# National Institute for Health and Clinical Excellence

## Economic analysis to inform the development of NICE public health intervention guidance on information, sun protection resources and physical changes to the environment to prevent skin cancer (phase 2)

Revised draft report

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# List of abreviations

| | |
|---|---|
| BCC | Basal cell carcinoma |
| ICER | Incremental cost effectiveness ratio |
| MM | Malignant melanoma |
| NHS | National Health Service |
| NICE | National Institute for Health and Clinical Excellence |
| NMSC | Non-melanoma skin cancer |
| NRPB | National Radiological Protection Board |
| ONS | Office for National Statistics |
| PHIAC | Public Health Interventions Advisory Committee |
| QALY | Quality adjusted life year |
| SCC | Squamous cell carcinoma |
| SED | Standard erythema dose |
| SPF | Solar protection factor |
| UK | United Kingdom |
| UV | Ultraviolet |
| UVR | Ultraviolet radiation |

# Contents

# 1.0 Executive summary

The aim of this research is to determine the cost effectiveness of interventions to prevent primary skin cancer attributable to UV exposure, including:

- changes to the natural or built environment;
- provision of sun protection resources; and
- multi-component interventions that combine one or more of the above and may also include the provision of information.

The systematic review of the evidence was undertaken by McDaid et al (2010). The review identified three studies assessing the effectiveness of provision of shade and 25 studies assessing the effectiveness of multi-component interventions delivered in different settings. No interventions focusing solely on provision of resources were identified. Only one cost-effectiveness study was identified (Gordon, 2009). This provided limited information on the cost-effectiveness of a multi-component intervention delivered in a community setting. Based upon quality and transferability criteria, six studies identified by McDaid et al (2010) were selected for the economic evaluation.

In addition, even though mass media campaigns were covered in the first phase of this work, an expert paper on mass media campaigns provided additional information allowing a break-even analysis to be undertaken.

In summary, this report provides economic evaluation for the following interventions:

- provision of shade;
- multi-component delivered in beaches and pools;
- multi-component delivered in the community;
- multi-component delivered in educational setting;
- multi-component delivered in a healthcare setting;
- multi-component delivered in a work-setting; and
- mass media campaign.

A model was built to estimate the incremental cost-effectiveness ratio (ICER) of the interventions, defined as the ratio of costs to quality adjusted life years (QALYs) gained. The model includes three components:

- a behavioural component simulating individuals' behaviour in terms of sun protection to estimate lifetime sun exposure and number of sunburns;
- an epidemiological component estimating the relationship between sun exposure and cases of non-melanoma skin cancer (NMSC) and malignant melanoma (MM); and
- an economic component estimating QALYs lost and health care cost associated with NMSC and MM.

The results of the analysis indicate that none of the interventions modelled are cost-effective when compared with an ICER threshold of £20,000 per QALY gained. This is a consequence of the following factors:

- the small effects in terms of sun protection behaviour achieved by the interventions;
- the relatively high unit costs of the interventions driven by the provision of resources such as sunscreen, hats, and educational material;
- the small QALY gain associated with prevented cases of NMSC; and
- the small number of avoided cases of MM.

The break even analysis for a mass media campaign indicates that for such an intervention to be cost-effective, use of sunscreen would need to increase between 2 and 6.6 percentage points. The main lesson learned from such analysis is that interventions need to have a very low unit cost to be cost-effective.

Several assumptions were made in conducting the model. Most of these work to underestimate the cost per QALYs gained estimates. Therefore the results of the analysis are unlikely to be sensitive to these assumptions. Sensitivity analysis to assess the effect of parameter uncertainty on model outcomes suggests that the conclusion that the interventions are not cost-effective is not affected by such uncertainty.

# 2.0 Introduction

## 2.1 Background

The National Institute for Health and Clinical Excellence (NICE) has been requested by the Department of Health to develop guidance on the provision of information, physical changes to the natural and built environment, and provision of sun protection resources for the prevention of primary skin cancer. The aim of such interventions is the reduction of exposure to ultraviolet (UV) radiation, which is considered a leading cause of skin cancer. In the first phase of this work (Phase 1) a systematic review of the evidence and economic analysis were undertaken to underpin the guidance on provision of information.

This report refers to the economic analysis of the second phase (Phase 2) which focuses on physical changes to the natural and built environment; provision of sun protection resources; and multi-component interventions to prevent primary skin cancer attributable to UV exposure.

## 2.2 Need for guidance

Skin cancer is the most common cancer in the UK, with 81,500 cases of non-melanoma cancer and 10,400 cases of melanoma (the most serious form of skin cancer) registered each year. Although most skin cancers are detected early and are not life-threatening, 2,600 people a year die from skin cancer in the UK. Both incidence rates and death rates have been rising rapidly over the past several decades (Cancer Research UK, 2009).

The main cause of skin cancer is exposure to UV radiation from sunlight or artificial sources such as sunbeds. Individuals can reduce their risk of skin cancer by:

- staying out of the sun, especially when sunlight is strongest around the middle of the day;
- wearing protective clothing; and
- using high sun protection factor (SPF) sunscreen.

The prevention of skin cancer is an important goal of the National Cancer Action Strategy (Department of Health, 2007). However, the primary focus of policy hitherto has been on raising awareness of the dangers of excessive sun exposure, and promoting early detection. Environmental approaches, such as increasing the amount of shade in public spaces, and resource provision strategies such as distributing sunscreen and protective clothing, may also have an important role to play in supporting and facilitating changes in sun protection behaviour.

In addition, such interventions have the potential to help reduce health inequalities between social groups. Resource provision could help to reduce the financial cost of engaging in sun protection behaviours. Environmental interventions have the potential to impact upon all groups within a population, and hence may be more effective in changing behaviour in hard-to-reach groups than interventions such as education. Finally, people who work outdoors are likely to be at elevated risk of skin cancer (Glanz et al, 2007) and to come disproportionately from lower-socioeconomic-status groups, so interventions targeting them may have the potential to reduce inequalities.

## 2.3 Objectives

The aim of this economic evaluation is to determine the cost effectiveness of interventions to prevent primary skin cancer attributable to UV exposure, including:

- changes to the natural or built environment;
- provision of sun protection resources; and
- multi-component interventions that combine one or more of the above and may also include the provision of information.

The rest of this report is organised as follows. Section 3 presents the interventions modelled. The model built to estimate the cost effectiveness of those interventions is described in Section 4. Section 5 presents the results of the analysis. The final section discusses the findings.

# 3.0 Interventions

The systematic review of the evidence on physical changes to the natural and built environment, provision of sun protection resources, and multi-component interventions to prevent primary skin cancer attributable to UV exposure was undertaken by McDaid et al (2010).[1] The review identified three studies assessing provision of shade and 25 studies assessing multi-component interventions delivered in five different settings: beaches and pools; community; educational; healthcare; and work-setting. No interventions focusing solely on provision of resources were identified. Only one cost-effectiveness study was identified (Gordon, 2009). This provided limited information on the cost-effectiveness of a multi-component intervention delivered in a community setting. Based on the evidence found, the economic modelling considers six types of interventions:

1. provision of shade;
2. multi-component delivered in beaches and pools;
3. multi-component delivered in the community;
4. multi-component delivered in educational setting;
5. multi-component delivered in a healthcare setting; and
6. multi-component delivered in a work-setting

In addition, we undertook a break-even analysis for a mass media campaign. The effectiveness and cost-effectiveness of mass media campaigns were covered in Phase 1. However, following result from the Public Health Interventions Advisory Committee (PHIAC) an expert paper covering this topic was produced. Using information from this paper, a break-even analysis was run to estimate the effect size that would be required for such an intervention to be cost-effective.

In the next section we describe the method employed to select the interventions that were modelled. Section 3.2 provides details on these interventions, including their effect and cost of delivery. Section 3.3 describes the method and data used in the break-even analysis for a mass media campaign.

## 3.1 Selection of interventions

Within each type of intervention, the economic evaluation was undertaken for the best available evidence study identified in the evidence review. The process for selecting studies to be modelled included two steps. The first step involved excluding studies that were not suitable for modelling, based on the following criteria. Studies were excluded if:

- only outcomes in terms of knowledge and attitudes (as opposed to sun-protection behaviour or sun exposure) were reported; and
- no statistically significant outcome was reported.

[1] Multi-component interventions are defined as those where the environmental intervention or provision of resources are combined or are accompanied by the provision of information.

No studies were excluded as a result of the first criterion. The second criterion resulted in four studies being excluded from further consideration (Barankin et al, 2001; Crane et al, 1999; Reding et al, 1996; Geller et al, 1999).

The second step consisted of selecting the best available evidence within each type of intervention. In order to do so, the studies were coded according to the following criteria: country of study; internal validity; external validity; and follow-up period. Table 1 summarises the scores given against these criteria, resulting in range of scores between 0 and 6.

**Table 1. Criteria for selecting studies to include in the economic modelling**

| **Criteria** | **Score** |
|---|---|
| Country | USA, Australia, Israel = 0<br>Canada, Germany, Sweden = 1 |
| Internal validity<br>(based on the grades given the paper by the review team) | - = 0<br>+ = 1<br>++ = 2 |
| External validity<br>(based on the grades given the paper by the review team) | - = 0<br>+ = 1<br>++ = 2 |
| Follow-up period | Less 1 year = 0<br>1 year or more = 1 |

The studies that received the highest scores within each intervention types were included in the economic analysis. These are summarised in Table 2. In one case (multi-component interventions delivered in a healthcare setting) there was no clear 'winner'. Two studies (Crane et al, 2006 and Norman et al, 2007) scored '1'. In conversations with NICE it was agreed that Norman et al (2007) which focused on adolescents –a key group– and delivered the intervention in primary care rather than a hospital, may have greater mileage. The decision was based on the assertion made by Armstrong and Kricker (2001) that the lifetime potential for skin cancer is determined to a substantial extent by sun exposure in the first ten years of life, and the extent to which this potential is realised is determined by sun exposure in later life.

**Table 2. Studies selected for economic modelling**

| **Intervention type** | **Author** | **Country** | **Internal validity** | **External validity** | **Follow-up period** | **Scoring** |
|---|---|---|---|---|---|---|
| Provision of shade | Dobbinson et al (2009) | Australia | ++ | + | Less 1 year | 3 |

| Intervention type | Author | Country | Internal validity | External validity | Follow-up period | Scoring |
|---|---|---|---|---|---|---|
| Multi-component: beaches and pools | Mayer et al (1997) | USA | + | + | Less 1 year | 2 |
| Multi-component: community | Dietrich et al (2000) | USA | + | + | 1 year or more | 3 |
| Multi-component: education | Bauer et al (2005) | Germany | + | + | 1 year or more | 4 |
| Multi-component: healthcare | Norman et al (2007) | USA | - | - | 1 year or more | 1 |
| Multi-component: work-setting | Mayer et al (2007) | USA | + | + | 1 year or more | 3 |

## 3.2 Effect and cost of the interventions

This section presents the effect and cost of the interventions included in the economic analysis and describes the methods employed to calculating them. Table 3 shows the change in sun protection behaviour due to the intervention and the cost per person required to delivering it.

Changes in sun protection behaviour are expressed as increases in the probability that individuals use protection either ‘always’ or ‘sometimes’ (and decreases in the probability that individuals ‘never’ use protection). These changes were obtained by converting the original effect data from the studies into a form that matched the behavioural component of the model (described in section 4.1). The general approach to make such conversion was to: (i) calculate the effect sizes from the original studies, and (ii) determine the change in behaviour by applying the effect sizes to the baseline values of the behavioural variables in the model –i.e. probability of using protection ‘always’, ‘sometimes’, or ‘never’. Given that studies used different outcomes and measures to account for the effect of the interventions, more details on the calculations made are provided in Tables A1.1 to A1.6 in Appendix 1.

It is worth noting that in most studies significant effects were reported as increases in the percentage of population using protection, without specifying whether that behaviour occurred ‘always’ or ‘sometimes’. Unless stated otherwise in the studies, it was decided to increase the probability of using protection ‘always’. This decision may result in overestimates of the effects due to the intervention.

The duration of the initial effect of the interventions was informed by the studies. Where the effect of the intervention was measured within a one year follow, it was assumed that the initial effect occurs in the year of implementation. For studies reporting two year follow-up, the effect was computed for two years. For studies reporting consecutive follow ups (e.g. 1 year, 2 year, 3 year, etc) the effect was applied for as long as it was found statistically significant. The longest follow-up period reported in the studies was three years. The model estimates how long the initial effect of the interventions is maintained. Section 4.1.5 describes the method for modelling the maintenance effect.

Several studies reported significant effects for more than one behavioural outcome –e.g. using sunscreen and wearing a hat. Where possible these effects were included in the model. Reasons for not including particular effects are specified in Appendix 1.

The cost of the interventions to the public sector was estimated as the incremental cost per person. Incremental cost is defined as the cost of the intervention less the cost for the comparator or counterfactual, as defined in the effect studies. In most studies, however, individuals in the control group received no intervention. Therefore, the incremental cost is given by the cost of the interventions. Costs were estimated by valuing the resources used to delivering the intervention, which were derived from the effect studies. Data on unit costs was drawn from a variety of sources, as specified in Tables A1.1 to A1.6 in Appendix 1.

Table 3 indicates that the effect of the intervention in terms of increased probability of using protection varies from 0.013 to 0.24 – it is important to note that this effect refers to different measures of protection across the interventions. The incremental cost person of interventions ranges between £0.59 and £52.04.

**Table 3. Effect and cost of the interventions modelled**

| Intervention type | Author | Intervention | Effect | Incremental cost per person |
|---|---|---|---|---|
| Provision of shade | Dobbinson et al (2009) | Intervention: construction of shade sail structures.<br><br>Comparator: no built shade. | Increase in probability of 'always' seeking shade by 0.08 (decrease in probability of 'never' seeking shade by 0.08).<br><br>Duration: 1year plus maintenance effect | £1.82 |
| Multi-component: beaches and pools | Mayer et al (1997) | Intervention: four five minute lessons before swimming class each covering sun protection behaviour; home-based curricula provided to parents, including several activities for children; SUNWISE board game and UV meter; sunscreen and hats were available at each lesson.<br><br>Comparator: no intervention. | Increase in probability of 'always' wearing a hat by 0.24 (decrease in probability of 'sometimes' wearing a hat by 0.24).<br><br>Duration: 1year plus maintenance effect | £19.92 |
| Multi-component: community | Dietrich et al (2000) | Intervention:<br>(1) school/day care: age- and grade-specific curriculum.<br>(2) beach: sun protection poster, sunscreen samples and educational pamphlets.<br>(3) primary care: office system manual to promote sun protection advice during patient visits, practice meeting for project staff, sun protection manual, patient education materials, sunscreen samples.<br><br>Comparator: no intervention. | 1. Increase in probability of 'always' wearing sunscreen by 0.05 (decrease in probability of 'never' wearing sunscreen by 0.05).<br><br>Duration: 1 year plus maintenance effect<br><br>2. Increase in probability of 'always' using four types of protection by 0.03 (decrease in probability of 'never' using four types of protection by 0.03)<br><br>Duration: 2 years plus maintenance effect<br><br>Effects 1 and 2 were modelled separately. | £0.59 |

| Intervention type | Author | Intervention | Effect | Incremental cost per person |
|---|---|---|---|---|
| Multi-component: education | Bauer et al (2005) | Intervention: 3 hour education session and educational letter at Easter, Pentecost and summer holidays with detailed information on proper sunscreen use, sun protection and information brochures from public melanoma prevention campaigns.<br><br>Comparator: 3 hour education session. | Increase in probability of using sunscreen 'sometimes' by 0.013 (decrease in probability of 'never' using sunscreen by 0.013).<br><br>Duration: 3 years plus maintenance effect | £3.85 |
| Multi-component: healthcare | Norman et al (2007) | Intervention: interactive computer session to assess stage of change; printed tailored feedback; brief counselling from healthcare provider; four follow-up telephone assessments and feedback; 90ml bottle of SPF sunscreen with each feedback; intermittent tip sheets.<br><br>Comparator: a physical activity and diet intervention. | 1. Increase in probability of 'always' using sunscreen by 0.03 (decrease in probability of 'never' using sunscreen by 0.03).<br><br>Duration: 2 years plus maintenance effect.<br><br>2. Increase in probability of 'always' using the four types of protection by 0.005 (decrease in probability of 'never' using the four types of protection by 0.005).<br><br>Duration: 2 years plus maintenance effect.<br><br>Effects 1 and 2 were modelled separately. | £12.27 |
| Multi-component: work-setting | Mayer et al (2007) | Intervention: Provision of protective hats and sunscreen, visual reminders, and brief educational sun safety messages.<br><br>Comparator: delayed intervention. | 1. Increase in probability of wearing sunscreen 'always' by 0.14 (decrease in probability of 'never' wearing sunscreen by 0.14).<br><br>Duration: 3 years plus maintenance effect.<br><br>2. Increase in probability of 'always' wearing hat by 0.15 (decrease in probability of 'never' wearing hat by 0.15).<br><br>Duration: 3 years plus maintenance effect.<br><br>Effects 1 and 2 were modelled jointly and applied to both occupational and recreational exposure. | £52.04 |

## 3.3 A mass media campaign

The effectiveness and cost-effectiveness of mass media campaigns were covered in Phase 1. Following result from the PHIAC, an expert paper covering this topic was produced and made available to Matrix in order to enable economic analysis. A break-even analysis was undertaken. This estimated the change in sun exposure behaviour due to the intervention that would be required for such an intervention to be cost-effective. As an indicator for cost-effectiveness, a threshold of £20,000 per QALY was used.

The break even analysis is based on a campaign with the following characteristics:

- the total population in England and Wales (including children, adolescents and adults) would be exposed to the campaign;
- the campaign would be run for a period of five years;
- a ‘low’ cost campaign would cost £707,000 and a ‘high’ cost campaign would cost £2,358,000 (in 2009 prices) over the five year period; and
- the campaign would improve individuals’ behaviour in terms of sunscreen use.

Information on cost was drawn from data on the amount of funding available to the UK SunSmart campaign (CRUK, 2010). Between 2003 and 2007, average annual funding was £168,000 (in 2009 prices). Between 2008 and 2010 funding increased to £573,000 per year (in 2009 prices). Based on these figures and population data for the UK, it was estimated that the unit cost (per person) was £0.0028 per year in the ‘low’ funding period and £0.0093 per year in the ‘high’ funding period. These figures plus population data for England and Wales were used to estimate the cost of the campaign over five years, as specified above.

# 4.0 Method for modelling cost-effectiveness

Assessing the cost-effectiveness of the interventions required building a model to convert the intervention outcomes in terms of sun protection behaviour into avoided cases of skin cancer, and then to QALYs gained and health care cost saved. The incremental cost effectiveness ratio (ICER) for the interventions was then calculated as the ratio of costs to QALYs gained.

This section describes the model built to undertake this task. For ease of interpretation, the model has been divided into three components:

1. a ***behavioural*** component simulating individuals' behaviour in terms of sun protection to calculate lifetime sun exposure and number of sunburns;
2. an ***epidemiological*** component to estimate cases of NMSC and MM using epidemiological relationships between sun exposure and skin cancer incidence; and
3. an ***economic*** component estimating the QALYs lost and health care cost associated with NMSC and MM.

The following sub-sections describe these three components in further detail. Appendix 3 provides a comparison of the methodological approach with that adopted in Phase 1.

## 4.1 Behavioural model of sun protection

The behavioural model simulates individuals' behaviour in terms of sun protection and calculates lifetime sun exposure and number of sunburns. Lifetime sun exposure is measured in terms of standard erythema dose (SED) as the cumulative sum of annual SED over the 80 year period.

