PROVIDING PUBLIC HEALTH INFORMATION TO PREVENT SKIN CANCER

Modelling strategies for primary prevention of skin cancer

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West Midlands Health Technology Assessment Collaboration

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WMHTAC work in close collaboration with the Peninsula Technology Appraisal Group (PenTAG) with respect to providing support to the CPHE.

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Executive Summary

The National Institute for Health and Clinical Excellence (NICE) has been asked by the Department of Health to develop guidance on public health interventions for the NHS and local authorities aimed at preventing skin cancer, specifically: the provision of information, physical changes to the environment and the supply of sun protection resources. This referral is being undertaken in several phases and the current phase focuses on provision of information. Physical changes to the environment and the supply of sun protection resources will be covered in later phases.

The evidence review by Malottki et al (2009) covers the effectiveness and cost-effectiveness evidence on the provision of information to prevent skin cancer. A second evidence review focuses on qualitative evidence related to information provision by Garside et al (2009). In the absence of existing economic analysis that is directly applicable in a UK context, this report outlines de novo economic analyses on the cost-effectiveness of methods of information provision, and is designed to accompany the review by Malottki et al (2009).

Because of the variety of different populations, settings, interventions, and outcomes reported in the effectiveness studies, no attempt at numerical synthesis of the different studies was made. Instead, this economic analysis was based on a range of separate effectiveness studies.

The method used for economic analysis was a "chaining" process whereby intermediate outcomes reported in individual effectiveness studies were converted into estimates of reduction in lifetime exposure to ultraviolet light, then into cases of skin cancer prevented (both malignant melanoma and non-melanoma skin cancer), and finally into quality adjusted life years gained. Costs saved from cases prevented were subtracted from the cost of running the programme, and an incremental cost-effectiveness ratio calculated. This was subjected to extensive sensitivity analysis. Studies were selected for analysis where it was felt that there was an outcome that could be taken through the chaining process.

For some other studies, it was not possible to complete the chaining process but it was possible to give a reasonable estimate of the cost per participant. These studies were included in a threshold analysis, showing the change in background exposure to ultraviolet light that would be necessary to make the intervention cost saving, or to be cost-effective at thresholds of £20,000/QALY and £30,000/QALY.

In line with the requirements of NICE, the costing perspective was public sector, and future costs and outcomes were discounted at an annual rate of 3.5% to the time of the intervention. No attempt was made to assess the harmful effects of reduced exposure to sunlight.

In view of the many assumptions that were necessary in order to complete the economic analysis, the results should be interpreted with caution, and this report should largely be taken as illustrative of the methods that can be used to perform economic analysis for this type of intervention.

In relation to a UK population, the results suggest that, if a reasonably inexpensive intervention can achieve equivalent effectiveness in terms of behaviour change to those carried out in sunnier climates, then such an intervention is likely to be cost-effective in terms of the benefits from reduced skin cancer. However, there is considerable uncertainty in these results, and, in view of the large number of participants required to achieve a gain of a small number of quality adjusted life years, this conclusion could easily be upset by including a realistic measure of the harms.

The analysis in this report strongly suggests that, if an intervention consisting of information provision is to be considered for use in a UK context, further research is necessary. Such research should consist of two parts. First, there is a need for primary studies which assess behavioural change through measures that are suitable for economic analysis. Second, uncertainties in the process of estimating final outcomes from short-term behavioural change need to be resolved.

1. Introduction

The National Institute for Health and Clinical Excellence (NICE) has been asked by the Department of Health (DH) to develop guidance on public health interventions for the NHS and local authorities aimed at preventing skin cancer, specifically: the provision of information, physical changes to the environment and the supply of sun protection resources. This referral is being undertaken in several phases and the current phase focuses on provision of information. Physical changes to the environment and the supply of sun protection resources will be covered in later phases.

The evidence review by Malottki et al (2009) covers the effectiveness and cost-effectiveness evidence on the provision of information to prevent skin cancer. A second evidence review focuses on qualitative evidence related to information provision by Garside et al (2009). This report outlines de novo economic analyses on the cost-effectiveness of methods of information provision, and is designed to accompany the review by Malottki et al (2009).

As was shown in the Malottki et al (2009) review, there is very little evidence of the effectiveness or cost-effectiveness of information resource interventions aimed at primary prevention of skin cancer that is directly applicable to a UK context. In particular, no cost-effectiveness study of relevance to a UK context was found. Accordingly, some new modelling is necessary.

