified. The paper was then drafted, reviewed by the editorial panel and subsequently sent for peer review by three independent experts in the field.

7. The literature search was conducted by Dr M. Firouz Mohd Mustapa, Information Scientist
8. The literature review was then sent to the editorial panel for evaluation (Dr Hazel Bell, Dr David Eedy, Dr Mark Goodfield) and key messages identified from the research.
9. The key messages were then written by the lead authors (Dr Mark Goodfield, Dr David Eedy, Ms Nina Goad) based on the review of evidence on all issues pertaining to skin cancer epidemiology, incidence, public prevention campaigns, health messages, primary prevention methods, including issues for discussion.
10. The draft document was circulated to the full editorial panel for review: Dr Mark Goodfield, Dr David Eedy, Dr Hazel Bell, Dr Catriona Irvine, Ms Nina Goad, Mrs Sheela Upadhyaya
11. The draft document was subsequently peer reviewed by three independent experts in public health, photobiology and skin cancer: Dr Val Doherty, Professor Julia Newton-Bishop and Professor Alex Anstey.
12. Additions and amendments from the three independent experts were incorporated into the final paper prior to submission to NICE.

Search methods for identification of studies - electronic database searches:

We searched the MEDLINE (Ovid), PubMed, EMBASE (DialogDatastar) using the search terms in Table 1. We also searched for “skin cancer” in the Cochrane Library and DARE.

Search methods for identification of studies - other resources:

We searched the websites for the World Health Organisation, Office for National Statistics, Cancer Research UK.

Data collection and analysis:

Three reviewers independently selected studies and publications, and assessed their relevance and quality.

Main results:

Study reports were included if they were in English, and concentrated on UVR induced skin damage, carcinogenesis and skin cancer prevention and protection. Such studies were analysed in detail by two reviewers, and their relevance were scored based on a 1-10 scale. Seventy two publications were identified as providing important evidence and were included in the work of the paper. Six reviews, two meta-analyses, four randomised controlled trials and two working party papers were used to provide data for the paper and its conclusions. Articles recently published, i.e. since 2005, were given a higher weighting than older papers.

Criteria for considering studies for this review - types of publication:

Meta-analyses, randomised controlled trials, case-control studies, journal and review articles and relevant data from various websites (WHO, ONS, CRUK) containing:

- Effects of ultraviolet radiation (UVR) on the skin
- Prevention, intervention and educational programmes or messages for melanoma and non-melanoma skin cancers
- Variables affecting sun exposure levels
- Role of sunscreen in skin cancer prevention
- Vitamin D production from sun exposure
- High risk groups

Search no.	Keywords	MEDLINE (Ovid) Hits	PubMed Hits	EMBASE (DialogDatastar) Hits
1	(melanoma OR nonmelanoma OR non-melanoma OR BCC OR SCC OR basal cell carcinoma OR squamous cell carcinoma).mp. [mp=title, original title, abstract, name of substance word, subject heading word]	112201	174327	113357
2	(ultraviolet OR UV* OR sun exposure OR sun protection OR skin protection OR sunscreen* OR sun screen* OR sun safety OR cloth*).mp.	188487	185493	138945
3	(prevent* OR strateg* OR program* OR educat* OR interven* OR public health).mp.	1957977	5556183	2641688
4	1 AND 3 AND 2	1120	3018	1272

5	vitamin D.mp.	33149	44812	33601
6	1 AND 2 AND 5	82	92	79
7	4 OR 6	1170	3032	1303
8	Limit 7 to (English language and humans)	968	2471	1085
9	Limit 8 to (2005 – present)	311	635	335
10	Limit 9 to (Clinical Trial* OR Meta-Analys* OR Meta Analys* OR Randomi* Control* Trial* OR Case Report* OR Control* Clinical Trial* OR Journal Article* OR Review*)	**300**	**612**	**320**
300 + 612 + 320 (= 1232) references combined in EndNote X2, with automatic and manual removal of duplicate/triplicate references, yielding 659 articles				

Table 1. Search terms, strategy and results.