In a given year, the annual SED can be calculated based on the following equation:

$$\text{Annual SED} = \text{U} \times \text{H} \times \text{SED}_\text{U} + \text{P} \times \text{H} \times \text{SED}_\text{P} \quad (1)$$

Where:

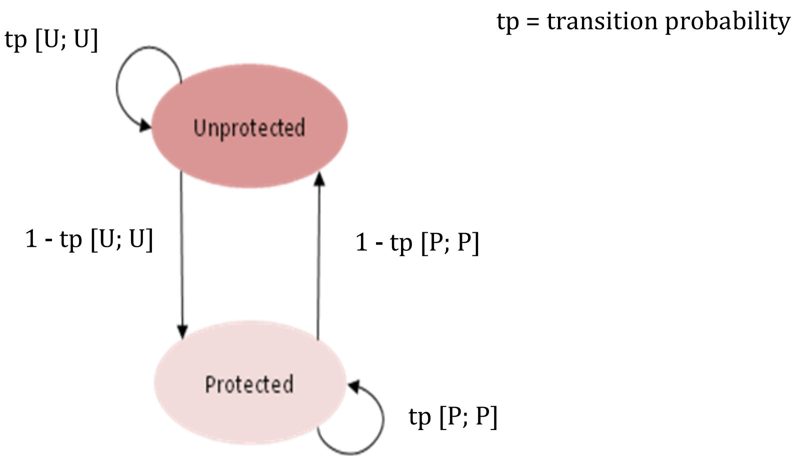
U = probability of being unprotected
P = probability of being protected
H = hours spend outdoors
$\text{SED}_\text{U}$ = SED per hour of unprotected sun exposure
$\text{SED}_\text{P}$ = SED per hour of protected sun exposure

Section 4.1.1 and 4.1.2 describe the method for calculating each of the variables included in equation (1). Section 4.1.3 presents estimates of annual and lifetime sun exposure. The estimated lifetime number of sunburns also relies on values for U, P, H, $\text{SED}_\text{U}$ and $\text{SED}_\text{P}$. The method for obtaining the number of sunburns is described in section 4.1.4. Finally, section 4.1.5 describes how the effects of the interventions in terms of behavioural outcomes are modelled.

### 4.1.1 Sun protection behaviour: probability of being protected or unprotected (U, P)

Individuals' behaviour in terms of sun protection was modelled using a dynamic Markov structure in which individuals are in one of two states in each annual period: ***protected*** and ***unprotected***. Figure 1 illustrates the structure of the model.

**Figure 1. Markov model of sun protection behaviour**




Four types of protection are considered: sunscreen, shade, protective clothing, and wearing a hat. Given that frequency of protection is likely to vary by age, the model was run for different sets of parameters reflecting individuals' behaviour during three life periods: childhood (0 to 12 years old); adolescence (13 to 20 years old) and adulthood (21 to 80 years old).[2] The model also considers outdoor workers as a separate population group (21 to 65 years old).[3] Data on frequency of sun protection among British outdoor workers is not available; therefore it was assumed their behaviour does not differ from that for adults.

Populating the behavioural model required estimates of the following parameters:

1. baseline data on frequency of sun protection behaviour; and
2. likelihood of transitioning between states over time.

The best available data for the country was used to populate the model. Baseline data on frequency of sun protection was drawn from Ling et al (2003). The authors collected data on frequency of sunscreen using a GP based survey in northwest England. The response rate was 97 per cent. The sample may not be representative of the population in England and Wales.

[2] Given that there is no single definition of childhood, adolescence and adulthood, the age breaks used are discretionary.
[3] Lowering the minimum age to 16 or 18 is unlikely to produce any significant changes in the effect of the interventions given the length of the period considered.

However the Markov was calibrated to ensure that the probability of being protected at any given point in time corresponds to the levels of protection observed in a UK representative sample (Miles et al, 2005).

Frequency of sunscreen use in Ling et al (2003) was measured as: regular, occasional and never. For the purpose of the model it was necessary to convert these categories into: always, sometimes and never by making the following assumptions: 50% of regular users always use sunscreen; and the remaining 50% plus the occasional users use sunscreen sometimes. Tables 4 to 6 present the data on frequency of protection. The figures indicate that among children, for instance, there is a 0.16 chance that they always use protection, a 0.76 chance that they sometimes use protection, and a 0.08 chance that they never use protection.

**Table 4. Probability of using sunscreen among children**

| Frequency | Probability | Source |
|---|---|---|
| Always | 0.16 | Adapted from Ling et (2003) |
| Sometimes | 0.76 | |
| Never | 0.08 | |

**Table 5. Probability of using sunscreen among adolescents**

| Frequency | Probability | Source |
|---|---|---|
| Always | 0.09 | Adapted from Ling et (2003) |
| Sometimes | 0.72 | |
| Never | 0.19 | |

**Table 6. Probability of using sunscreen among adults (including outdoor workers)**

| Frequency | Probability | Source |
|---|---|---|
| Always | 0.13 | Adapted from Ling et (2003) |
| Sometimes | 0.64 | |
| Never | 0.23 | |

Frequency of use of the other types of protection was assumed the same as for sunscreen. This assumption is supported by survey data representative of the British population (Miles et al, 2005) showing that, when asked about sun protection behaviour, the percentage of population reporting use of different protection strategies is similar: high sunscreen factor (36.6 per cent); staying in the shade (36.6 per cent); and covering up (38.1 per cent). The survey was conducted through the Office for National Statistics as part of their Omnibus survey. Data was collected through a randomly selected sample, stratified for region.

Using frequency of protection estimates reported in Tables 4 to 6, in the first year of each life period individuals were allocated in one of the two states. This required making an assumption about the distribution of individuals who ‘sometimes’ use protection between the ***protected*** and ***unprotected*** states. In order to calibrate the model and obtain levels of protection relevant for the population of interest (as reported in Miles et al, 2005), it was assumed that ‘sometimes’ implies being protected one out of three times and being unprotected two out of three times.

After the first year, individuals were allowed to transition between states over a period of 80 years. Given that the model comprises two states, four transitions are possible. Tables 7 to 9 show the transition matrices for each life period. The figures indicate that among children, for instance, the probability of being unprotected in one year is 0.712 if unprotected in the previous year, and 0.413 if protected in the previous year. Similarly, the probability of being protected in one year is 0.587 if protected in the previous year, and 0.288 if unprotected in the previous year. The fact that the probability of staying in the unprotected state (0.712) is higher than the probability of staying in the protected state (0.587) is a reflection of the assumption that individuals who ‘sometimes’ protect are more likely to be unprotected than protected.

**Table 7. Transition matrix between protected and unprotected states for children**

| Transition from | To | |
|---|---|---|
| | Unprotected | Protected |
| Unprotected | 0.712 | 0.288 |
| Protected | 0.413 | 0.587 |

**Table 8. Transition matrix between protected and unprotected states for adolescents**

| Transition from | To | |
|---|---|---|
| | Unprotected | Protected |
| Unprotected | 0.759 | 0.241 |
| Protected | 0.481 | 0.519 |

**Table 9. Transition matrix between protected and unprotected states for adults (including outdoor workers)**

| Transition from | To | |
|---|---|---|
| | Unprotected | Protected |
| Unprotected | 0.782 | 0.218 |
| Protected | 0.413 | 0.587 |

Using the above probabilities of using protection and the transition probabilities, the Markov model was used to estimate the probabilities of being in the unprotected or protected states over time (U and P). Table 10 presents these probabilities for the population groups considered. The Markov was calibrated to ensure that the probability of protection for each population group was stable at that level identified in survey data representative of the UK population (Miles et al, 2005).

**Table 10. Probabilities of being unprotected or protected (U, P)**

| Population group | Unprotected | Protected |
|---|---|---|
| Children | 0.59 | 0.41 |
| Adolescents | 0.67 | 0.33 |
| Adults (incl. outdoor workers) | 0.65 | 0.35 |

### 4.1.2 Sun exposure: hours outdoors and SED per hour (H, $SED_U$, $SED_P$)

As indicated in equation (1) sun exposure is modelled as a function of the following variables:

- hours spent outdoors;
- standard erythema dose (SED) per hour of ***unprotected*** sun exposure;
- standard erythema dose (SED) per hour of ***protected*** sun exposure.

In order to estimate sun exposure, the calendar year was divided into three periods: a non-risk period (October to March); a risk-period (April to September); and a holiday period (three weeks in July)[4]. Given the low levels of ultraviolet radiation (UVR) during the non-risk period (Diffey, 2008) it was assumed that individuals receive the same SED, regardless of their sun protection behaviour –i.e. during the non-risk period $SED_U = SED_P$. Based on data on overseas travel and tourism provided by the ONS (2000), the model assumes that 40 per cent of the population spends the three week holidays in England and Wales and that 60 per cent of the population spends two out of the three weeks in a sunnier climate. [5] This impact of this assumption on the results was assessed in the sensitivity analysis.

Table 11 presents the average hours spent outdoors per day and the SED per hour of ***unprotected*** exposure during each of these periods. A distinction is made between recreational and occupational exposure. For recreational exposure, the data was drawn from Diffey (2008) and takes into account time spent outdoors and climate conditions relevant to the population in England and Wales. Data on time spent outdoors was collected through a web-based survey

[4] Note that taking holidays in August would imply negligible differences given that in the context of this topic climate conditions in July and August are relatively similar (for further detail refer to Diffey, 2008).

[5] Even though more recent data on overseas travel and tourism is available from the ONS and the percentage of the population going abroad has continued to increase, for the purpose of estimating individuals' lifetime exposure it was thought more appropriate to use a dated figure. The 2000 figure however is likely to be an overestimate of the population spending their holidays in sunnier climates as the ONS statistics refer to ***number of visits abroad*** for holiday.

hosted by Cancer Research UK in 2007. Climate conditions are representative of northern Europe (50° N 0° W) and Florida (28° N 82° W). For occupational exposure, the same climate conditions apply while hours spent outdoors were taken from the study providing evidence on the effect of a multi-component intervention in a work-setting (Mayer et al, 2007). The sensitivity analysis tests the impact on the results of increases in the number of hours spent outdoors during occupational exposure.

**Table 11. Average hours spent outdoors per day and SED per hour of unprotected exposure (H, $SED_U$)**

| Exposure | Period | Hours outdoors per day | SED per hour of unprotected exposure | Source |
|---|---|---|---|---|
| Recreational | Non-risk period (Oct – Mar) | 0.64 | 0.10 | Diffey (2008) |
| | Risk period (Apr – Sept) | 0.93 | 0.45 | Diffey (2008) |
| | Holiday period in England and Wales (July) | 5.00 | 0.67 | Diffey (2008) |
| | Holiday period in sunnier climate (July) | 5.00 | 1.48 | Diffey (2008) |
| Occupational (for outdoor workers) | Non-risk period (Oct – Mar) | 4.00 | 0.10 | Mayer et al (2007) and Diffey (2008) |
| | Risk period (Apr – Sept) | 4.00 | 0.45 | Mayer et al (2007) and Diffey (2008) |

The SED per hour of ***protected*** sun exposure can be estimated as a percentage of the SED per hour of ***unprotected*** sun exposure, where the percentage depends on four variables:

- protection offered by the different types of protection (i.e. the sun protection factor, SPF);
- body areas protected by each type of protection;
- percentage of body covered by each type of protection for children and adolescents and adults; and
- frequency of protection, as discussed above.

Table 12 presents the SPF afforded by different types of protection. These represent effective, as opposed to nominal, SPFs. The difference is particularly relevant for sunscreen. Given that thickness of product applied is usually below recommended values, effective SPF is below nominal SPF. We use 5 SPF but it could actually be as low as 2 SPF.

**Table 12. SPF afforded by each type of protection**

| Protection type | Effective SPF | Source |
|---|---|---|
| Sunscreen | 5 | Expert communication from Professor Diffey (March 2010) |
| Shade | 10 | |
| Protective clothing | 20 | |
| Hat | 10 | |

Table 13 presents the body areas and percentages of body covered by each type of protection. The body areas selected are arbitrary. It is unlikely, however, that changes to these assumptions, would make a significant difference in the overall level of sun exposure experienced by individuals.

**Table 13. Body areas and percentage of body covered by each type of protection**

| Type of protection | Children | | | | Adolescents and adults (incl. outdoor workers) | | | | Source |
|---|---|---|---|---|---|---|---|---|---|
| | Head | Chest and back | Arms | Legs | Head | Chest and back | Arms | Legs | |
| | 18% | 36% | 18% | 28% | 9% | 36% | 18% | 37% | Hettiaratchy and Papini (2004) |
| Sunscreen | x | x | x | x | x | x | x | x | Assumption |
| Shade | x | x | x | x | x | x | x | x | |
| Protective clothing | | x | | x | | x | | x | |
| Hat | x | | | | x | | | | |

Based on Table 12 and Table 13, the SPF for all possible combinations of types of protection was estimated by multiplying the levels of SPF afforded by each type of protection. Table 14 presents a summary of possible combinations and the corresponding levels of sun absorption, calculated as the inverse of the combined SPF – i.e. 1/combined SPF x 100.

**Table 14. Percentage of sun exposure absorbed by skin for different combinations of sun protection**

| Type of protection | % sun absorbed by skin | |
|---|---|---|
| | Children | Adolescents and adults |
| Sunscreen + Shade + Protective clothing + Hat | 0.5% | 0.6% |
| Sunscreen only | 20.0% | 20.0% |
| Shade only | 10.0% | 10.0% |
| Protective clothing only | 39.2% | 30.7% |
| Hat only | 83.8% | 91.9% |
| Sunscreen + Shade + Protective clothing | 0.9% | 0.7% |
| Sunscreen + Shade + Hat | 2.2% | 2.6% |
| Sunscreen + Protective clothing + Hat | 5.4% | 5.6% |
| Shade + Protective clothing + Hat | 2.4% | 2.4% |
| Sunscreen + Shade | 2.6% | 2.7% |
| Sunscreen + Protective clothing | 8.7% | 7.2% |
| Sunscreen + Hat | 22.4% | 25.8% |
| Shade + Protective clothing | 4.1% | 3.3% |
| Shade + Hat | 8.4% | 9.2% |
| Protective clothing + Hat | 24.4% | 24.4% |

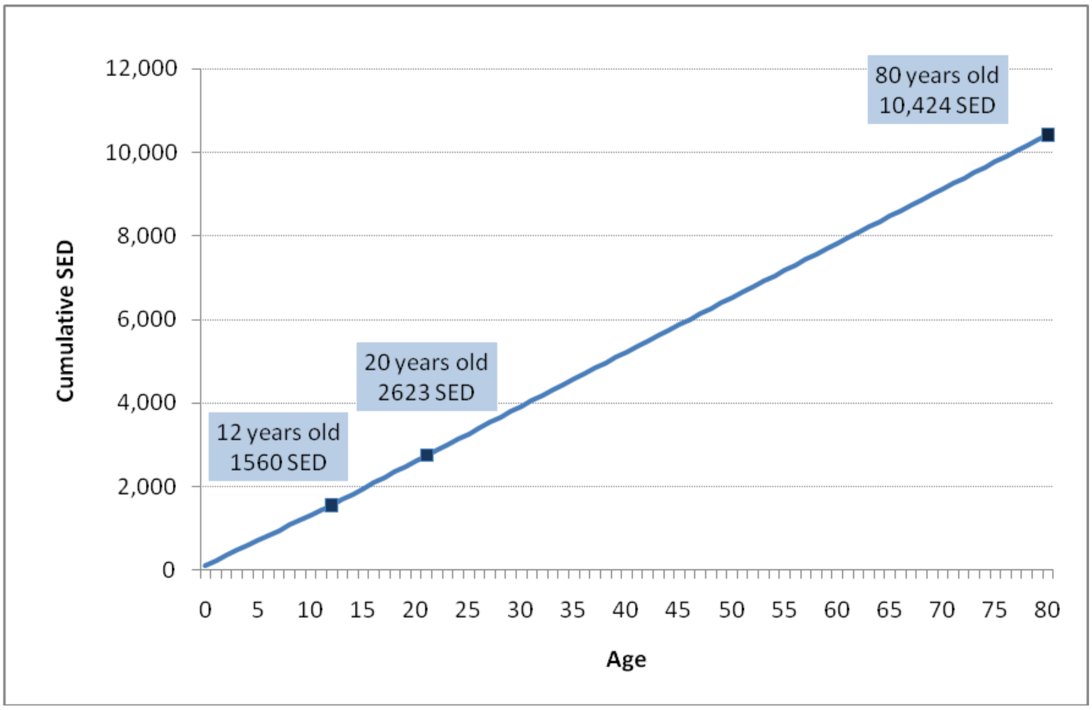
Table 14 indicates that the amount of sun absorbed by the skin in children when all four types of protection are used is equivalent to 0.5 per cent the SED for unprotected exposure. When the four types of protection are used alone and not in combination with others, the percentage of SED absorbed by the skin varies between 10 per cent for shade to 83.8 per cent for hat. Combining two or three types of protection results in a percentage of sun absorbed by the skin between 0.9 per cent and 24.4 per cent of the SED for unprotected exposure. Similar values apply to adolescents and adults.

How was the previous data employed in the model? Individuals in the ***unprotected*** state received 100 per cent of the SED per hour of unprotected exposure. Individuals in the ***protected*** state were divided in two groups. The proportion always using all four types of protection (as described in Tables 4-6) were applied the lowest percentage of absorption (0.4 per cent). For the rest of the individuals in the protected state, the average for all other levels of absorption (using one, two or three types of protection) was used.

### 4.1.3 Annual and lifetime sun exposure

Annual exposure can be estimated using equation (1) and variables U, P, H, $SED_U$, and $SED_P$ as defined in sections 4.1.2 and 4.1.3. Lifetime sun exposure is then calculated by aggregating annual exposure across the 80 year period for which the model was run. Figure 2 shows the lifetime profile of accumulated sun exposure measured in SED modelled for the non-intervention scenario.

**Figure 2. Lifetime profile of accumulated sun exposure (SED)**




### 4.1.4 Annual and lifetime number of sunburns

The probability of experiencing sunburn depends on the SED received per day. On average, individuals experience sunburn if they are exposed to an SED per day that is higher than a specified SED threshold. Based on expert communication from Professor Diffey (March 2010), we used a 5 SED threshold. Therefore, the probability of experiencing sunburn ($S_t$) can be expressed as:

$$S_t = 1 \; if \; SED_t \geq 5 \tag{2}$$

Table 15 presents the SED per day received by children, adolescents, adults and outdoor workers during the different risk periods and depending on whether they are in the protected or unprotected state.

**Table 15. SED per day for protected and unprotected states**

| Exposure | Population group | Period | SED per day of unprotected exposure | SED per day of protected exposure |
|---|---|---|---|---|
| Recreational | Children | Non-risk | 0.06 | 0.06 |
| | | Risk period | 0.42 | 0.04 |
| | | Holiday in E & W | 3.34 | 0.35 |
| | | Holiday in sunnier climate | 7.38 | 0.78 |
| | Adolescents | Non-risk | 0.06 | 0.06 |
| | | Risk period | 0.42 | 0.05 |
| | | Holiday in E & W | 3.34 | 0.41 |
| | | Holiday in sunnier climate | 7.38 | 0.91 |
| | Adults | Non-risk | 0.06 | 0.06 |
| | | Risk period | 0.42 | 0.05 |
| | | Holiday in E & W | 3.34 | 0.36 |
| | | Holiday in sunnier climate | 7.38 | 0.79 |
| Occupational | Outdoor workers | Non-risk | 0.39 | 0.06 |
| | | Risk period | 1.80 | 0.19 |
| | | Holiday in E & W | N/A | N/A |
| | | Holiday in sunnier climate | N/A | N/A |

N/A: not applicable.

The figures indicate that for all population groups and regardless of the risk period, protected individuals will not experience sunburn given that the SED per day is lower than the 5 SED per day threshold. Therefore the probability of experiencing sunburn in the protected state is always equal to 0.

For the unprotected individuals, the SED received per day is higher than the 5 SED per day threshold only during the holiday period in a sunnier climate. Therefore the probability of experiencing sunburn in the unprotected state is 1 for the holiday period in a sunnier climate and 0 for the other periods.

In other terms, the following probabilities of sunburn ($S_t$) apply:

Protected $S_t = 0$ regardless of period

Unprotected $S_t = 0$ if non-risk
$S_t = 0$ if risk period
$S_t = 0$ if holiday in England and Wales
$S_t = 1$ if holiday in sunnier climate

It is assumed that when the probability of experiencing sunburn is 1, individuals experience 1 sunburn during that period. This assumption is based on expert communication from Professor Diffey (March 2010) indicating that after experiencing sunburn individuals will tend to change their sun protection behaviour and protect from further intensive exposure.

The average number of sunburns on a given year ($NS_t$) can then be calculated as follows:

$$NS_t = U_{\text{Holiday sunnier climate}} \text{ x 1 x \% Spending holiday in sunnier climate} \quad (3)$$

The lifetime number of sunburns is calculated by adding up the annual number of sunburns ($NS_t$) over the 80 years period. The model estimates that on average individuals will experience 31.12 sunburns over lifetime.

### 4.1.5 The effect of the interventions on individuals' sun exposure behaviour

The effect of the interventions is modelled by changing the frequency of protection –i.e. the probability of using protection always, sometimes and never. The impact of this change in the behavioural component of the model is twofold: (a) it modifies the allocation of individuals in one of the two states, protected and unprotected, as described in section 4.1.1, and (b) it changes the percentage of SED absorption in the protected state, which is calculated as described in section 4.1.2.

These changes apply to the year of implementation of the intervention. The maintenance effect of the intervention is modelled using the behavioural Markov model (Tables 7 to 9). The result of applying this Markov structure to model the maintenance of effects is that protection behaviour gradually returns to the pre-intervention levels. The model allows this maintenance effect until the end of each lifetime period (childhood, adolescence, and adulthood).