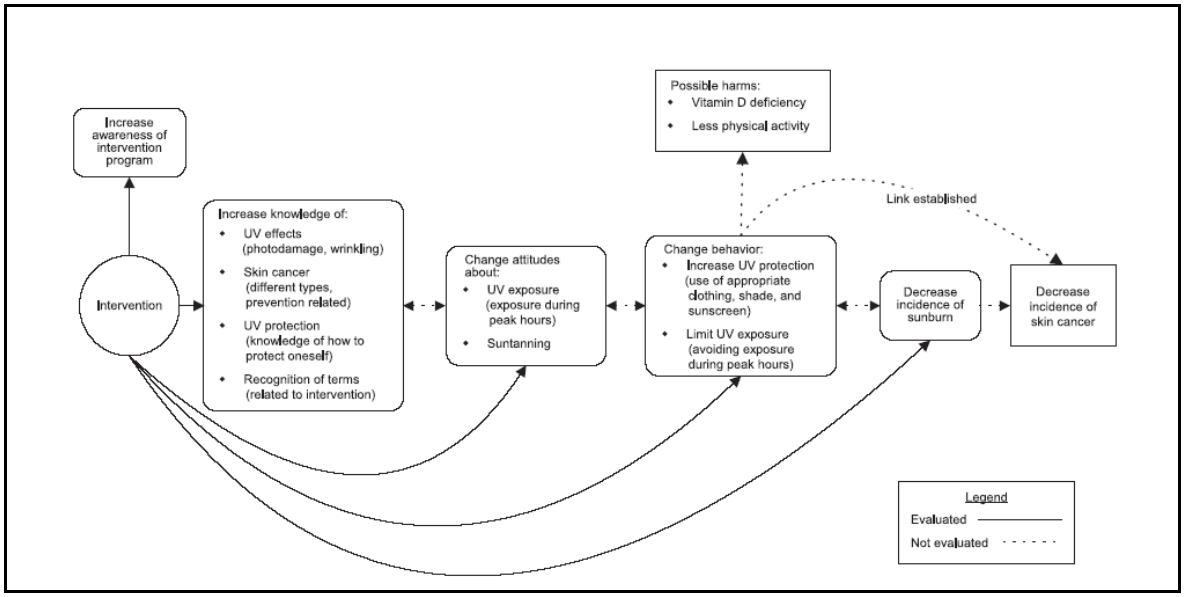
The next best thing to a UK study is one in which an intervention was carried out in a non-UK setting, but the effectiveness results can be transferred to the UK and UK costs applied. In the field of technology assessment, this is generally a reasonable thing to do. For a drug, it is likely that an appropriate summary statistic, for example relative risk, hazard ratio, or odds ratio, can be expected to be stable between (say) Arizona or Australia and the UK.

However, for information provision aimed at primary prevention of skin cancer, it is not necessarily reasonable to assume that effectiveness is directly transferable in the

same way. It is in principle possible to consider the relative risk of skin cancer from a study carried out in Arizona or Australia, and apply it to the background risk appropriate to the UK. However, an important part of the intervention is to reduce risk taking behaviour. This requires understanding and acceptance of the importance of the problem. In a much less sunny climate, it cannot be assumed that the same intervention would be equally effective at reducing risk taking behaviour. The best that can be done, in the absence of direct evidence of the effects of the intervention in a UK context, is to model a range of assumptions and assess the cost-effectiveness of the intervention across that range of assumptions.

It should also be noted that there is potential harm in reducing exposure to direct sunlight as a result of vitamin D deficiency.

Figure 1 Outcomes from interventions to prevent skin cancer



Taken from: Saraiya M., et al. Interventions to Prevent Skin Cancer by Reducing Exposure to Ultraviolet Radiation: A Systematic Review. Am J Prev Med 2004; 27(5):422-466

Figure 1 is taken from the report by the United States Centers for Disease Control (Saraiya *et al*, 2004). It is convenient to separate the behavioural changes into actions taken or avoided (such as use of sunscreen and avoiding spending time in strong sunlight) and actual exposure to ultraviolet light. For the purpose of NICE, it is also

appropriate to consider final outcomes in quality adjusted life years. Then results from primary studies can be classified as belonging to the following chain of outcomes:

(1) Knowledge change
(2) Attitude change
(3) Behaviour change
(4) Change in exposure to ultraviolet light
(5) Cases of sunburn prevented
(6) Cases of skin cancer prevented (malignant melanoma and non-melanoma)
(7) Quality adjusted life years (QALYs) gained

Where studies report outcomes at intermediate points of this chain, it may be possible to convert the outcomes into QALYs gained by "chaining": that is, using information from other sources to infer a later outcome from an earlier outcome.