Figure 3 and 4 illustrate the modelled maintenance of effect. They demonstrate how effect is maintained following an intervention that increases the proportion of children aged 6 always using sunscreen (and reduces the proportion of children who never use sunscreen) by 0.10. In the first year of implementation, this change will: (a) increase the proportion of children aged 6 in the protected state from 0.41 to 0.44, and (b) decrease the percentage of SED absorption from 10.6 per cent to 10.0 per cent. Figures 3 and 4 illustrate how behavioural Markov model predicts that protection behaviour gradually returns to pre-intervention levels over the following 4-5 years.

**Figure 3. Example of modelled maintenance of effect on probability of being protected**

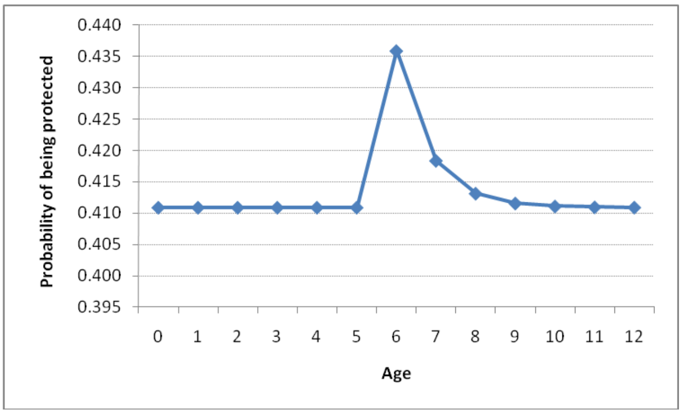
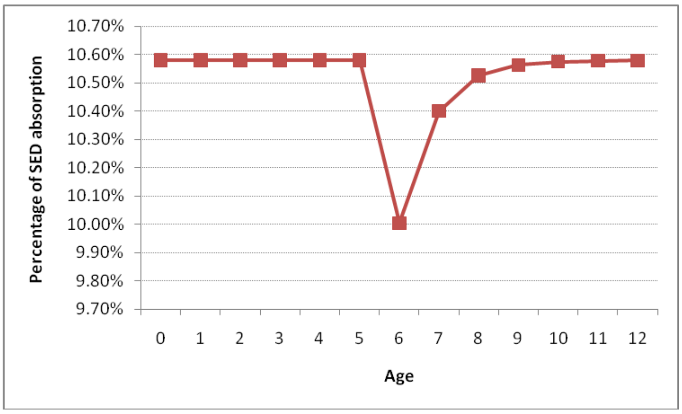


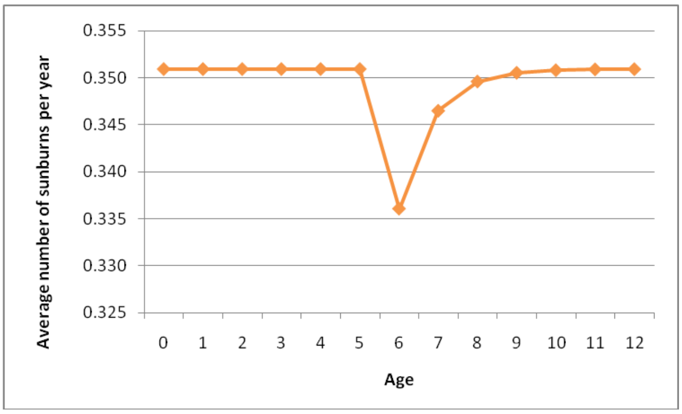

**Figure 4. Example of modelled maintenance of effect on percentage of SED absorption in the protected state**




The behavioural impacts described above produce a corresponding effect on annual SED, which in our example decreases from 120 SED to 116 SED in the first year, and then gradually returns to pre-intervention levels, as demonstrated in Figures 5. Similarly, the average number of sunburns per year is affected via the reduction in the probability of being unprotected (described in equation 3), as illustrated in Figure 6.

**Figure 5. Example of modelling maintenance of effect on annual SED**


**Figure 6. Example of modelled maintenance of effect on average number of sunburns per year**




## 4.2 Epidemiological component

The epidemiological component of the model estimates avoided cases of skin cancer due to changes in sun exposure. A different approach is adopted for non-melanoma skin cancer (NMSC) and malignant melanoma (MM) as:

1. Data on sun dose-response relationships are available to allow quantitative estimates to be made of the risk of NMSC. However, these data remain unknown for MM (NRPB 1995 and personal communication with Professor Diffey in March 2010).
2. Evidence suggests that MM is related to pattern as well as amount of sun exposure. In particular, MM is associated with high levels of recreational or intermittent exposure (Armstrong and Kricker, 2001).
3. Sunburn is generally thought to be an indicator of high levels of intermittent sun exposure (Armstrong and Kricker, 2001) and an important risk factor for MM (Dennis et al, 2008).

The following sections elaborate on the methods used to estimate avoided cases of NMSC and MM.

### 4.2.1 Non malignant skin cancer

The model predicts incidence of both types of NMSC –i.e. basal cell carcinoma (BCC) and squamous cell carcinoma (SCC). The age specific incidence rate is estimated using a sun dose-risk relationship derived from multivariate analysis of epidemiological data showing that, for a group of subjects with a given genetic susceptibility, age and sun exposure are the two most important factors in determining risk (Diffey 1992; NRPB 1995). The relationship can be expressed as follows:

$$R_T = \Gamma \left( \sum_{t=0}^{t=T} \mathrm{SED}_t \right)^{\beta-1} \sum_{t=0}^{t=T} \mathrm{SED}_t \, (T - t)^{\alpha-\beta} \qquad (4)$$

Where:

$R_T$ = age T specific incidence rate
$\Gamma$ = genetic susceptibility factor
$\alpha$ = age exponent
$\beta$ = dose exponent
$\mathrm{SED}_t$ = annual SED at age t (as described in section 5.1)

$\mathrm{SED}_t$ was estimated using the method described above. Table 16 presents the values for α, β and Γ for BCC and SCC. Population data used corresponds to England and Wales (ONS, 2009).

**Table 16. Parameters required to calculate the sun dose-risk relationship for BCC and SCC**

| Skin cancer type | Parameter | Value | Source |
|---|---|---|---|
| BCC | Age exponent | 3.2 | Diffey (1995) |
| | Dose exponent | 1.7 | |
| | Genetic susceptibility factor | 2.83E-07 | |
| SCC | Age exponent | 5.1 | |
| | Dose exponent | 2.3 | |
| | Genetic susceptibility factor | 1.65E-12 | |

Using equation (4) we calculated the age specific incidence rates of BCC and SCC in the baseline and in the intervention scenarios. Applying these to the population in England and Wales and calculating the difference between baseline and intervention scenarios provides an estimate of the number of cases of BCC and SCC averted due to the intervention. A 3.5 per cent rate per year was applied to discount cases avoided in the future.

In order to validate the model we calculated the age-standardised incidence rates for BCC and SCC and compared them with actual data. The age-standardised incidence rate can be calculated as follows:

$$R = \frac{\sum_{t=0}^{T} R_t \, N_t}{\sum_{t=0}^{T} N_t} \qquad (5)$$

Where:

R = age standardised incidence rate
$R_t$ = age t specific incidence rate (as described in equation 4)
$N_t$ = population in England and Wales at age t

Our model estimates 122 cases of BCC (per 100,000 population) and 25 cases of SCC (per 100,000 population). The estimated incidence of NMSC is therefore 147 cases (per 100,000 population). This figure is higher that the incidence rate reported by Cancer Research UK[6]. Registration data indicates that in 2006 the incidence rate of NMSC in the UK was 94.9 cases per 100,000 population. However, registration of NMSC is incomplete and previous research (Holme et al, 2000) has shown that this figure is likely to underestimate actual incidence.

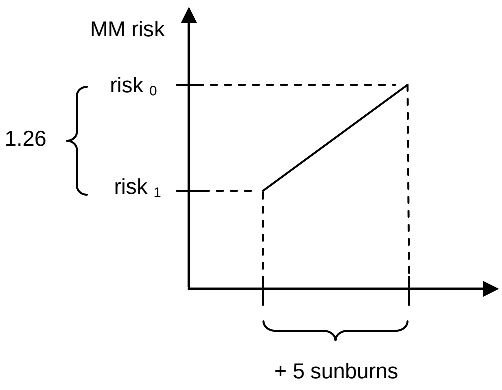
### 4.2.2 Malignant melanoma

MM is associated with high levels of recreational or intermittent exposure. Sunburn –an indicator of such pattern of exposure– is an important risk factor for MM. Dennis et al (2008) undertook a meta-analysis to quantify the overall magnitude of association between MM and increasing number of sunburns. Based on this evidence, the method for estimating avoided cases of MM consists of linking reduced number of sunburns with the relative risk of experiencing MM.

Dennis et al (2009) calculated that the odds ratio (OR) of MM for an increase of 5 sunburns during lifetime is 1.26. Assuming a linear relationship, we estimated that one additional sunburn increases the risk of MM by 0.259. Figure 7 illustrates this relationship.

[6] http://info.cancerresearchuk.org/cancerstats/types/skin/index.htm

**Figure 7. Relationship between sunburn and risk of MM**




Then, the relationship between sunburn and incidence of MM can be expressed as:

$$I_{MM} = c + r\,NS \qquad (6)$$

Where:

$I_{MM}$ = incidence of MM (17.16 per 100,000 population)
$r$ = risk for an additional sunburn = 0.259
$NS$ = lifetime number of sunburns = 31.12

Therefore, the origin ordinate $c$ must be equal to 16.

The effect of the interventions is modelled by applying equation (6) to the lifetime number of sunburns post-intervention to obtain incidence of MM post-intervention. The difference in incidence rates is then used to estimate avoided cases of MM among the targeted population.

Latency of the disease was assumed based on actual distribution of cases by age (Cancer Research UK, 2009). In other terms, the current distribution of registered cases of MM was used to estimate time of occurrence of avoided cases of MM. A 3.5 per cent discount rate was applied to obtain discounted figures.

## 4.3 Economic component

The economic component of the model converts cases of NMSC and MM averted into QALYs saved and health care cost savings. The incremental cost-effectiveness ratios (ICERs) for the interventions are then calculated as follows:

$$ICER = \frac{\text{Incremental cost}}{\text{QALYs saved}}$$

In addition, the total incremental cost-effectiveness ratios are calculated by deducting the health care costs avoided (i.e. treatment costs) from the cost of delivering the interventions.

$$\text{ICER} = \frac{\text{Incremental cost} - \text{health care cost savings}}{\text{QALYs saved}}$$

The method for estimating the cost of the interventions is described in section 3.2. The following sections describe the method for calculating the QALY gain and health care costs savings associated with NMSC and MM.

### 4.3.1 QALY gain

The method for estimating QALY gain from prevented cases of skin cancer followed a similar approach to that adopted in Phase 1 of this project. The QALY loss associated with NMSC –i.e. BCC and SCC– is 0.028, equivalent to 10 days in full health. No data distinguishing BCC from SCC was found. The QALY loss associated with MM is 6.09. The latter comprises two elements:

- QALYs lost due to morbidity associated with non-fatal cases of MM; and
- QALYs lost due to morbidity and premature mortality associated with fatal cases of MM.

Table 17 summarises the method for calculation and corresponding values.

**Table 17. QALY gain associated with avoided cases of NMSC and MM**

| Disease | Calculation | Value | Source |
|---|---|---|---|
| NMSC | Morbidity loss: ten days in full health. | 0.028 | Freedberg et al (1999) cited in Phase 1. |
| Non-fatal MM | Morbidity loss: average between 127.8 and 212.2 days in full health. | 0.466 | Freedberg et al (1999) cited in Phase 1. |
| Fatal MM | Morbidity loss: average between 127.8 and 212.2 days in full health.<br>Mortality loss: 22.5 years in full health. | 23 | Freedberg et al (1999) and Phase 1 estimation of life years lost. |
| MM | Weighted average of non-fatal MM and fatal MM. Assumes 25% of MM cases are fatal. | 6.09 | Freedberg et al (1999) and Phase 1 estimation of life years lost. |

Note: Phase 1 did not include morbidity loss associated with fatal MM.

### 4.3.2 Health care costs savings

Estimates of the health care costs associated with skin cancer were calculated from data on treatment costs provided by Morris et al (2009). The authors estimated the cost of MM and

NMSC to the National Health Service (NHS), using data on health services use and unit costs from published sources in the UK. Cost estimates were reported in 2002 prices. The resulting costs per case inflated to 2009 prices are £1,367 for NMSC and £2.593 for MM.[7] Table 18 summarises the method for calculation and corresponding values.

**Table 18. Health care costs to the NHS associated with NMSC and MM**

| Disease | Calculation | Value (£2009) | Source |
|---|---|---|---|
| NMSC | Total cost to the NHS (£57,878,000) divided by number of registrations (50,394) inflated to 2009 prices. | £1,367 | Morris et al (2009) and HM Treasury (2010) |
| MM | Total cost to the NHS (£13,208,000) divided by number of registrations (6,062) inflated to 2009 prices. | £2,593 | Morris et al (2009) and HM Treasury (2010) |

[7] Adjustment for inflation was done by applying the GDP deflator at market prices published by HM Treasury (2010).

# 5.0 Results

## 5.1 Model results

This section reports the results of the cost-effectiveness analysis. Table 19 summarises the following information for the interventions modelled:

- age of population receiving the intervention;
- cost per person of delivering the intervention;
- estimates of the benefits of the interventions in terms of QALYs gained due to avoided cases of NMSC and MM; and
- estimates of the ICERs (cost per QALYs gained) and total ICERs (net cost per QALYs gained).

The results show that all the ICERs exceed a £20,000 - £30,000 threshold. Specifically, the ICERs vary from c£256,000 to c£82,311,000. Similarly, when cost savings are included in the analysis, the total ICERs vary from c£207,000 to c£82,265,000. These findings suggest that none of the interventions modelled are cost-effective. Results for specific types of cancer and additional details for the interventions modelled are provided in Table 20.

**Table 19. Cost of intervention per QALYs gained for interventions modelled**

| Intervention type | Author | Interventions | Age group | Cost per person (£2009) | QALYs gained | ICER (£2009) | Total ICER (£2009) |
|---|---|---|---|---|---|---|---|
| Provision of shade | Dobbinson et al (2009) | Intervention: construction of shade sail structures. | 13 to 17 | £1.82 | 3.01 | £2,442,992 | £2,394,901 |
| Multi-component: beaches and pools | Mayer et al (1997) | Intervention: four five minute lessons before swimming class each covering sun protection behaviour; home-based curricula provided to parents, including several activities for children; SUNWISE board game and UV meter; sunscreen and hats were available at each lesson. | 6 to 9 | £19.92 | 0.22 | £10,670,576 | £10,621,954 |
| Multi-component: community | Dietrich et al (2000) | Intervention:<br>(1) school/day care: age- and grade-specific curriculum.<br>(2) beach: sun protection poster, sunscreen samples and educational pamphlets.<br>(3) primary care: office system manual to promote sun protection advice during patient visits, practice meeting for project staff, sun protection manual, patient education materials, sunscreen samples. | 2 to 11 | £0.59 | 3.27 | £1,118,074 | £1,069,469 |
| | | | 2 to 11 | £0.59 | 14.30 | £255,911 | £207,339 |
| Multi-component: education | Bauer et al (2005) | Intervention: 3 hour education session and educational letter at Easter, Pentecost and summer holidays with detailed information on proper sunscreen use, sun protection and information brochures from public melanoma prevention campaigns. Comparator: 3 hour education session. | 2 to 7 | £3.85 | 0.44 | £32,547,414 | £32,498,835 |
| Multi-component: healthcare | Norman et al (2007) | Intervention: interactive computer session to assess stage of change; printed tailored feedback; brief counselling from healthcare provider; four follow-up telephone assessments and feedback; 90ml bottle of SPF sunscreen with each feedback; intermittent tip sheets. | 13 to 15 | £12.27 | 1.02 | £50,986,399 | £50,940,170 |
| | | | 13 to 15 | £12.27 | 0.63 | £82,310,786 | £82,264,556 |
| Multi-component: work-setting | Mayer et al (2007) | Intervention: Provision of protective hats and sunscreen, visual reminders, and brief educational sun safety messages. Comparator: delayed intervention. | 21 to 65 | £52.04 | 38.60 | £1,348,003 | £1,298,476 |

**Table 20. Cost of intervention per QALYs gained due to prevented cases of BCC, SCC and MM for interventions modelled**

| **Intervention** | **Provision of shade** | **Multi-component: beaches and pools** | **Multi-component: community setting** | **Multi-component: community setting** | **Multi-component: education setting** | **Multi-component healthcare setting** | **Multi-component healthcare setting** | **Multi-component work setting** |
|---|---|---|---|---|---|---|---|---|
| **Author** | Dobbinson et al (2009) | Mayer et al (1997) | Dietrich et al (2000) | Dietrich et al (2000) | Bauer et al (2005) | Norman et al (2007) | Norman et al (2007) | Mayer et al (2007) |
| **Setting** | Schools | Swimming lessons | School/day care beach primary care | School/day care beach primary care | Nursery schools | Primary care | Primary care | Postal stations |
| **Population** | | | | | | | | |
| Age group | 13 to 17 | 6 to 9 | 2 to 11 | 2 to 11 | 2 to 7 | 13 to 15 | 13 to 15 | 21 to 65 |
| Targeted population | 4,051,400 | 120,250 | 6,214,000 | 6,214,000 | 3,707,800 | 4,247,110 | 4,247,110 | 1,000,000 |
| **Cost of intervention** | | | | | | | | |
| Per person | 1.82 | 19.92 | 0.59 | 0.59 | 3.85 | 12.27 | 12.27 | 52.04 |
| Total | 7,357,121 | 2,395,380 | 3,660,653 | 3,660,653 | 14,281,440 | 52,121,934 | 52,121,934 | 52,037,104 |
| **BCC** | | | | | | | | |
| Cases avoided | 89 | 7 | 97 | 423 | 13 | 29 | 18 | 1054 |
| Cost savings (£2009) | 121,275 | 9,090 | 132,347 | 578,076 | 17,706 | 39,550 | 24,499 | 1,440,580 |
| QALYs gained | 2.43 | 0.18 | 2.65 | 11.59 | 0.35 | 0.79 | 0.49 | 28.88 |
| **SCC** | | | | | | | | |
| Cases avoided | 17 | 1 | 20 | 85 | 3 | 6 | 3 | 345 |
| Cost savings (£2009) | 23,506 | 1,822 | 26,755 | 116,559 | 3,605 | 7,676 | 4,755 | 471,189 |
| QALYs gained | 0.47 | 0.04 | 0.54 | 2.34 | 0.07 | 0.15 | 0.10 | 9.45 |
| **Total NMSC** | | | | | | | | |
| Cases avoided | 105.928 | 7.984 | 116.406 | 508.225 | 15.592 | 34.553 | 21.404 | 1398.734 |
| Cost savings (£2009) | 144,781 | 10,912 | 159,101 | 694,635 | 21,311 | 47,227 | 29,254 | 1,911,769 |
| QALYs gained | 2.90 | 0.22 | 3.19 | 13.92 | 0.43 | 0.95 | 0.59 | 38.32 |
| **ICER (£2009)** | **2,535,064** | **10,950,906** | **1,147,830** | **262,903** | **33,431,994** | **55,058,906** | **88,884,800** | **1,357,910** |
| **Total ICER (£2009)** | **2,485,176** | **10,901,018** | **1,097,943** | **213,015** | **33,382,106** | **55,009,018** | **88,834,912** | **1,308,022** |

| Intervention | Provision of shade | Multi-component: beaches and pools | Multi-component: community setting | Multi-component: community setting | Multi-component: education setting | Multi-component healthcare setting | Multi-component healthcare setting | Multi-component work setting |
|---|---|---|---|---|---|---|---|---|
| **Melanoma** | | | | | | | | |
| Cases avoided | 0.018 | 0.001 | 0.014 | 0.062 | 0.002 | 0.012 | 0.008 | 0.046 |
| Cost savings (£2009) | 47 | 2 | 36 | 162 | 5 | 32 | 20 | 120 |
| QALYs gained | 0.11 | 0.01 | 0.08 | 0.38 | 0.01 | 0.08 | 0.05 | 0.28 |
| **ICER (£2009)** | **67,264,294** | **416,838,641** | **43,129,285** | **9,622,632** | **1,230,104,076** | **689,318,701** | **1,112,893,543** | **184,776,464** |
| **Total ICER (£2009)** | **67,263,868** | **416,838,215** | **43,128,859** | **9,622,206** | **1,230,103,650** | **689,318,275** | **1,112,893,117** | **184,776,038** |
| **Total** | | | | | | | | |
| Cost savings (£2009) | 144,828 | 10,915 | 159,138 | 694,797 | 21,316 | 47,259 | 29,274 | 1,911,889 |
| QALYs gained | 3.01 | 0.22 | 3.27 | 14.30 | 0.44 | 1.02 | 0.63 | 38.60 |
| **ICER (£2009)** | **2,442,992** | **10,670,576** | **1,118,074** | **255,911** | **32,547,414** | **50,986,399** | **82,310,786** | **1,348,003** |
| **Total ICER (£2009)** | **2,394,901** | **10,621,954** | **1,069,469** | **207,339** | **32,498,835** | **50,940,170** | **82,264,556** | **1,298,476** |
| **Sectors affected** | | | | | | | | |
| Costs | Education | Local councils | Education and local councils | Education and local councils | Education | Health | Health | Employers |
| Benefits | Health | Health | Health | Health | Health | Health | Health | Health |

## 5.2 Sensitivity analysis

Inevitably, the parameters required to model short-term behavioural outcomes into longer-term health effects are subject to uncertainty. The model was put through a series of iterations to examine the effect of different parameters on ICERs. Table 21 shows key model parameters and their expected relationship with ICER estimates. It also provides details about the parameters' values used in the model and the range used in the sensitivity analysis.