2. Interventions and information sources

The research question addressed in this report is the cost-effectiveness of interventions consisting of provision of information for primary prevention of skin cancer. In line with the general principles adopted by NICE, the costing perspective is public sector, and the intention is to measure outcomes in QALYs. A lifetime horizon is used, and the estimated QALYs gained from an intervention include those gained from both mortality and morbidity effects from skin cancers prevented. Future costs and QALYs are discounted at 3.5% per year to the time of the intervention.

The populations to be considered are general populations. Interventions are considered as applicable to children or adults, with separate analysis for these groups. In all cases, the comparator was taken as current practice in the absence of the planned intervention.

Following discussion with the NICE technical team, interventions to be modelled were selected within the following groups:

(a) Verbal advice
(b) Mass media campaigns
(c) Printed materials
(d) New media
(e) Combined verbal advice and printed materials
(f) Combined mass media and printed materials
(g) Combined verbal advice, printed materials and new media

Where multi-component interventions are to be considered, they are to be considered as a package, with a single analysis.

2.1 Selection criteria for areas to model

It was agreed with NICE that an attempt would be made to cover a range of possibilities by considering individual studies which had reported statistically significant outcomes at least as far on the scale of outcomes as behaviour change.

While a number of studies have reported favourable changes in knowledge and attitude, these are measured in a variety of different ways and it is not at all clear whether they are accompanied by actual changes in behaviour that would lead to improved health outcomes.

2.2 Information available for chaining from intermediate outcomes to quality adjusted life years

Data used for linking intermediate outcomes to QALYs were obtained from searching through the papers retrieved for the systematic review of cost-effectiveness studies and from additional non-systematic searches in bibliographic databases (PubMed, NHS EED). Further evidence was obtained from studies found in relevant papers' reference lists and PubMed related article searches performed on relevant papers. Further information was obtained from the Cancer Research UK website. It was beyond the remit of this report to undertake a full systematic review on these items.

3. Details of modelling undertaken

Following discussion with NICE, it was agreed to attempt to model studies with a positive outcome for behaviour change or beyond in the chain of outcomes noted in Chapter 1. Of the studies considered, Table 1 lists those which were deemed to have effectiveness outcomes from which it would be possible to attempt a full economic evaluation:

Table 1 Studies for full economic evaluation

Study	Location	Population	Intervention type	Outcome used
Turrisi (2004)	US (Idaho and Tennessee)	Children at home	Verbal advice	Sunburn frequency
Buller (1994)	US	Children in school	Verbal advice	Behaviour change
Jackson (2006)	US (Arizona)	University students	Verbal advice	Behaviour change

Other studies for which it was not possible to complete a full evaluation, but it was possible to estimate a cost per participant which could be used for a threshold analysis, are shown in Table 2.

Table 2 Studies for threshold analysis

Study	Location	Population	Intervention type	Outcome used
Buller (1997)	US (Arizona)	Children in elementary school	Verbal advice	Behaviour change
Buller (2006)	US (Colorado, New Mexico and Arizona)	Children in middle schools	Verbal advice	Behaviour change
Bauer (2005)	Germany	Children in nursery schools	Printed material	Behaviour change, incidence of

Study	Location	Population	Intervention type	Outcome used
				melanocytic naevi
Prochaska (2005)	US	Adults (mean age 44.7)	Printed material	Behaviour change
Borland (1991)	Australia	Adults (outdoor workers)	Mass media and printed material	Behaviour change
Mayer (1997)	US	Children	Verbal advice and printed material	Behaviour change

The Jackson study was selected for full analysis as it was the nearest study available to a general population study measuring behaviour change. The behaviour change was measured comparing intervention and control groups. Although both groups were given sunscreen samples, the comparative analysis controls for this and is therefore the best available analysis of the effect of the information provision alone.

Because of the variation in the outcomes reported in different studies, no attempt was made to synthesise the results of the different studies: instead, a separate analysis was performed based on each of the effectiveness studies.

Throughout this report, methods are illustrated by numerical calculations. The results of intermediate calculations are usually shown rounded to a reasonable number of significant figures, but full computer accuracy was maintained in the actual calculations used.

3.1 Background Calculations

Before considering individual interventions, the background effects of skin cancer need to be calculated in a form that is suitable for economic evaluation. Based on information from Cancer Research UK, estimates can be made of the number of cases

expected per 100,000 participants in a programme. Full details of the information sources and calculations appear in Appendix 2.

Table 3. Results of background calculations for malignant melanoma

Population	Expected number of cases of malignant melanoma	Expected cases discounted	Expected fatalities	Expected life years lost	Expected fatalities discounted	Expected life years lost discounted
males age 12	1329	264	332	6500	66	869
females age 12	1468	343	367	9259	86	1292
overall age 12	1399	303	350	7880	76	1081
males age 22	1314	353	329	6239	88	1129
females age 22	1427	438	357	8590	109	1595
overall age 22	1370	395	343	7415	99	1362
males age 42	1167	501	292	4513	125	1360
females age 42	1154	512	288	5289	128	1546
overall age 42	1160	507	290	4901	127	1453

Legend: overall population results for a given age assume that the intervention is applied to equal number of males and females

Table 3 shows the results of the background calculations for malignant melanoma for various age ranges. The incidence of non-melanoma skin cancer is taken in the base case analysis to be ten times that of malignant melanoma. Note that, for ease of interpretation, both undiscounted and discounted figures are shown, but only the discounted figures contribute to the final results.

Assuming that the intervention is applied to equal numbers of boys and girls, we find that for every 100,000 12-year-olds, the expected lifetime number of cases of malignant melanoma is $n_m = 1399$ ($n_{md} = 303$ discounted at 3.5%), the expected number of cases of NMSC is $n_n = 13990$ ($n_{nd} = 3030$ discounted), the expected number of skin cancer deaths is $d = 350$ (76 discounted) and the expected number of life years lost is $y = 7880$ (1081 discounted). Note that discounting has a heavier impact on the life years lost than on other figures, because life years lost are potentially later in life than onset of a cancer. These numbers were used for the base case analysis. For sensitivity analysis, the values calculated for males and females separately were taken as limits of a uniform distribution.

3.1.1 Estimating QALYs lost

The QALY loss from skin cancer in the general population is made up of QALYs lost due to premature mortality and due to morbidity associated with non-fatal cases. For

mortality first, it can be argued that these should be accounted for at $q_p = 1$ full QALY for each life year lost. Alternatively, a lower value of q_p representing lower quality of life due to comorbidities can be applied. For the base case analysis, the value $q_p = 1$ was used, with lower values in the one-way sensitivity analysis.

Turning now to non-fatal cases, the best available evidence here is expert opinion reported by Freedberg et al (1999). They report a QALY loss equivalent to 10 days in full health for NMSC, and figures ranging from 127.8 to 212.2 days for malignant melanoma. These can be interpreted in the base case as a loss of $q_n = \frac{10}{365} = 0.028$ for NMSC and $q_n = \frac{127.8+212.2}{2\times365} = 0.466$ for melanoma.

Then the undiscounted QALY loss due to melanoma is $Q_m = q_p y + s q_m n_m = 1\times 7880 + 0.75\times 0.466\times 1399 = 8368,$ where the factor $s = 0.75$ is the proportion of non-fatal cases (or survival rate) of malignant melanoma. Similarly, the QALY loss due to NMSC is $Q_n = q_n n_n = 0.028\times 13990 = 383.$ When discounting at 3.5% is applied, these figures become $Q_{md} = 1187$ and $Q_{nd} = 83$ respectively. In other words, a cohort of 100,000 current 12-year-olds can expect to lose a total of $Q_{md} + Q_{nd} = 1270$ discounted QALYs as a result of skin cancer. This is the maximum gain that could be obtained from a 100% successful prevention programme.

3.1.2 Cost savings from cases prevented

Estimates of the cost savings per skin cancer case prevented were obtained from Morris et al (2009). The authors estimated and reported the cost of malignant melanomas and non-melanoma skin cancer to the NHS, using data on health services use and unit costs from published sources in the UK. Cost estimates were reported in 2002 prices. Values of £2945 for malignant melanoma and £1339 for NMSC were inflated to 2008 according to Bank of England's inflation rates (Bank of England, 2009), giving cost estimates to use in the model of $c_m = £3590$ and $c_n = £1{,}630$ respectively.

3.2 Turrisi (2004)

The intervention assessed by Turrisi et al (2004) involved giving parents of children involved in the study a 25 page handbook including sections on skin cancer incidence, developmental changes that occur from childhood to adolescence, strategies for improving communication between parents and children and in-depth discussion on how to reduce the risk of developing skin cancer. Parents were asked to read the handbook and engage in conversations with their children. From the public sector perspective, the cost of implementing this intervention consists of the cost of the 25 page handbook. The unit cost for such a handbook, obtained from the Central Printing Unit of the University of Birmingham, was estimated at £0.90 per handbook.