**Table 21. Parameters used in sensitivity analysis and expected relationship with ICERs**

| Parameter | Expected relationship with cost per QALY | Value used in model | Range used in sensitivity analysis |
|---|---|---|---|
| Effect of the intervention | Negative | Given by the intervention | [0.10; 0.50] |
| Cost per person of delivering the intervention | Positive | Given by the intervention | [1; 40] |
| Probability of spending two week holiday in a sunnier climate | Negative | 0.6 | [0.5; 0.9] |
| SED threshold for experiencing sunburn | Positive | 5 | [2; 6] |
| Number of sunburns per period | Negative | 1 | [1; 5] |
| QALY loss for NMSC | Negative | 0.027 | [0.025; 0.125] |
| QALY loss for MM | Negative | 6.09 | [6; 7] |
| Discount rate for health benefits | Positive | 0.035 | [0.015; 0.035] |
| Hours of occupational outdoor exposure | Negative | 4 | [4; 8] |

The results of the sensitivity analysis are reported in Figures A2.1 to A2.64 in Appendix 2. The results demonstrate that changing the value of key parameters within the ranges indicated in Table 21 does not alter the findings of the model in terms of the cost-effectiveness of the interventions.

The intervention related to provision of shade deserves particular attention. Dobbinson et al (2009) evaluated the effectiveness of building shade structures in existent schools. The cost per student was estimated at £1.82. It is possible, however, that for new buildings the cost could be considerably less if provision of shade is incorporated into designs and constructed from outset, rather than being an add-on feature. With that in mind, we estimated the unit cost that would be required for the intervention to be cost-effective. If the cost per student was £0.015 the cost per QALY would be just above the £20k threshold (£20,180). In interpreting this result however is important to note that the generalisability of the study is limited given that as indicated in the evidence review it is unclear whether such shaded areas would have similar usage in a cooler climate such as the UK (McDaid et al, 2010).

## 5.3 Mass media campaign

A break-even analysis was undertaken to estimate the effect that would be required for a five year mass media campaign to be cost-effective. As an indicator for cost-effectiveness a threshold of £20,000 per QALY was used. Table 22 summarises the cost of two possible campaigns and the required effect in terms of increase in the probability of 'always' using sunscreen (reduction in the probability of 'never' using sunscreen) for the campaigns to be cost-effective. Figures 8 and 9 illustrate the relationship between increase in the probability of 'always' using sunscreen and cost per QALYs gained.

The results indicate that for a 'low' cost campaign to be cost-effective, the campaign would have to increase the probability of 'always' using sunscreen by 0.02. For a 'high' cost campaign to be cost-effectiveness, the required increase in the probability of 'always' using sunscreen would be 0.066.

These results should be interpreted having in mind that the expert paper on mass media campaigns found that this type of interventions can lead to changes in knowledge and attitudes but only very poor associational data on the effect on behaviour change was found.

**Table 22. Five year mass media campaigns: cost and effect required for cost-effectiveness**

| Campaign | Annual cost per person (£2009) | Total cost (£2009) | Effect required |
|---|---|---|---|
| 'Low' cost | £0.0028 | £707,344 | Increase probability of 'always' using sunscreen by 0.02 (decrease probability of 'never' using sunscreen by 0.02) |
| 'High' cost | £0.0093 | £2,358,756 | Increase probability of 'always' using sunscreen by 0.066 (decrease probability of 'never' using sunscreen by 0.066) |

**Figure 8. 'Low cost' five year mass media campaign: cost per QALY for different changes in probability of using sunscreen due to the intervention**

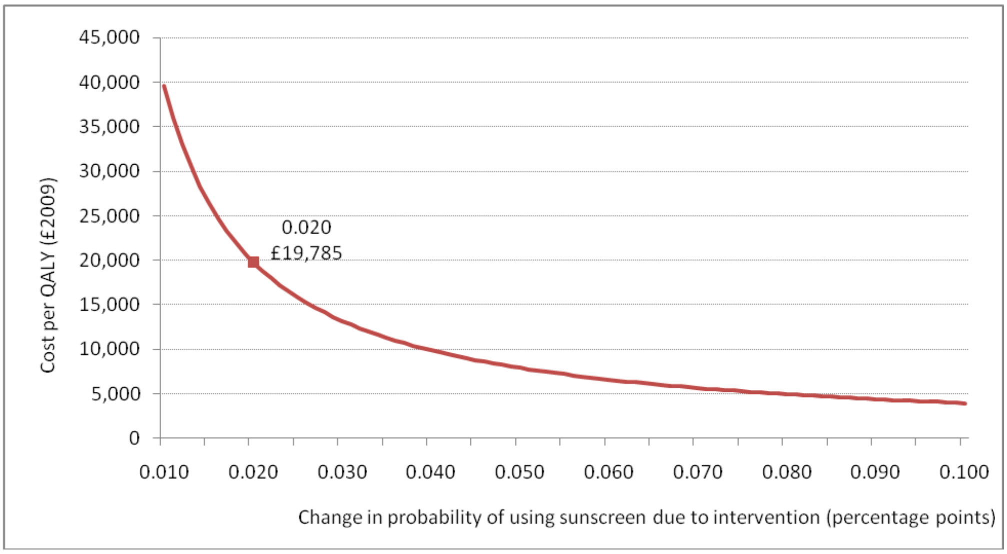
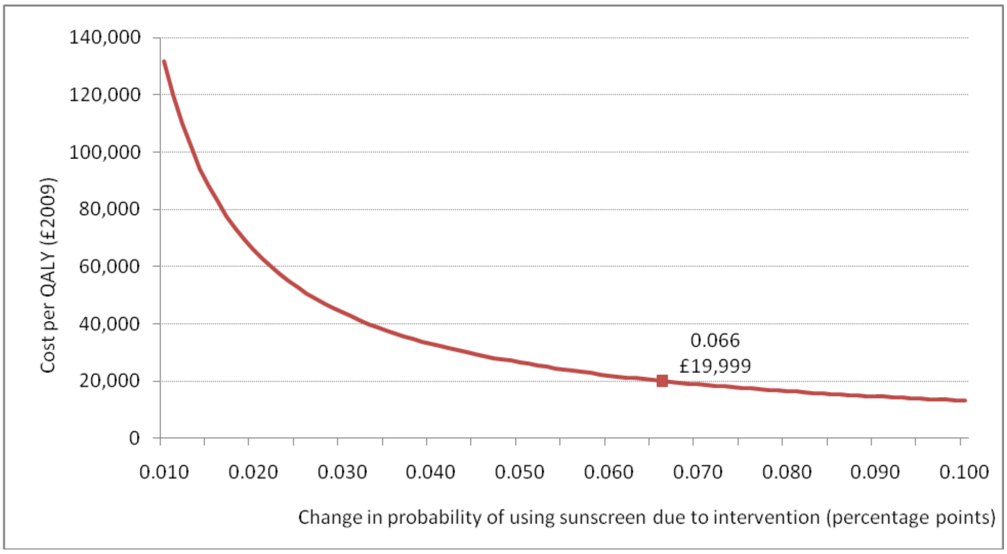



**Figure 9. 'High cost' five year mass media campaign: cost per QALY for different changes in probability of using sunscreen due to the intervention**



# 6.0 Discussion

## 6.1 Provision of shade and multi-component interventions (Phase 2)

The analysis indicates that none of the interventions modelled are cost-effective. For all six types of interventions modelled, the estimated ICERs are far above a £20,000 threshold. This result is a consequence of the following factors:

- the small effects in terms of sun exposure behaviour achieved by the interventions;
- the relatively high unit costs of the interventions driven by the provision of resources such as sunscreen, hats, and educational material;
- the small QALY gain associated with prevented cases of NMSC; and
- the small number of avoided cases of MM.

It is illustrative to consider how the effect of an intervention 'works through' the model to generate QALY gains. For instance, consider an intervention that increases the proportion of children aged 6 always using sunscreen (and reduces the proportion of children who never use sunscreen) by 10 percentage points. Within the model this effect generates QALY gains through the following steps.

- In the first year of implementation, this change increases the proportion of children aged 6 in the protected state from 0.41 to 0.44, and decreases the percentage of SED absorption from 10.6 per cent to 10.0 per cent.
- This effect is maintained for 4-5 years, gradually decreasing in magnitude over this period.
- This change in behaviour produces a corresponding effect on annual SED, which decreases from 120 SED to 116 SED in the first year. Similarly, the average number of sunburns per year reduces from 0.350 to 0.335.
- The change in SED and sunburns generates the following number of averted cases of cancer: 113 cases of BCC; 30 cases of SCC; and 0.069 cases of MM.
- When represented in discounted QALYs gained, these effects are: 0.55 QALYs gained through avoided cases of BCC; 0.11 QALYs gained through avoided cases of SCC; and 0.18 QALYs gained through avoided cases of MM.

The above example illustrates how even a 10 percentage point increase in the proportion of children always using sunscreen generated only few QALY gains. There are a number of reasons why this is the case. Perhaps most importantly, changing somebody's behaviour for a small number of years has a limited impact on their chance of experiencing MM later in life.

Given the limited effect associated with increased use of sunscreen generated in the example above, it is not necessarily that surprising that an intervention that increases the probability that people wear hats by 5 percentage points also has limited impacts. This limited effect is exacerbated by the fact that hats only cover a small proportion of the body.

## 6.2 Mass media campaign (Phase 1)

The break even analysis on the mass media campaign demonstrates that it is possible for interventions designed to prevent skin cancer to be cost-effective. However, it is worth noting that if these interventions had any quantifiable detrimental effects –such as reduced levels of physical activity or deficient levels of vitamin D– the overall ICERs would be unfavourably affected.

The lesson from this analysis is that interventions need to have a very low unit cost to be cost-effective. To illustrate this point it is useful to compare the unit cost for a mass media campaign against that for the interventions modelled in Phase 2. The unit cost of a mass media campaign was estimated at £0.0028 and £0.0093. Interventions modelled in Phase 2 are significantly more costly. The unit cost for shade provision was estimated at £1.82 and the estimated unit cost for multi-component interventions ranges between £0.59 and £52.04.

## 6.3 General approach to modelling interventions

The results of this economic evaluation should be interpreted with caution. Estimating the cost effectiveness of interventions to prevent primary skin cancer attributable to UV exposure faces important methodological challenges. Table A3.1 in Appendix 3 summarises the general approach we adopted for dealing with these challenges and provides a comparison with the approach followed in Phase 1.

The behavioural and epidemiological components of the effect of the interventions are complex, while the data available to model these effects is limited. For instance, the effect studies inevitably cover only a limited timeframe. In order to compensate for this limitation in the data, our model attempts to capture the complex behavioural dynamics that determine whether changes in behaviour are maintained by adopting a dynamic Markov structure.

Another example of the uncertainty to which the analysis is subject is the lack of knowledge on the relationship between sun exposure and incidence of MM. Even though sun exposure is one of the leading causes for MM, the dose-response relationship remains unknown. Current knowledge is limited to associations between sun exposure and MM, generally derived from countries with sunnier climates.

In order to account for this uncertainty, a sensitivity analysis was undertaken. This suggests that the conclusion of the analysis –that the interventions modelled are not cost-effective– is not impacted by this uncertainty.

A number of assumptions were made in conducting the analysis, the effects of which are not tested in the sensitivity analysis. These work to both underestimate and overestimate the cost per QALYs gained estimates. Table 23 summarises the assumptions made and their likely impact on the cost per QALYs gained estimates. Given the magnitude of the ICERs estimates, it is unlikely that the results are sensitive to these assumptions.

**Table 23. Assumptions made in the model**

| Assumptions that cause the model to underestimate the cost per QALYs gained | Assumptions that cause the model to overestimate the cost per QALYs gained |
|---|---|
| It was assumed that the effect of the interventions impacts on behaviour beyond the setting of the intervention. For example, increase in probability of seeking shade during school breaks will be transferred to individuals' behaviour beyond that particular setting. | It is assumed that the interventions have no impact on the SPF afforded by the different types of protection. If, for example, as a result of the intervention individuals made more appropriate use of sunscreen, the effect of the intervention would be underestimated. |
| In general it was assumed that changes in behaviour will translate into individuals 'always' (rather than 'sometimes') using protection. | SED values are calculated for mean weather conditions in northern Europe and average hours spent outdoors. Unusual values on these variables may cause individuals to exceed the 5 SED threshold for experiencing sunburn during the risk-period. This however would have little impact on the cost-effectiveness estimates unless the magnitude of the interventions effect was significant. |
| Given the high cost per QALYs gained estimates, it was assumed that no harmful effects associated with reduced sun exposure occur. If the interventions led to a reduction in levels of vitamin D or physical activity, the cost per QALYs gained would be higher. | No consideration is given to potential productivity losses. However, given the small health losses prevented by the interventions, it is unlikely that the results would change if productivity losses were considered. |

## 7.0 Appendix 1: effect and cost of the intervention

This appendix summarises the effect and cost of the intervention. The effect section in each table provides: (i) information on the significant effects of the interventions, drawn from the evidence review (McDaid et al, 2010), and (ii) the behavioural changes used in the analysis to model such effects. The cost section provides details on the calculation of the incremental cost per person, including assumptions made and data sources used.

**Table A1.1. Provision of shade**

| | | |
|---|---|---|
| Reference | Dobbinson et al (2009) | |
| Description | Population: 13 to 17 years old<br>Targeted population: Assumed that 100% of children in relevant age group would receive the intervention<br>Setting: schools<br>Intervention: construction of shade sail structures.<br>Comparator: no built shade. | |
| Significant effects | Evidence review<br><br>Student use of primary site during lunch times in Spring and Summer terms<br><br>There was a statistically significant difference in mean change in the use of the primary site.<br><br>Mean use (SD)<br>Baseline: intervention 3.24 (2.83) (range 0-30 students); control 3.49 (2.82) (range 0-59 students)<br><br>Post intervention: intervention 5.87 (4.70) (range 0-47); control 3.46 (2.69) (range 0-34) | Behavioural change in model<br><br>Increase in probability of 'always' seeking shade by 0.08 (decrease probability of 'never' seeking shade by 0.08).<br><br>Calculation<br><br>(a) Effect size = 0.83<br>adjusted baseline intervention = 3.24 * 3.46 / 3.49 = 3.21<br>difference divided by adjusted baseline intervention = (5.87 - 3.21) / 3.21 = 0.83<br><br>(b) Change = 0.08<br>baseline model * (1 + effect size) - baseline model = 0.09 * (1 + 0.83) - 0.09 |

| Reference | Dobbinson et al (2009) | |
|---|---|---|
| Incremental cost per person (2009 prices) | Cost per person<br><br>Shade structure: cost estimate from Dobbinson et al (2009): £5,205 in 2005 prices. Inflated to 2009 prices: £5,745.<br><br>Shade installation: cost estimate from Dobbinson et al (2009): AUD 22,000 in 2005. Converted to GBP and inflated to 2009 prices: £10,199.<br><br>Total cost shade: £15,944<br>Annual cost shade: £1,594<br>Total unit cost: £1,82 | Comments<br><br>Unit cost calculated as total annual cost divided by school size in terms of number of students (878 students on average), as reported by Dobbinson et al (2009).<br><br>Assumptions<br><br>No additional implementation costs should be incurred.<br>Shade will last for a period of 10 years.<br>School sizes from Dobbinson et al (2009) are comparable to the UK school sizes. |

**Table A1.2. Multi-component: beaches and pools**

| | | |
|---|---|---|
| Reference | Mayer et al (1997) | |
| Description | Population: 6 to 9 years old<br>Targeted population: assumed that 5% of children in relevant age group would attend swimming lessons<br>Setting: swimming lessons<br>Intervention: four five minute lessons before swimming class each covering a sun protection behaviour; home-based curricula provided to parents, including several activities for children; SUNWISE board game and UV meter; sunscreen and hats were available at each lesson.<br>Control: no intervention | |
| Significant effects | <u>Evidence review</u><br><br>How often child wears a hat<br><br>Post intervention children in the intervention group (n=76 children) were statistically significantly more likely to wear a hat than those in the control group (n=76 children).<br><br>Mean Likert scale value (SD): 1 never; 5 always<br><br>Baseline: intervention 2.21 (0.94); control 2.59 (1.10)<br><br>Post-test: intervention 2.74 (1.00); control 2.62 (1.08)<br><br>Adjusted post-test: intervention 2.84; control 2.52; p=0.029 (results remained the same when controlling for age and gender) | <u>Behavioural change in model</u><br><br>Increase in probability of 'always' wearing a hat by 0.24 (decrease in probability of 'sometimes' wearing a hat by 0.24).<br><br><u>Calculation</u><br><br>(a) Effect size = 0.23<br>adjusted baseline intervention = 2.21 * 2.62/ 2.59 = 2.24<br>difference intervention versus control divided by adjusted baseline intervention = (2.74 - 2.24) / 2.24 = 0.23<br><br>(b) Baseline score for UK data = 3.16<br>always (5) = 0.16<br>sometimes (3) = 0.76<br>never (1) = 0.08<br><br>(c) Baseline average frequency of protection for model data = 54%<br>always (100%) = 0.16<br>sometimes (50%) = 0.76<br>never (0%) = 0.08 |

| Reference | Mayer et al (1997) | |
|---|---|---|
| | | (d) Post-intervention score<br>baseline score * (1 + effect size) = 3.16 * (1 + 0.23) = 3.86<br>(e) Post-intervention average frequency of protection for model data = 66%<br>post-intervention score * baseline average frequency / baseline score = 3.86 * 54% / 3.15 = 66%<br><br>(f) Increase post-intervention = 0.24<br>66% = (0.16 + x) * 100% + (0.76 - x) * 50% + 0.08 * 0% |
| Incremental cost per person (2009 prices) | <u>Cost per person</u><br><br>(1) Aquatics curricula including four five minute lessons<br>Four 5-min sunwise lessons: £0.44<br>Sunscreen: £4.6<br>Hat: £5.3<br><br>(2) Home-based curricula, including several activities for children<br>Manual for parents: £2.9<br>Calendar and stickers: £1.7<br><br>(3) SUNWISE board game and UV meter<br>Sunwise "jeopardy" game: £3<br>UVR meter: £1.99<br><br>Total unit cost: £19.9 | <u>Sources and assumptions</u><br><br>Lessons. Lifeguards salary is assumed to be 5.80/hr, thus 5 min lesson costs 50p, 4 lessons cost £2. In each group there were ~4.5 kids, so unit cost is 0.44.<br>Sunscreen. Assumed 1 100ml bottle per child. Source: Boots.<br>Hat. Source: The Kids Window.<br>Manual. Each 24-page manual costs £2.9 to print. Manual development costs not included and number of pages is assumed.<br>Calendar and stickers. Assumed similar calendar with stickers can be use. Source: Amazon.<br>Sunwise "jeopardy" game. Use cost of a similar game. Source: Amazon.<br>UVR meter. Source: Amazon.<br><br><u>Assumptions</u><br><br>Lifeguards wore hats and sunscreen and encourage children to do so, this activity was considered as a voluntary one and has not been costed.<br><br>No additional implementation costs required |

**Table A1.3 Multi-component: community setting**

| | | |
|---|---|---|
| Reference | Dietrich et al (2000) | |
| Description | Population: 2 to 11 years old<br>Targeted population: assumed that 100% of children in relevant age group would receive the intervention<br>Setting: school/day care; beach; primary care<br>Intervention:<br>(1) school/day care: age- and grade-specific curriculum.<br>(2) beach: sun protection poster, sunscreen samples and educational pamphlets.<br>(3) primary care: office system manual to promote sun protection advice during patient visits, practice meeting for project staff, sun protection manual, patient education materials, sunscreen samples.<br>Comparator: no intervention. | |
| Significant effects | <u>Evidence review</u><br><br>a) Proportion of children wearing sunscreen on at least one body area<br><br>There was a statistically significant greater mean change for the intervention, between baseline and follow up 1, compared with control (mean difference 0.17, p=0.011).<br><br>Baseline: intervention 0.57 (n=456 children); control 0.65 (n=409 children)<br>Follow up 1: intervention 0.75 (n=561 children); control 0.66 (n=504 children)<br><br>Note: There was no statistically significant difference between groups in mean change from baseline to follow up 2 (mean difference 0.21, p=0.056). | <u>Behavioural change in model</u><br><br>Increase in probability of 'always' wearing sunscreen by 0.05 (decrease in probability of 'never' wearing sunscreen by 0.05)<br><br><u>Calculation</u><br><br>(a) Effect size = 0.30<br>adjusted baseline intervention = 0.57 * 0.66 / 0.65 = 0.58<br>difference intervention versus control divided by adjusted baseline intervention = (0.75 - 0.58) / 0.58 = 0.30<br><br>(b) Change = 0.05<br>baseline model * (1 + effect size) - baseline model = 0.16 * (1 + 0.30) - 0.16 |
| Significant effects | <u>Evidence review</u><br><br>b) Sunscreen used on face<br><br>There was a statistically significant greater mean change for the intervention, between baseline and follow up 1, compared with control (mean difference 0.15, p=0.031). | Not modelled - body area specific - model would overestimate effect |

| | | |
|---|---|---|
| Reference | Dietrich et al (2000) | |
| Significant effects | Evidence review<br><br>c) Sunscreen used on torso/back<br><br>There was a statistically significant greater mean change for the intervention, between baseline and follow up 1 and baseline and follow up 2, compared with control (mean difference 0.17, p=0.008; 0.20, p=0.041 respectively). | Not modelled - body area specific - model would overestimate effect |
| Significant effects | Evidence review<br><br>d) Protections on one or more body area by sunscreen, clothes, and/or shade<br><br>There was a statistically significant greater mean change for the intervention, between baseline and follow up 1 and baseline and follow up 2, compared with control (mean difference 0.13, p=0.029; and 0.12, p=0.033 respectively)<br><br>Baseline: intervention 0.78 (n=456 children); control 0.85 (n=409 children)<br>Follow up 1: intervention 0.87 (n=561 children); control 0.80 (n=504 children)<br>Baseline: intervention 0.58 (n=446 children); control 0.67 (n=408 children)<br>Follow up 2: intervention 0.73 (n=746 children); control 0.70 (n=744 children) | Behavioural change in model<br><br>Average: Increase in probability of 'always' using four types of protection by 0.03 (decrease in probability of 'never' using four types of protection by 0.03)<br><br>Calculation<br><br>(a) Effect size<br>Follow up 1:<br>adjusted baseline intervention = 0.78 * 0.80 / 0.85 = 0.73<br>difference intervention versus control divided by adjusted baseline intervention = (0.87 - 0.73) / 0.73 = 0.185<br>Follow up 2:<br>adjusted baseline intervention = 0.58 * 0.70 / 0.67 = 0.61<br>difference intervention versus control divided by adjusted baseline intervention = (0.73 - 0.61) / 0.61 = 0.205<br>Average: 0.195<br><br>(b) Change<br>Average: baseline model * (1 + effect size) - baseline model = 0.16 * (1 + 0.195) - 0.16 = 0.03 |

| Reference | Dietrich et al (2000) | |
|---|---|---|
| Incremental cost per person (2009 prices) | Cost per person<br><br>(1) School/day care<br>Three 40 min visits and one 20 min visit per school: £0.32<br>Headmaster's time: £0.21<br>Dissemination of training: £0.09<br>Marketing materials: £0.07<br><br>Total unit cost: £0.69<br><br>(2) Beach<br>Two 40 min visits and one 20 min visit: £0.23<br>Marketing materials: £0.05<br><br>Total unit cost: £0.28<br><br>(3) Primary care<br>One 40 min visit and one 20 min visit: £0.07<br>Clinician implementing intervention: £0.70<br>Marketing materials: £0.03<br><br>Total unit cost: £0.80<br><br>Average cost for three settings: £0.59 | Comments and assumptions<br><br>(1) School/day care<br>School visits. Project research assistant's salary is £12.88/hr. About 25.7 hours of visits were required. Assumed that 1 hr would be required for a return trip to each school, bringing up researcher's time to 44 hrs (4 visits for each of 11 schools+25.7hrs)=~70 hours * £12.88=£901.6.  Travelling cost is assumed to be £10 per trip.  Total cost is £901.6+£440 (£10*44 trips)= £1342. Divided by 4,200 recipients.<br>Headmaster's time. School principal's time costs £35/hr (annual salary of £62,607) 2.33 hrs of each headmaster's time was required at 11 schools 2.33*11*£35=£898. Divided by 4,200 recipients..<br>Dissemination of training. Materials were used at least during 2 class periods. Calculation additional teacher's time is not relevant as number of teaching hours has not increase.  It was assumed that each principle spent 1 hr disseminating information to teachers. 11hrs*£35=£385. Divided by 4,200 recipients.<br>Marketing materials. It was assumed that marketing materials cost the same as in the primary care intervention described in [Dietrich et al. (2000) Sun Protection Counselling for Children Primary Care Practice Patterns and Effect of an Intervention on Clinicians. Arch Fam Med 9: 155-159.].  $25/school (1999 prices) = £20 (2009 prices) Total cost of marketing materials: £20*11=£220. Divided by 4,200 recipients.<br><br>(2) Beach<br>Visits. There is no information on how many beaches were visited.  Assumption was made that it's 5 (1 beach for each town).  We assumed 1.67 hrs of researcher's time per beach + 15 hours for travelling (1 hr return trip to each beach 3 times).  (1.67+3)*5*£12.88 = £301+travelling (15 trips at £10) = 451.  No information was provided on how many people were reached by the beach intervention, we assumed 2000.<br>Marketing materials. Same methodology as above. Divided by 2,000 beach goers. |

| Reference | Dietrich et al (2000) | |
|---|---|---|
| | | (3) Primary care<br>Visits. 15 practices including 51 clinicians agreed to participate. Each one was seeing not less than 10 children per week, thus it was estimated that the intervention could have impacted 12,000 kids in 1 year (considering that 50% of visits were repeat visits rather than new patients, that GP worked 48 weeks and saw at least 10 kids /week). [Dietrich et al. (2000)]. Divided by 12,000 recipients.<br>Clinician implementing intervention. 15 hours of clinician's time was required (1 hr at each practice) to accommodate the project visitor. Assumed salary of a physician is 73.39/hr. Total cost £1,100. It is not indicated how many minutes physician spent counselling a patient on sun safety. Not all patients have been counselled. We assumed that 1 minute of counselling has been spent on 50% of visitors, total time of 100 hours @ £73.39=£7,339. Total cost of implementation is £8,439. Divided by 12,000 recipients.<br>Marketing materials. Same methodology as above. Divided by 12,000 recipients.<br><br>Sun-screen samples were provided for free by manufacturers, thus excluded from calculation. |

**Table A1.4 Multi-component: education setting**

| | | |
|---|---|---|
| Reference | Bauer et al (2005) | |
| Description | Population: 2 to 7 years old<br>Targeted population: assumed that 100% of children in relevant age group would receive the intervention<br>Setting: nursery schools<br>Intervention: 3 hour education session and educational letter at Easter, Pentecost and summer holidays with detailed information on proper sunscreen use, sun protection and information brochures from public melanoma prevention campaigns.<br>Comparator: 3 hour education session | |
| Significant effects | <u>Evidence review</u><br><br>a) Use of sunscreen<br><br>There was a statistically significant difference in the % using sunscreen since 1998 (p=0.033)<br><br>Education and sunscreen: 99.4%<br>Education: 99.7%<br>Control: 98%<br><br>(There was no statistically significant difference between the two intervention groups or between the education and sunscreen group and control)<br><br>Notes:<br>There was no statistically significant difference in the % 'almost always' using sunscreen since 1998. There was no statistically significant difference between groups in the proportion of children with sunburn experience 1998-2001 (p=0.844) (n as for primary outcome)<br><br>Education and sunscreen: 22%<br>Education: 21.5%<br>Control: 23.2% | <u>Behavioural change in model</u><br><br>Increase in probability of using sunscreen 'sometimes' by 0.013 (decrease in probability of 'never' using sunscreen by 0.013).<br><br><u>Calculation</u><br><br>(a) Effect size = 0.017<br>percentage using sunscreen if 'education' minus percentage using sunscreen if 'control' divided by percentage using sunscreen if 'control' = (99.7% - 98%) / 98% = 0.017<br><br>(b) Change = 0.013<br>baseline model * (1 + effect size) - baseline model = 0.76 * (1 + 0.017) - 0.76 = 0.013 |

| | | |
|---|---|---|
| Reference | Bauer et al (2005) | |
| Significant effects | <u>Evidence review</u><br><br>b) Median weeks on holiday in sunny climates<br><br>There was a statistically significant difference between groups in the median weeks on holiday in sunny climates (p=0.021)<br><br>Education and sunscreen: Median 4 weeks (IQR 2, 7.5)<br>Education: 6 (2, 8)<br>Control: 5 (2, 8) | Not modelled as we don't allow for change in duration of holidays between 'No intervention' and 'Intervention'. We could introduce this, although is difficult to see how an intervention would have such an impact, especially in children. |
| | <u>Evidence review</u><br><br>c) Median score of country of holiday<br><br>There was a statistically significant difference between groups in the median score of country of holiday (p=0.009).<br><br>Education and sunscreen: Median 4 (IQR 3, 6)<br>Education: 4 (3, 6)<br>Control: 4 (3, 6) | Not modelled as we only consider UK and sunnier destinations |
| Incremental cost per person (2009 prices) | <u>Cost per person</u><br><br>Total unit cost = £3.85 | <u>Comments and assumptions</u><br><br>Estimated in Phase 1 (Andronis et al, 2009) and inflated to 2009 prices |

**Table A1.5 Multi-component: health care setting**

| | | |
|---|---|---|
| Reference | Norman et al (2007) | |
| Description | Population: 13 to 15<br>Targeted population: Assumed that 86% of adolescents would visit their GP. Based on the National survey of local health services 2008, the percentage of individuals who made an appointment with a doctor from their GP practice/ health centre in the last 12 months was 86% (Healthcare Commission, 2008). Sample population covers 16+ individuals, thus this percentage is likely to be an overestimate of the percentage of adolescents visiting a GP.<br>Setting: primary care<br>Intervention: interactive computer session to assess stage of change; printed tailored feedback; brief counselling from healthcare provider; four follow-up telephone assessments and feedback; 90ml bottle of SPF sunscreen with each feedback; intermittent tip sheets.<br>Comparator: a physical activity and diet intervention. | |
| Significant effects | Evidence review<br><br>a) Sun-protection behaviours<br><br>At 24 months, adolescents in the intervention group responded significantly more to 'often' or 'always' avoiding the sun, limiting exposure to the sun, using sunscreen, using SPF 15 sunscreen on the face, and using SPF 15 sunscreen on all sun-exposed body parts (all $p<0.05$). There were no significant differences between groups in the use of shirts or shade.<br><br>Frequencies of adolescents responding 'often' or 'always' at 24 months: sun smart; control<br>shirt: 82.5%; 83.9%<br>shade: 44.1%; 45.2%<br>avoid sun: 39.7%; 29.9% (*)<br>limit exposure: 37.1%; 30.5% (*)<br>sunscreen use: 53.3%; 41.6% (*)<br>SPF 15 on face: 62.2%; 45.5% (*)<br>SPF 15 all exposed areas: 54.0%; 39.9% (*)<br><br>(*) $p<0.05$ | Behavioural change in model<br><br>Increase in probability of 'always' using sunscreen by 0.03 (decrease in probability of 'never' using sunscreen by 0.03).<br><br>Calculation<br><br>(a) Effect size = 0.32<br>sunscreen use = (0.533 - 0.416) / 0.416 = 0.28<br>SPF 15 all exposed areas = (0.54 - 0.399) / 0.399 = 0.35<br>average = 0.32<br><br>(b) Change = 0.03<br>baseline model * (1 + effect size) - baseline model = 0.09 * (1 + 0.32) - 0.09<br><br>Notes<br><br>SPF 15 on face - body area specific - model would overestimate effect<br>Avoid sun - not modelled as not a type of protection considered in the model<br>Limit exposure - not modelled as not a type of protection considered in the model |

| Reference | Norman et al (2007) | |
|---|---|---|
| Significant effects | <u>Evidence review</u><br><br>b) Mixed effects repeated-measures model<br><br>Baseline<br>There was no statistically significant difference in baseline sun protection behaviour status for the two groups, parameter estimate -0.05 (95% CI: -1.43 to 1.32, p=0.94). (This means no difference in the intercept (48.03) which represents the initial sun protection behaviour status).<br><br>Group X time<br>There was a statistically significant increase in sun protection behaviours in both groups over time, parameter estimate 1.74 (95% CI: 0.66 to 2.82, p=0.002); with a greater increase over time in the intervention group compared with the control group, parameter estimate 2.36 (95% CI: 0.79 to 3.94, p=0.03). | <u>Behavioural change in model</u><br><br>Increase in probability of 'always' using the four types of protection by 0.005 (decrease in probability of 'never' using the four types of protection by 0.005).<br><br><u>Calculation</u><br><br>(a) Effect size = 0.049<br>Group X time effect divided by intercept = 2.36 / 48.03 = 0.049<br><br>(b) Change = 0.005<br>baseline model * (1 + effect size) - baseline model = 0.09 * (1 + 0.049) - 0.09 = 0.005 |
| Incremental cost per person (2009 prices) | <u>Cost per person</u><br><br>20 min computer session: £0.50<br>2-3 min counselling: £3<br>Tip-sheets: £0.14<br>90ml bottles of SPF 15: £7<br>Computer terminal and training programme: £1.63<br><br>Total unit cost: £12.27 | <u>Comments and assumptions</u><br><br>20 min computer session. No relevant cost data available. Assumed that using computer software costs 50p/participant.<br>2-3 min counselling. Salary of a physician is 73.39/hr; £3 per session per person (for 3 min).<br>Tip sheets. Assumed development cost for a leaflet: 1 working day at £14 per hour = £112 + printing (1 colour) at £28.20. Total cost (£140.2) divided by recipients (983).<br>Sunscreen. Average cost of broad-spectrum 25SPF sunscreen in the UK is £6/100 ml (Source: Boots) + postage of £1<br>Computer terminal and training programme. Processor + Display + Keyboard + Mouse = £525; Printer Canon i-SENSYS LBP3010 @ £76.91; (Source: Cube). Software cost is unknown, assumed £1000.<br><br>Resource use associated with the research not included. |

**Table A1.6 Multi-component: work-setting setting**

<table>
<tr><td>Reference</td><td colspan="2">Mayer et al (2007)</td></tr>
<tr><td>Description</td><td colspan="2">Population: working age (assumed 21 to 65)<br>Targeted population: assumed 3% (number of outdoor workers in the UK divided by total population in relevant age group)<br>Setting: postal stations<br>Intervention: Provision of protective hats and sunscreen, visual reminders, and brief educational sun safety messages.<br>Comparator: delayed intervention.</td></tr>
<tr><td>Significant effects</td><td><u>Evidence review</u><br><br>a) Postal workers in the intervention group used significantly more sunscreen that the control group at all time periods; group-by-time interaction, p=0.018.<br><br>Baseline (always): Intervention (26.9%), Control (23.5%)<br>3 months: Intervention (39.4%), Control (23.1%), OR 2.78 (95% CI: 2.20 to 3.51)<br>1 year: Intervention (41.6%), Control (28.1%), OR 2.11 (95% CI: 1.68 to 2.65)<br>2 years: Intervention (39.2%), Control (26.3%), OR 2.03 (95% CI: 1.60 to 2.58)<br><br>Note:<br>At 3 year follow-up (control groups had received 1-year intervention) there were no significant differences between intervention and control groups: Intervention (38.3%), Control (34.3%), OR 1.08 (95% CI: 0.85 to 1.36).</td><td><u>Behavioural change in model</u><br><br>Average: Increase in probability of wearing sunscreen 'always' by 0.14 (decrease in probability of 'never' wearing sunscreen by 0.14).<br><br><u>Calculation</u><br><br>(a) Effect size<br>1 year OR: 2.11<br>2 year OR: 2.03<br>Average OR: 2.07<br><br>(b) Change<br>Average: baseline model * effect size - baseline model = 0.13 * 2.07- 0.13 = 0.14</td></tr>
</table>

| | | |
|---|---|---|
| Reference | Mayer et al (2007) | |
| Significant effects | <u>Evidence review</u><br><br>b) The intervention group wore wide-brim hats significantly more often than controls; group interaction OR 2.88 (95% CI: 2.31 to 3.61, p<0.001).<br><br>Baseline (always): Intervention (46.3%), Control (40.1%)<br>3 months: Intervention (67.7%), Control (39.4%), OR 3.13 (95% CI: 2.43 to 4.03)<br>1 year: Intervention (63.6%), Control (40.9%), OR 2.40 (95% CI: 1.87 to 3.09)<br>2 years: Intervention (62.4%), Control (42.0%), OR 2.64 (95% CI: 2.03 to 3.43)<br><br>Notes:<br>At 3 year follow-up the difference remained significant: Intervention (43.8%), Control (33.0%), OR 1.44 (95% CI: 1.12 to 1.85). | <u>Behavioural change in model</u><br><br>Average: Increase in probability of 'always' wearing hat by 0.15 (decrease in probability of 'never' wearing hat by 0.15).<br><br><u>Calculation</u><br><br>(a) Effect size<br>1 year OR: 2.40<br>2 year OR: 2.64<br>3 year OR: 1.44<br>Average OR: 2.16<br><br>(b) Change<br>Average: baseline model * effect size - baseline model = 0.13 * 2.16 - 0.13 = 0.15 |

| Reference | Mayer et al (2007) | |
|---|---|---|
| Incremental cost per person (2009 prices) | Cost per person<br><br>Wide brim hat: £16<br>Sunscreen: £16<br>Posters: £2.8<br>Water bottles: £0.16<br>Marketing products: £12.47<br>5-10 min sun safety messages: £4.37<br>Implementation of intervention: £0.15<br><br>Total unit cost: £52.04 | Comments and assumptions<br><br>Wide brim hat. Source: M&S is £16. Cost of replacement not included. Discounts for replacement hats were offered but there is no info how much and to how many. Replacement hats were not free.<br>Sunscreen. Coppertone Continuous Spray Twin-Pack Sport SPF #30 (cost of refills not included) Source: Amazon. Sunscreen bottles were refilled regularly but there is no info by how much. Bottles were communal (large size) but not everyone used the cream, also perhaps sunscreen was bought in bulk and cheaper than retail price I quote, so we assumed that 12oz of sunscreen per person under the intervention has been used.<br>Posters. It is assumed that 1 marketing product was given to each participant. Six Posters were placed in postal station break rooms (35) and updated monthly over 2 years: total of 840 posters. Poster development cost is not accounted for. Cost of printing is 4.25/poster for A1 size printing of 200+ copies. Source: Zip-posters. Cost of poster design is not included. Total cost of posters is 3570, cost of posters per participant = 3570/1257 = 2.8.<br>Water bottles. It is assumed that water bottles were distributed only once. 12 pack of highland still water at £3.09. Source: Tesco. (www.tesco.com)<br>Marketing products. Mouse pad (£3.49), key ring (£2.99), magnetic clip (£5.99). Source: Visit Print.<br>5-10 min sun safety messages. It has been assumed that a researcher who is paid an hourly salary of £14 (£25,000 annual income) is responsible for developing and delivering messages. 1 hour was allocated per trip to the postal station to deliver the message and return. Total of 6 hours *35 stations = 210 hours in 2 years. 4 days were allocated for developing educational messages and visual aids and 20£ were allocated per return trip to the postal site. Total hours worked on the project: 8*(4days)+ 210 hours = 242 hrs. Cost: 242*£14=£3,388. Transportation costs: 210*£10=2,100£. Total cost £2,100+£3,388=£5,488.<br>Additional implementation costs include visiting postal stations to distribute hats, water, sunscreens, and merchandise. We estimated that 35 stations can be visited in 2 days. [Standard courier delivers 20-40 parcels/day]. Courier salary is £6/hr, total cost £6*16 hours = £96. We assumed that postal stations are within 5 miles from each other and rate per mile is £0.40 (to compensate for fuel and vehicle wear), then 175 miles will be travelled to distribute merchandise, plus additional ~30 miles/day to return to original position. Total cost of transport 235miles * £0.40 = £94. |

# 8.0 Appendix 2: Sensitivity analysis

This appendix presents the results of the sensitivity analysis. Figures A2.1 to A2.64 illustrate the relationship between key parameters and the estimated cost per QALY. For the purpose of enabling interpretation, a brief description is provided for the figures relating to provision of shade. The same logic applies to multi-component interventions.

## Provision of shade

Figure A2.1 illustrates the relationship between the change in behaviour due to the intervention and the cost per QALY in 2009 prices. The negative slope indicates that as the increase in the probability of using protection grows, the benefits of the intervention are higher and thus the cost per QALY decreases. However, for the whole range considered, the cost per QALY remains far above a £20,000 threshold.

**Figure A2.1. Sensitivity of cost per QALY to change in behaviour due to intervention**


Figure A2.2 illustrates the relationship between the unit cost of delivering the intervention and the cost per QALY in 2009 prices. The positive slope indicates that as the unit cost increases, the cost per QALY also increases. For the whole range considered, the cost per QALY remains far above a £20,000 threshold.

**Figure A2.2. Sensitivity of cost per QALY to cost of intervention**

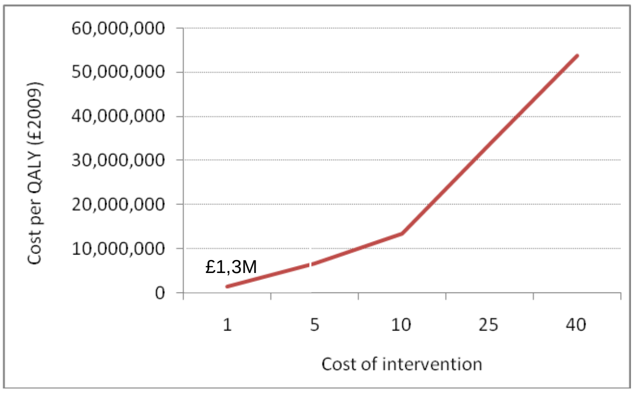


Figure A2.3 illustrates the relationship between the probability of going on holidays to sunnier climates and the cost per QALY in 2009 prices. The baseline value used in the model was 0.60. The negative slope indicates that as the probability of going on holiday increases, the benefits of the intervention are higher and thus the cost per QALY decreases. However, even if the probability of going on holiday to sunnier climate increased to 0.90, the cost per QALY would remain far above a £20,000 threshold.

**Figure A2.3. Sensitivity of cost per QALY to probability of going on holidays to sunnier climates**

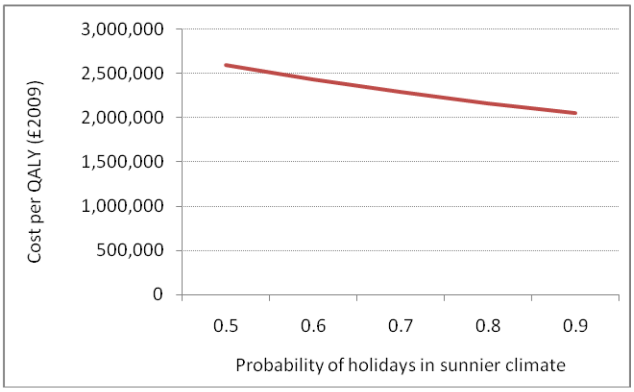



Figure A2.4 illustrates the relationship between the SED threshold for experiencing sunburn and the cost per QALY in 2009 prices. The model was run using a threshold of 5 SED. The curve indicates that even if the sunburn threshold was lower –e.g. 2 or 3 SED– the cost per QALY would remain far above £20,000.

**Figure A2.4. Sensitivity of cost per QALY to SED threshold**

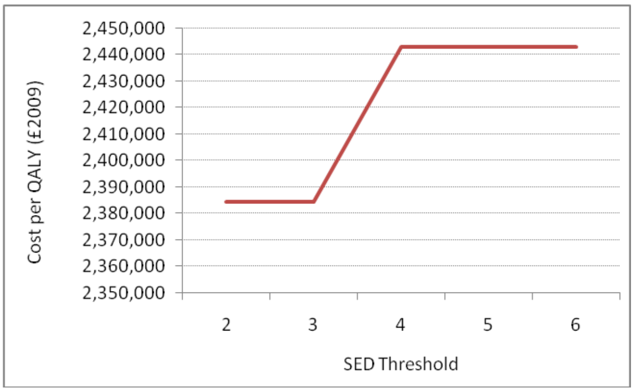


Figure A2.5 illustrates the relationship between the number of sunburns per period and the cost per QALY in 2009 prices. The model was run for a baseline value of one sunburn per period. The negative slope indicates that as the number of sunburns experienced during one period increases, the benefits of the intervention are higher and thus the cost per QALY decreases. However, the cost per QALY remains far above a £20,000 even when up to five sunburns are allowed.

**Figure A2.5. Sensitivity of cost per QALY to number of sunburns per period**

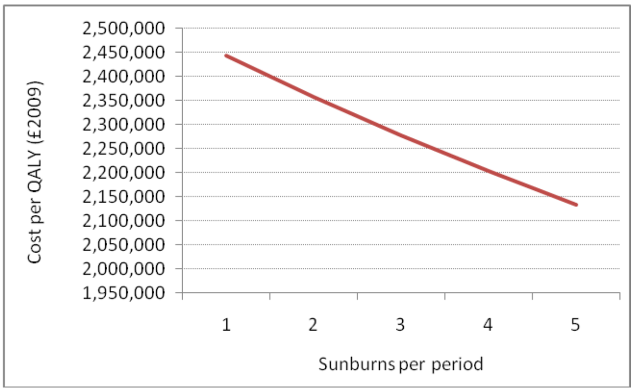



Figure A2.6 illustrates the relationship between the QALY loss associated with NMSC and the cost per QALY in 2009 prices. The baseline QALY loss value used in the model was 0.028. For the sensitivity analysis values were allowed to vary within the minimum-maximum interval reported in Freedberg et al (1999). The negative slope indicates that as the QALY loss increases, the benefits of the intervention are higher and thus the cost per QALY decreases. However, the cost per QALY remains far above a £20,000 throughout the range considered.

**Figure A2.6. Sensitivity of cost per QALY to NMSC QALY loss**

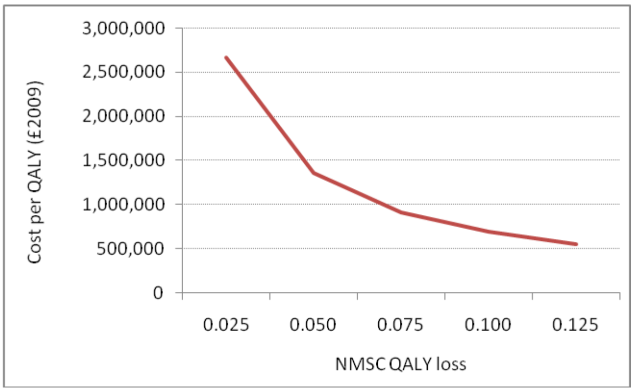


Figure A2.7 illustrates the relationship between the QALY loss associated with MM and the cost per QALY in 2009 prices. The baseline QALY loss value used in the model was 6.09. For the sensitivity analysis values were allowed to vary within the minimum-maximum interval reported in Freedberg et al (1999). The negative slope indicates that as the QALY loss increases, the benefits of the intervention are higher and thus the cost per QALY decreases. However, the cost per QALY remains far above a £20,000 throughout the range considered.

**Figure A2.7. Sensitivity of cost per QALY to MM QALY loss**

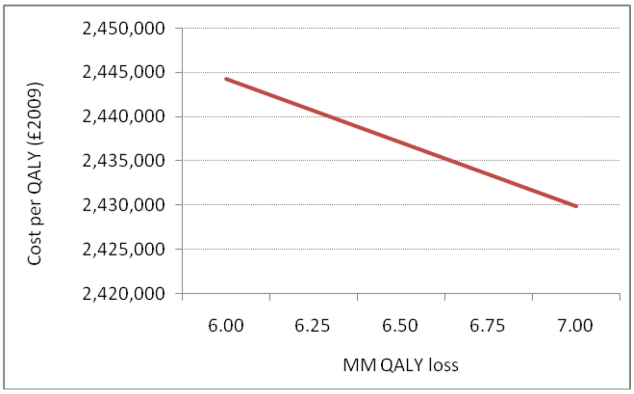
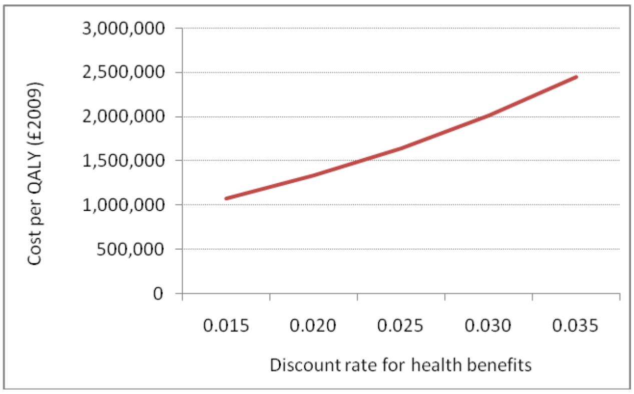



Figure A2.8 illustrates the relationship between the rate used to discount health benefits and the cost per QALY in 2009 prices. The positive slope indicates that as the discount rate increases, the present value of the benefits of the intervention is smaller and thus the cost per QALY increases. The results indicate that even for a 1.5 per cent discount rate for health benefits the cost per QALY remains far above a £20,000.

**Figure A2.8. Sensitivity of cost per QALY to discount rate for health benefits**



## Multi-component: beaches and pools

**Figure A2.9. Sensitivity of cost per QALY to change in behaviour due to intervention**

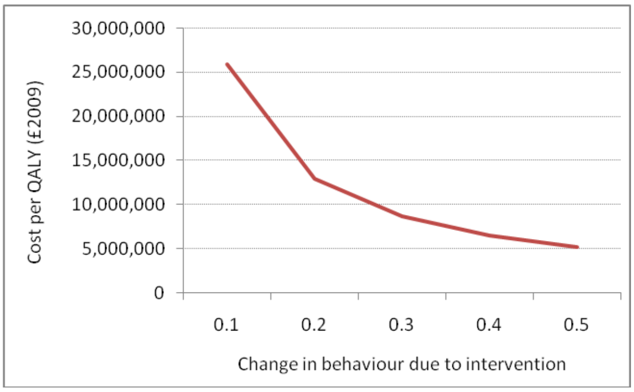



**Figure A2.10. Sensitivity of cost per QALY to cost of intervention**

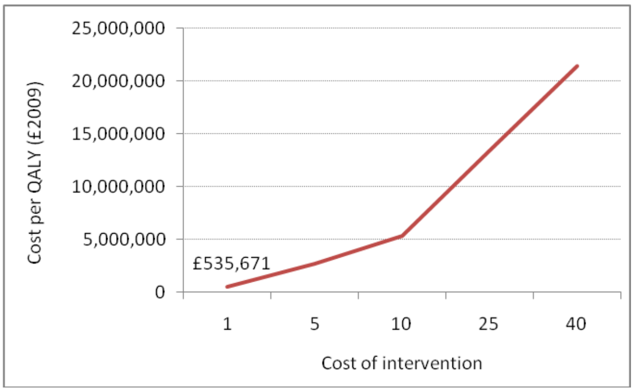



**Figure A2.11. Sensitivity of cost per QALY to probability of going on holidays to sunnier climates**

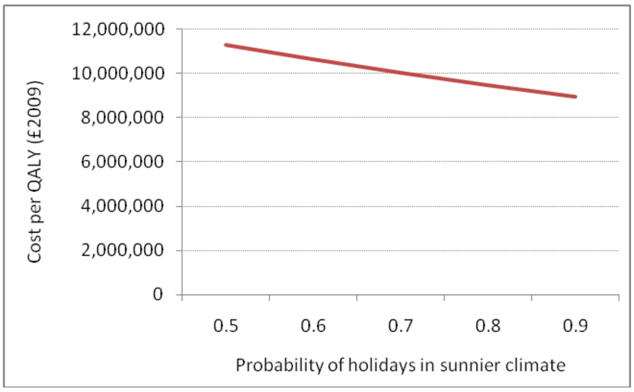


**Figure A2.12. Sensitivity of cost per QALY to SED threshold**

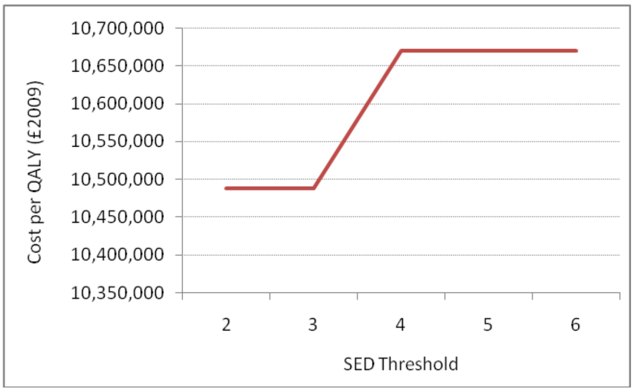



**Figure A2.13. Sensitivity of cost per QALY to number of sunburns per period**

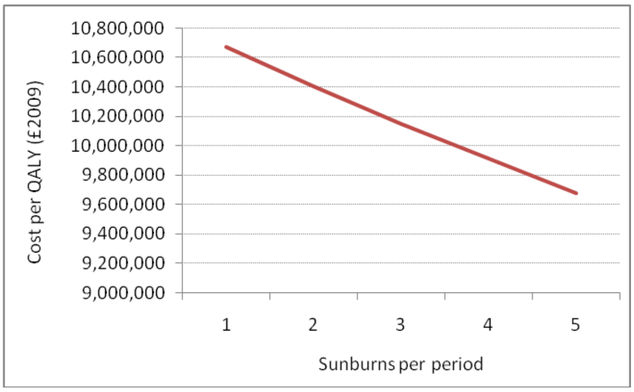



**Figure A2.14. Sensitivity of cost per QALY to NMSC QALY loss**

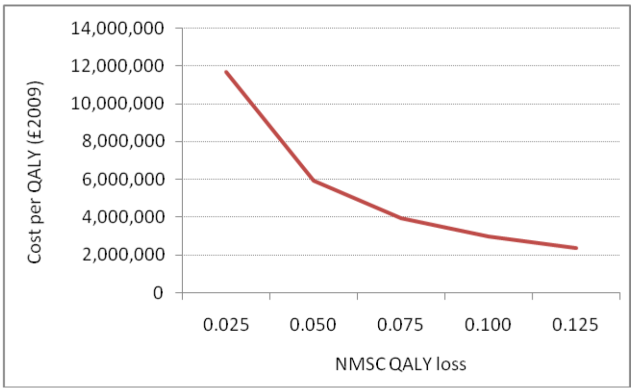


**Figure A2.15. Sensitivity of cost per QALY to MM QALY loss**

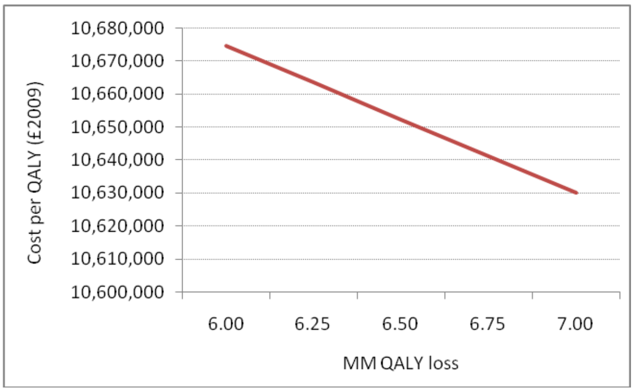
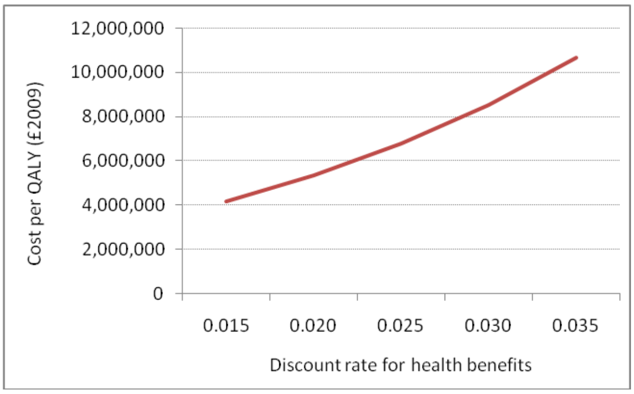



**Figure A2.16. Sensitivity of cost per QALY to discount rate for health benefits**




## Multi-component: community setting – effect on sunscreen use

**Figure A2.17. Sensitivity of cost per QALY to change in behaviour due to intervention**

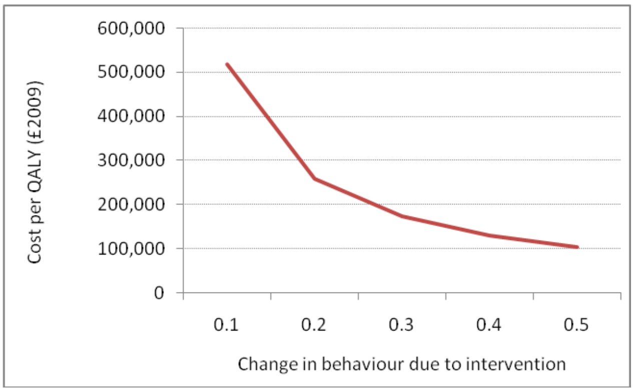


**Figure A2.18. Sensitivity of cost per QALY to cost of intervention**

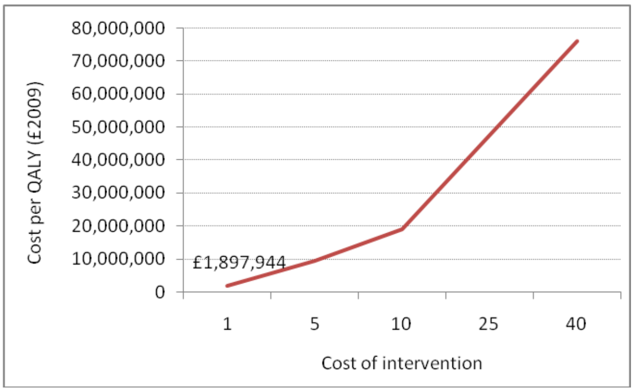



**Figure A2.19. Sensitivity of cost per QALY to probability of going on holidays to sunnier climates**

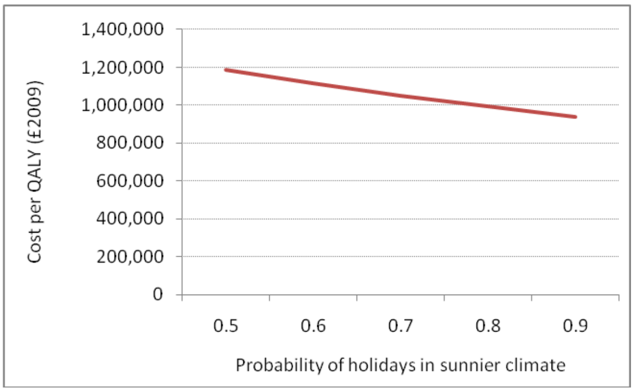



**Figure A2.20. Sensitivity of cost per QALY to SED threshold**

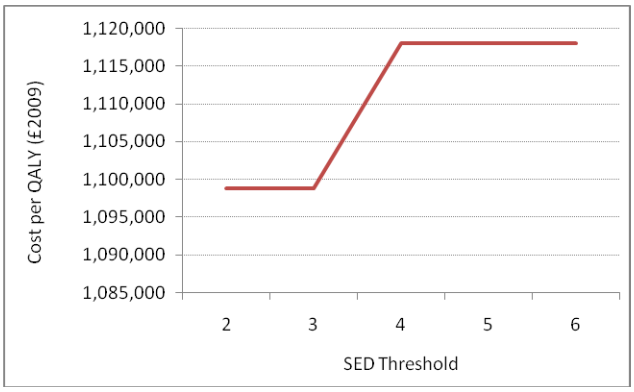


**Figure A2.21. Sensitivity of cost per QALY to number of sunburns per period**

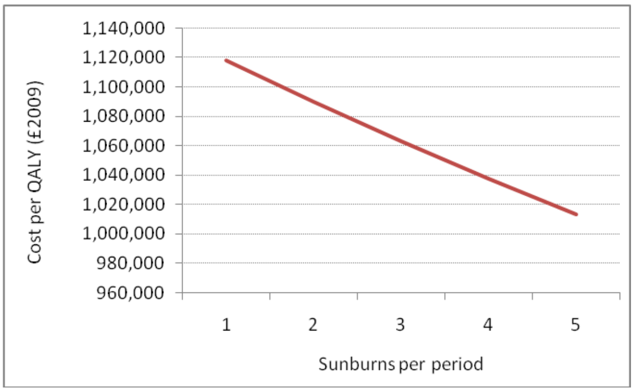



**Figure A2.22. Sensitivity of cost per QALY to MM QALY loss**

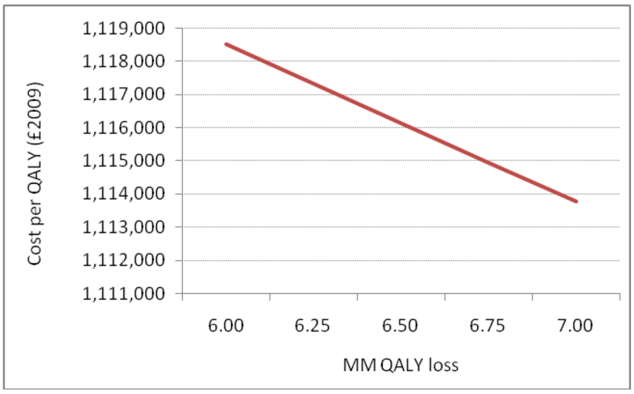
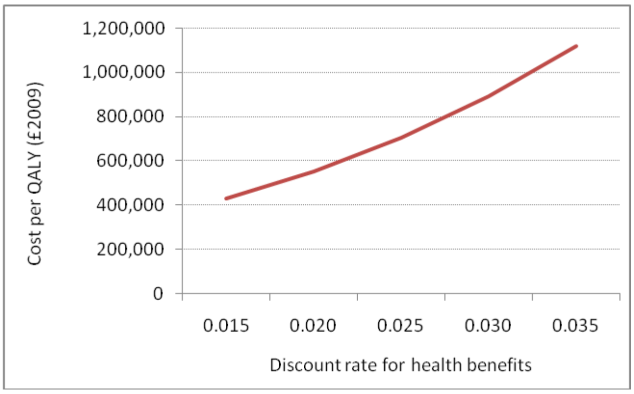



**Figure A2.23. Sensitivity of cost per QALY to discount rate for health benefits**



## Multi-component: community setting – effect on all types of protection

**Figure A2.24. Sensitivity of cost per QALY to change in behaviour due to intervention**

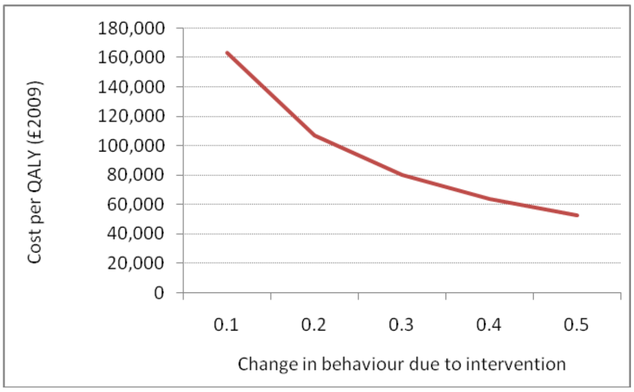



**Figure A2.25. Sensitivity of cost per QALY to cost of intervention**

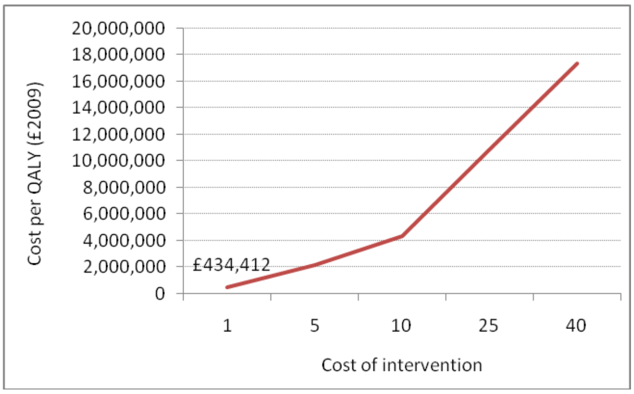



**Figure A2.26. Sensitivity of cost per QALY to probability of going on holidays to sunnier climates**

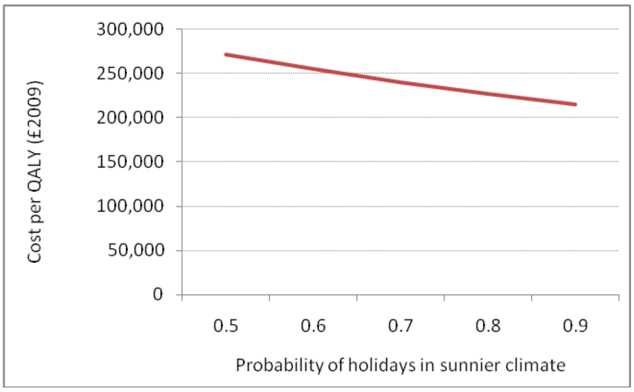


**Figure A2.27. Sensitivity of cost per QALY to SED threshold**

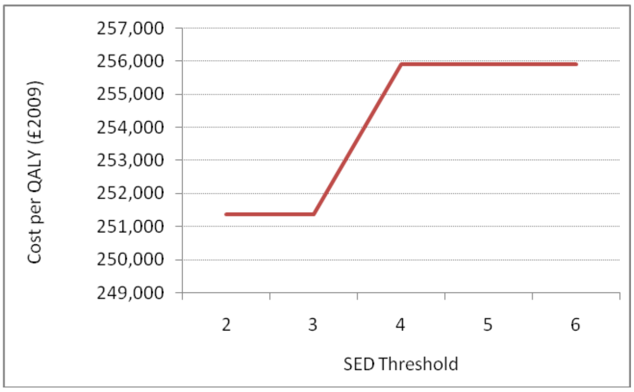



**Figure A2.28. Sensitivity of cost per QALY to number of sunburns per period**

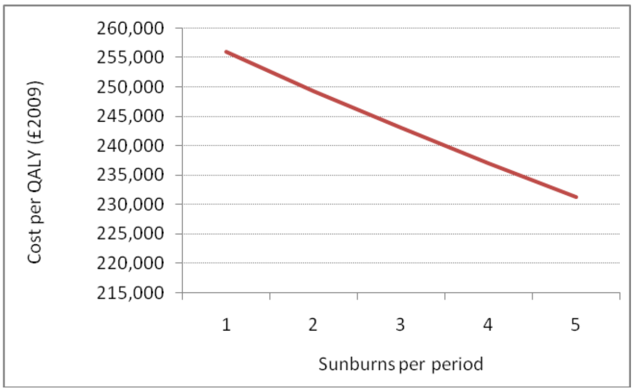



**Figure A2.29. Sensitivity of cost per QALY to NMSC QALY loss**

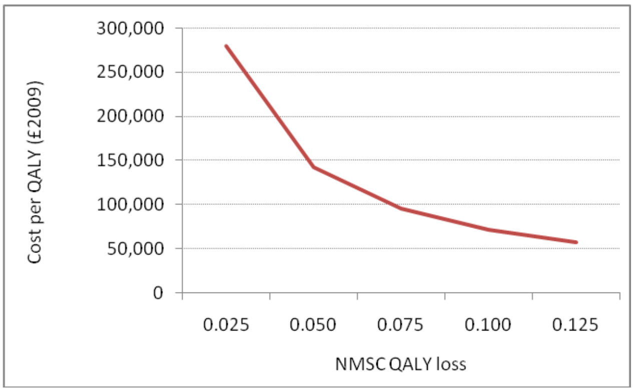


**Figure A2.30. Sensitivity of cost per QALY to MM QALY loss**

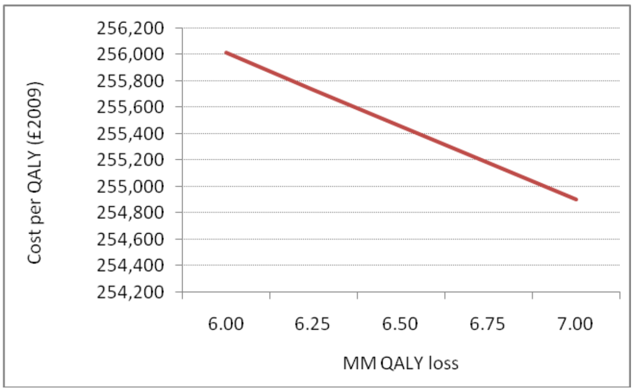
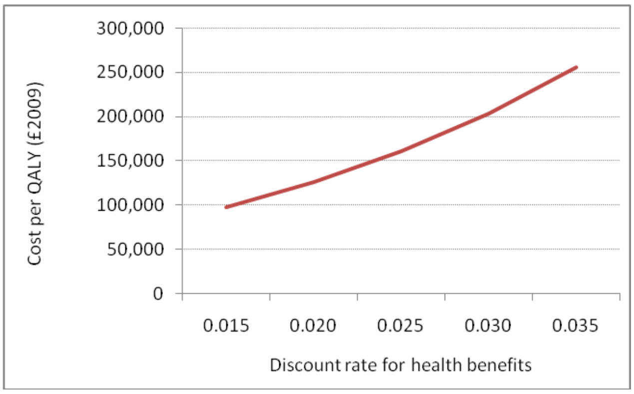



**Figure A2.31. Sensitivity of cost per QALY to discount rate for health benefits**




## Multi-component: education

**Figure A2.32. Sensitivity of cost per QALY to change in behaviour due to intervention**

**Figure A2.33. Sensitivity of cost per QALY to cost of intervention**

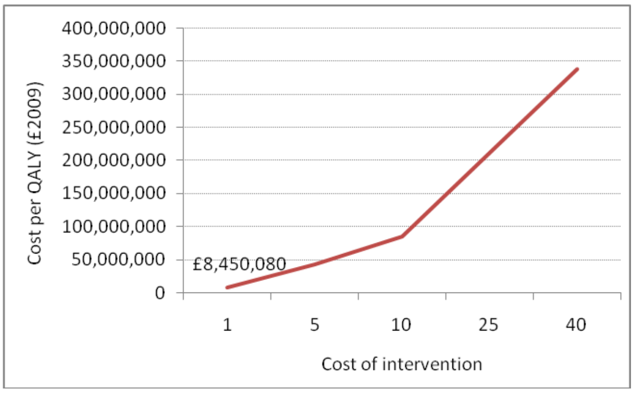



**Figure A2.34. Sensitivity of cost per QALY to probability of going on holidays to sunnier climates**

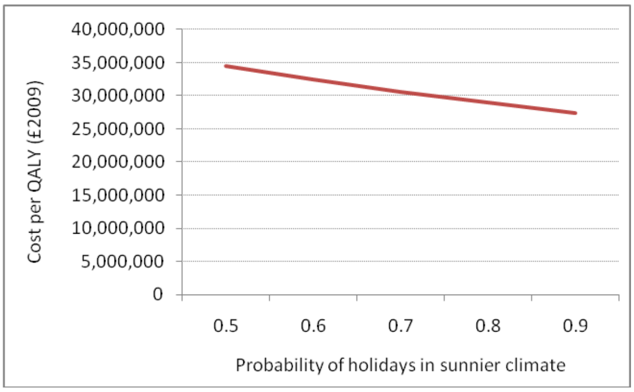



**Figure A2.35. Sensitivity of cost per QALY to SED threshold**

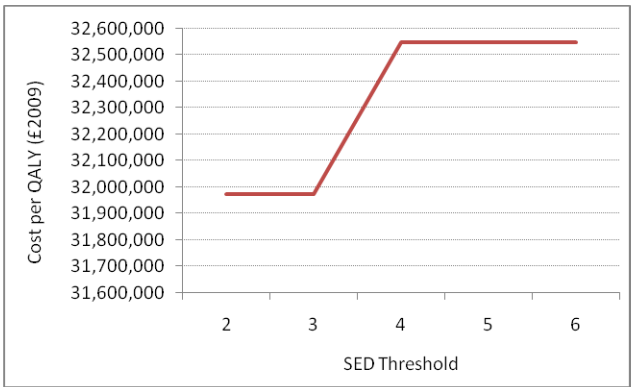


**Figure A2.36. Sensitivity of cost per QALY to number of sunburns per period**

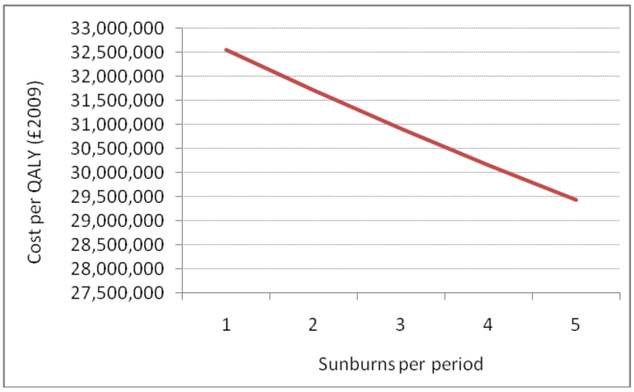



**Figure A2.37. Sensitivity of cost per QALY to NMSC QALY loss**

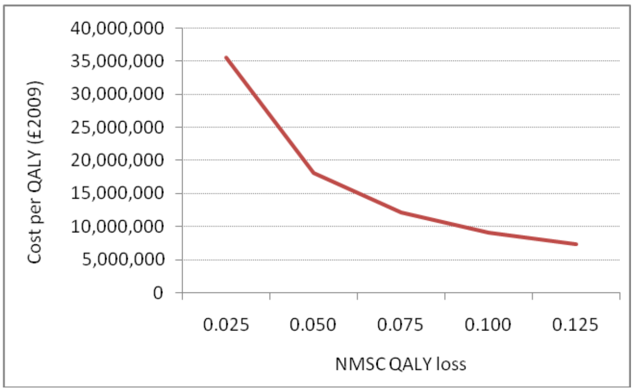



**Figure A2.38. Sensitivity of cost per QALY to MM QALY loss**

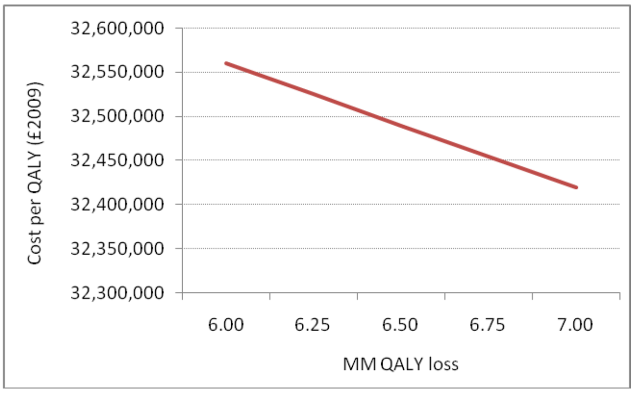
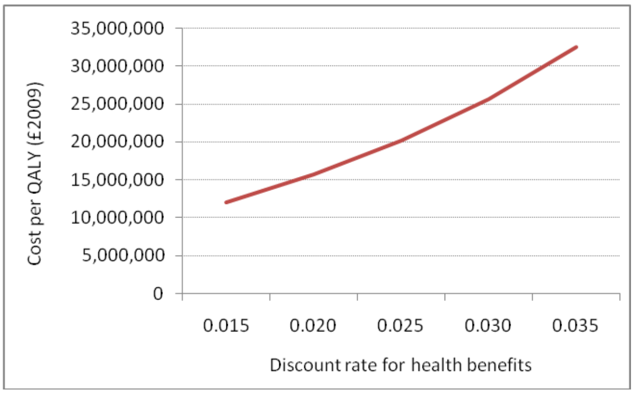


**Figure A2.39. Sensitivity of cost per QALY to discount rate for health benefits**




## Multi-component: health care – effect on sunscreen use

**Figure A2.40. Sensitivity of cost per QALY to change in behaviour due to intervention**


**Figure A2.41. Sensitivity of cost per QALY to cost of intervention**

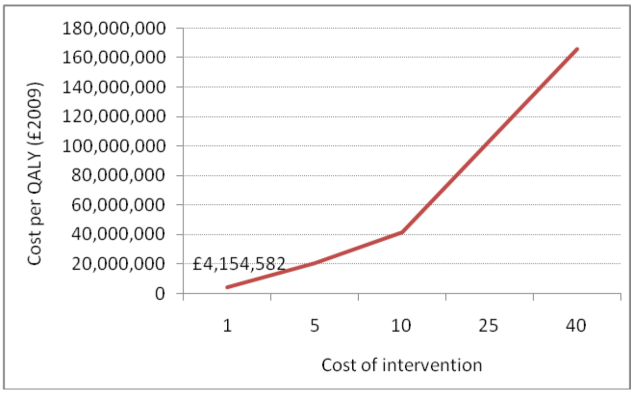


**Figure A2.42. Sensitivity of cost per QALY to probability of going on holidays to sunnier climates**

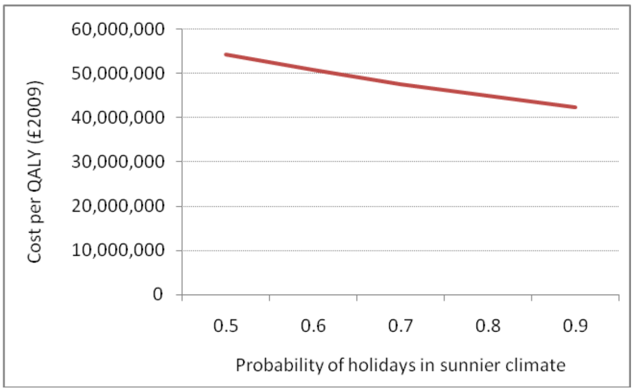



**Figure A2.43. Sensitivity of cost per QALY to SED threshold**

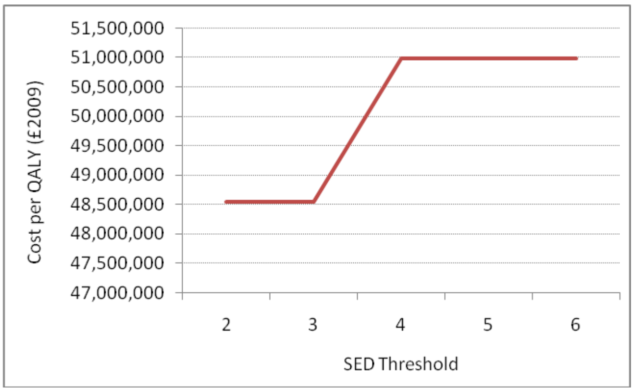



**Figure A2.44. Sensitivity of cost per QALY to number of sunburns per period**

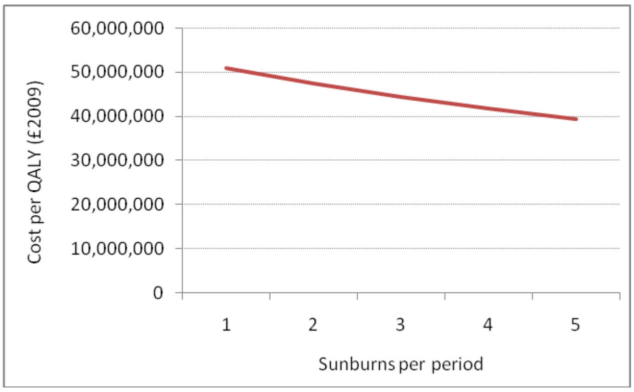


**Figure A2.45. Sensitivity of cost per QALY to NMSC QALY loss**

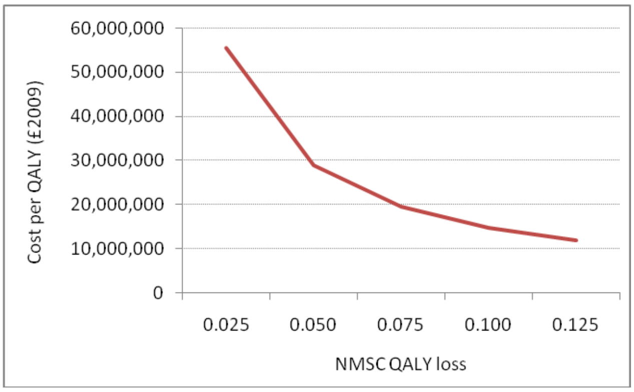



**Figure A2.46. Sensitivity of cost per QALY to MM QALY loss**

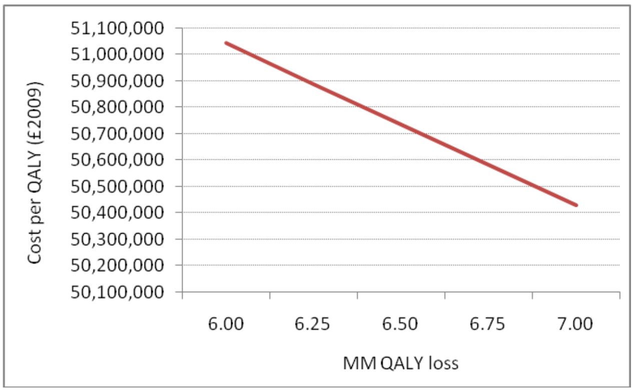
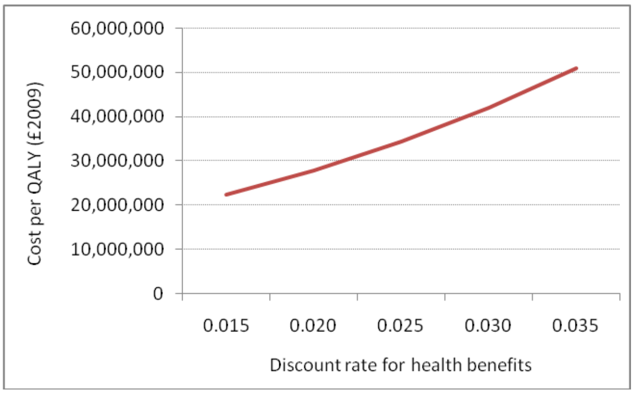



**Figure A2.47. Sensitivity of cost per QALY to discount rate for health benefits**



### Multi-component: healthcare setting – effect on all four types of protection

**Figure A2.48. Sensitivity of cost per QALY to change in behaviour due to intervention**


**Figure A2.49. Sensitivity of cost per QALY to cost of intervention**

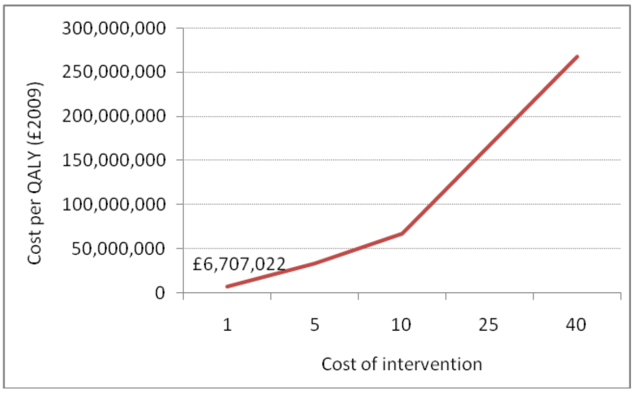



**Figure A2.50. Sensitivity of cost per QALY to probability of going on holidays to sunnier climates**

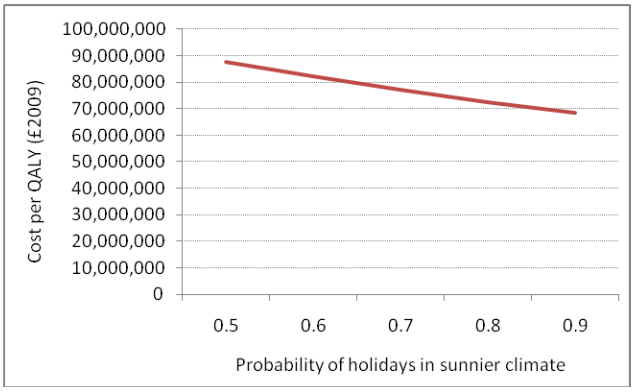


**Figure A2.51. Sensitivity of cost per QALY to SED threshold**

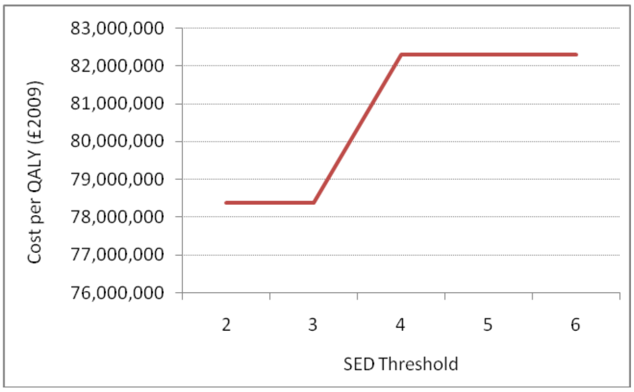



**Figure A2.52. Sensitivity of cost per QALY to number of sunburns per period**

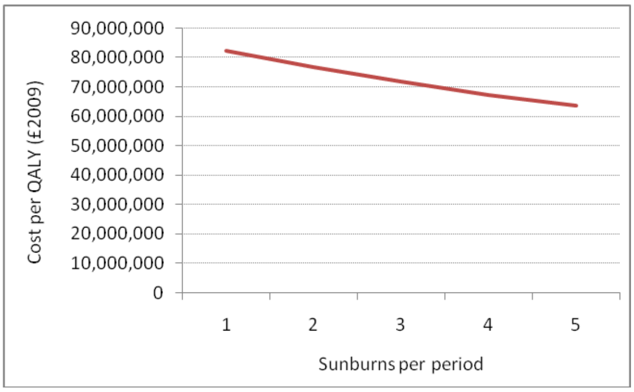



**Figure A2.53. Sensitivity of cost per QALY to NMSC QALY loss**

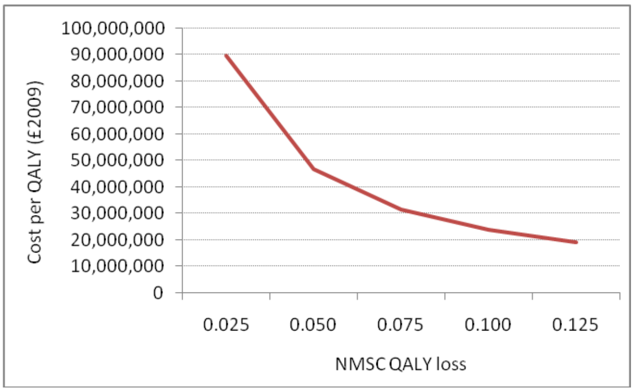


**Figure A2.54. Sensitivity of cost per QALY to MM QALY loss**

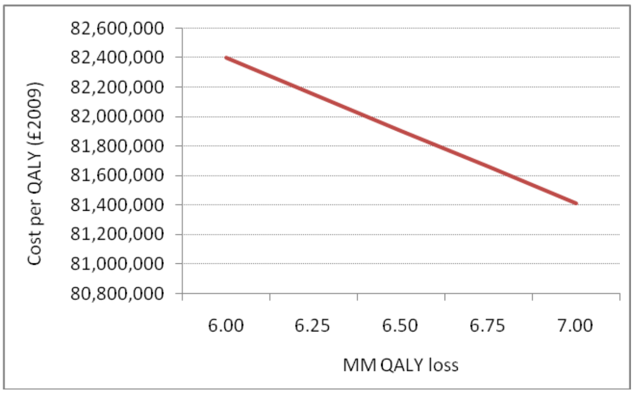
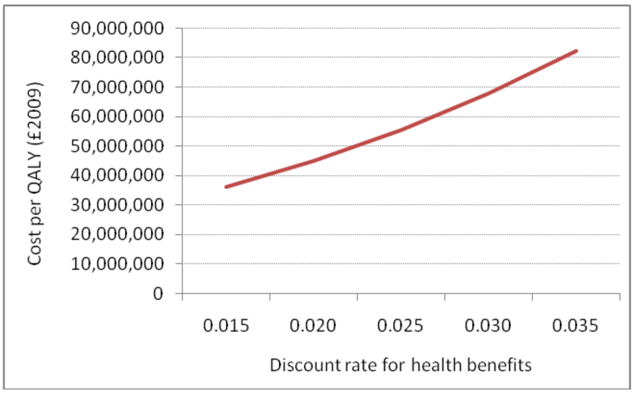



**Figure A2.55. Sensitivity of cost per QALY to discount rate for health benefits**




## Multi-component: work setting

**Figure A2.56. Sensitivity of cost per QALY to change in behaviour due to intervention**

**Figure A2.57. Sensitivity of cost per QALY to cost of intervention**

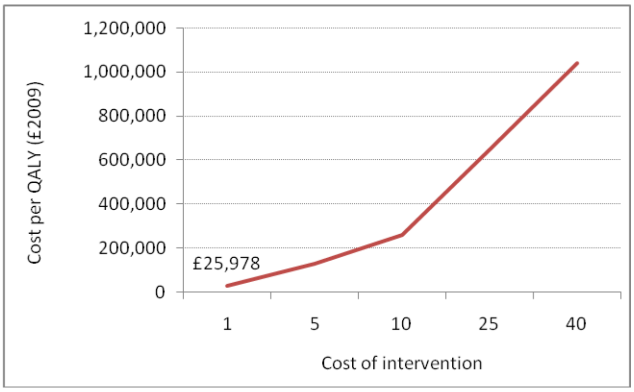



**Figure A2.58. Sensitivity of cost per QALY to probability of going on holidays to sunnier climates**

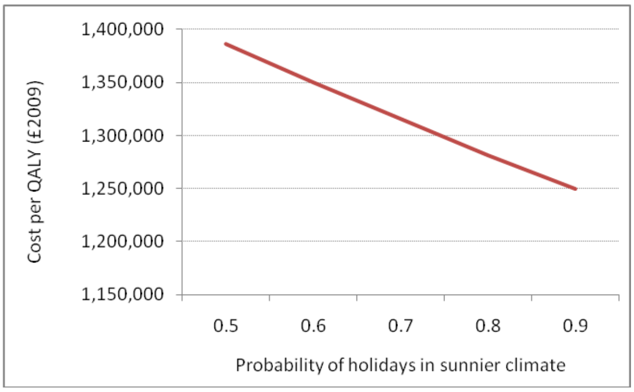



**Figure A2.59. Sensitivity of cost per QALY to hours of occupational outdoor exposure**

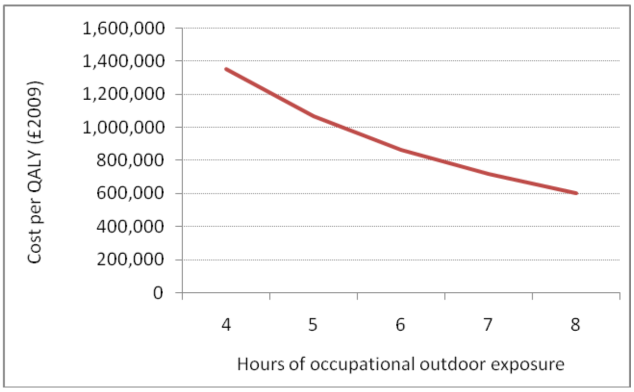


**Figure A2.60. Sensitivity of cost per QALY to SED threshold**

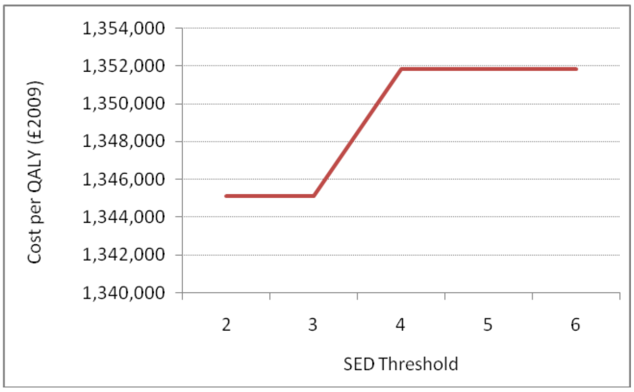



**Figure A2.61. Sensitivity of cost per QALY to number of sunburns per period**

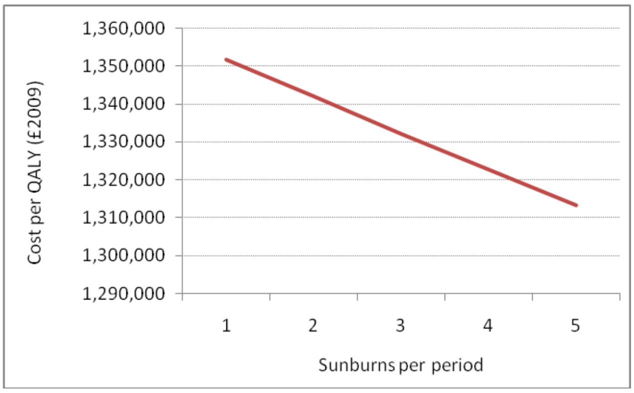



**Figure A2.62. Sensitivity of cost per QALY to NMSC QALY loss**

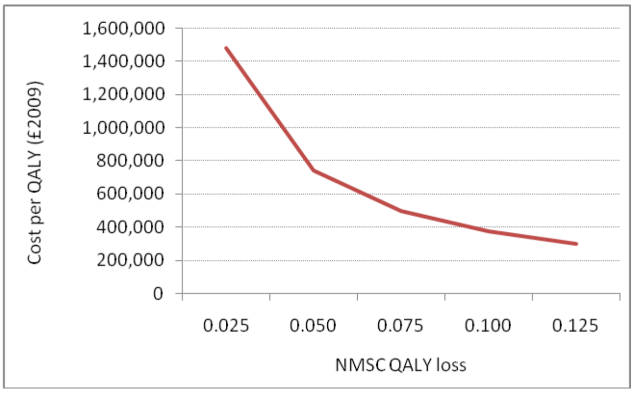


**Figure A2.63. Sensitivity of cost per QALY to MM QALY loss**

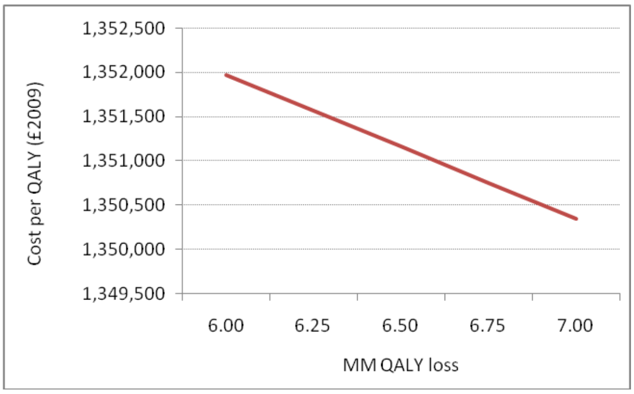
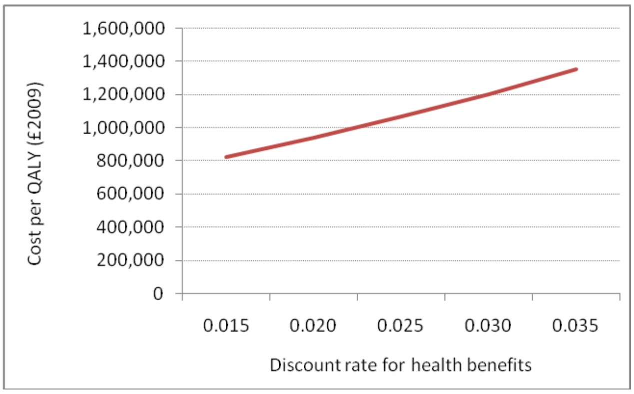



**Figure A2.64. Sensitivity of cost per QALY to discount rate for health benefits**



# 9.0 Appendix 3: Comparison of phase 1 and phase 2 approaches

**Table A3.1. Comparison of phase 1 and phase 2 approaches**

| | Phase1 | Phase 2 | Comments |
|---|---|---|---|
| Cost of intervention | Turrisi (2004) = £0.90<br><br>Buller (1994) = £9.07<br><br>Jackson (2006) = £2.115 | Dobbinson et al (2009) = £1.82<br><br>Mayer et al (1997) = £19.92<br><br>Dietrich et al (2000) = £0.59<br><br>Bauer et al (2005) = £3.85<br><br>Norman et al (2007) = £12.27<br><br>Mayer et al (2007) = £52.04 | Interventions modelled in Phase 2 are generally more expensive than those in Phase 1. This is possibly due to the fact that most interventions in Phase 2 are multi-component. |
| Effect sizes | The effect sizes are measured in various different scales and cannot be compared across interventions (e.g. frequency of sunburn; frequency of different types of protection in a scale of 1 to 3; frequency of protection in a 1 to 7 scale). It is not possible therefore to assess if interventions modelled in Phase 1 had greater effect than those modelled in Phase 2. Such a comparison would require recalculating effect sizes for Phase 1, applying the approach adopted in Phase 2. | | |
| Behaviour change to lifetime sun exposure | The effect of interventions is converted into reduced lifetime exposure. Different approaches apply to every intervention. | The effect of interventions is converted into frequency of behaviour -i.e. always, sometimes or never use of four types of protection (sunscreen, shade, protective clothing, and hat). The model then converts changes in frequency of protection into reduced lifetime exposure and reduced number of sunburns. The method takes into account: protection offered by each type of protection; body parts protected by each type of protection; hours spent outdoors in each month of the year and during holiday period; duration and location of holidays (UK or Florida); ambient conditions in UK and Florida. | Phase 2 approach allows:<br><br>* Comparing effects across interventions.<br>* Converting protection behaviour into lifetime exposure using parameter values for the UK population.<br>* Identifying potential sources for under/over estimation. |

| | Phase1 | Phase 2 | Comments |
|---|---|---|---|
| Maintenance effect | Adjustment of change in lifetime exposure for maintenance effect: assumes that behaviour change lasts for 2.75 years and that 23% of lifetime exposure occurs before the age of 18. This is equivalent to multiplying change in lifetime exposure by 0.035. | Maintenance effect is not imposed but modelled through the behavioural part of the model -i.e. via frequency of protection and transition probabilities between the protected and unprotected states. The model allows the effect to be maintained until the end of each lifetime period (childhood; adolescence; and adulthood). | Phase 2 approach to modelling maintenance of effect is based on individual's behaviours in terms of frequency of protection. |
| Lifetime exposure to incidence of MM | Reduced lifetime exposure is converted into relative reduction in the incidence of MM, based on the relationship between lifetime exposure and melanoma incidence in Australia as reported by Carter et al (1999). | The model estimates reduced number of sunburns based on individuals sun protection behaviour, as described above. Reduced number of sunburns is converted into reduced cases of melanoma based on the odds ratio of melanoma for five additional sunburns. The odds ratio was obtained from a meta-analysis of 26 studies evaluation the relationship between melanoma and sunburn (Dennis et al 2008). | Phase 2 takes into account evidence showing that incidence of melanoma is more strongly related to intermittent sun exposure than to amount of sun exposure. Sunburn is thought to be an indicator of high levels of intermittent sun exposure (Armstrong and Kricker 2001) and used in Phase 2 to estimate the incidence of melanoma. |
| Lifetime exposure to incidence of NMSC | Incidence of NMSC is assumed ten times higher than incidence of MM. | Incidence of NMSC is estimated using a sun dose-risk relationship derived from multivariate analysis of epidemiological NMSC data (Diffey, 1992; NRPB, 1995). Sun dose (annual and lifetime) was estimated based on UK data for sun protection behaviour, under UK behaviour and ambient conditions). | Phase 2 makes use of established relationships between sun exposure and NMSC to estimate reduced incidence of BCC and SCC. |
| QALYs lost<br>QALYs lost | NMSC = 0.028<br><br>Equivalent to 10 days lost. | NMSC = 0.028<br><br>Equivalent to 10 days lost. | Same figures used in Phase 1 and Phase 2. |
| | MM = 5.98<br><br>Equivalent to 0.466 QALYs lost for non-fatal cases and 22.5 QALYs lost for fatal cases. Fatal cases account for 25% of MM cases. | MM = 6.09<br><br>Equivalent to 0.466 QALYs lost for non-fatal cases and 23 QALYs (0.466 + 22.5) lost for fatal cases. Fatal cases account for 25% of MM cases. | Phase 2 considers QALYs loss for fatal cases should include mortality as well as morbidity loss. In Phase 1, only mortality loss was included. |

| | Phase1 | Phase 2 | Comments |
|---|---|---|---|
| Cost savings | NMSC = £1,339 (£2008)<br><br>Based on Morris et al (2009) | NMSC = £1,367 (£2009)<br><br>Based on Morris et al (2009) | Same source (Morris et al 2009); however it has not been possible to track down calculations done in Phase 1. Phase 2 calculates total cost of disease for the NHS based on Morris et al (2009) and inflation rates (2002 to 2009). |
| | MM = £2,945 (£2008)<br><br>Based on Morris et al (2009) | MM = £2,593 (£2009)<br><br>Based on Morris et al (2009) | |

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