In this study, results were reported in the form of change in sunburn frequency. Since no source was found to go forward in the chain of outcomes from this point, the method used was to infer changes in exposure from changes in outcome, and then chain forward from exposure to incidence of skin cancer and QALYs gained. Since the same method of chaining forward from UVR exposure was applied to other studies, the analysis of the Turrisi study is divided into three parts. In Section 3.2.1 the method of inferring UVR exposure from sunburn frequency is described. The method of estimating outcomes including cases prevented and QALYs gained from change in UVR exposure follows in Section 3.2.2, and the results of the analysis appear in Section 3.2.3.

3.2.1 Converting sunburn frequency to UVR exposure

The results from the Turrisi study included sunburn frequency (cases of sunburn in the last 30 days) with a mean of $f_i = 0.816$ (SD 1.53) in the intervention group and $f_c = 1.74$ (SD 3.13) in the control group. In this section, the calculations are shown only using the mean values, but the standard deviations were used to inform the probabilistic sensitivity analysis reported in Section 3.2.3. Initial analysis assumes that the outcome from the Turrisi study can be replicated in full in a UK context: this (somewhat optimistic) assumption was varied in one way sensitivity analysis.

The relative frequency of sunburn exposure is calculated as $r = \frac{f_i}{f_c} = \frac{0.816}{1.74} = 0.469.$

Carter et al (1999) indicates that a 20% reduction in lifetime UVR corresponds to a one third reduction in sunburn frequency. Solving the equation $r = \left(\frac{2}{3}\right)^x$ when $r = 0.469$ gives $x = \frac{\ln r}{\ln\left(\frac{2}{3}\right)} = 1.87$ and we can infer that the relative frequency of sunburn reported corresponds to a relative reduction in lifetime UVR of $u = 1 - 0.8^x = 1 - 0.8^{1.87} = 0.341.$ Kyle et al (2008) assumed that improved behaviour from their programme would last for an equivalent of $s = 2.75$ years, and that $P = 23$ percent of lifetime exposure occurs before the age of 18. If we sustain this assumption then the achievable relative reduction in lifetime UVR exposure is calculated as

$$a_r = \frac{s}{18} \times \frac{P}{100} \times u = \frac{2.75}{18} \times 0.23 \times 0.341 = 0.012.$$

3.2.2 Converting UVR exposure into QALYs gained

Given a relative reduction in lifetime UVR exposure of $a_r = 0.012,$ this can be converted into an incidence ratio for each type of cancer, as follows.

Carter and colleagues (1999) report a log-linear relationship between incidence of each type of cancer and lifetime UVR exposure, whereby a reduction of 10% from an Australian baseline figure of 2000 units (not specified) gives a 17% reduction in incidence of NMSC and a 16.5% reduction in incidence of melanoma. This can be interpreted as an incidence ratio of 0.83 (or 0.835) for each 200 units reduction in lifetime UVR exposure.

Cancer research UK (2009a) report incidences (per 100,000 per year) of malignant melanoma of $m_{em} = 8.4$ cases for males, and $m_{ef} = 10.0$ for females, in Northern Europe, compared with $m_{am} = 37.7$ for males and $m_{af} = 29.4$ for females in Australia/New Zealand. (These figures for Northern Europe are used in preference to the incidence figures quoted in the scope for this project because they are directly comparable with the equivalent figures for Australia/New Zealand.) To combine this with the information in the previous paragraph, we can write the ratio of incidences as a power of 0.835. For males and females, these ratios are respectively

$\frac{m_{em}}{m_{am}} = \frac{8.4}{37.7} = 0.223 = 0.835^{8.3} = 0.835^{t_m}$ and

$\frac{m_{ef}}{m_{af}} = \frac{10.0}{29.4} = 0.340 = 0.835^{6.0} = 0.835^{t_f}$. We can therefore assume a reduction in baseline exposure from Australia to the UK of between $200t_f = 200 \times 6.0 = 1200$ and $200t_m = 200 \times 8.3 = 1660$ units. Taking the mean of these two figures gives a baseline exposure of $e_0 = 2000 - 1430 = 570$ units, with sensitivity analysis covering a range from 340 to 800 units.

Therefore, using base case values, the relative reduction of $a_r = 0.012$ becomes an absolute reduction of $a_a = a_r e_0 = 0.012 \times 570 = 6.83$ units. The incidence of NMSC is multiplied by a factor 0.83 for every 200 units reduction, as noted above based on Carter et al (1999). Therefore the incidence of NMSC is multiplied by 0.83^x, where $x = \frac{6.83}{200} = 0.0342$. Then $0.83^x = 0.83^{0.0342} = 0.9937$ for the relative incidence of NMSC, so the relative reduction is $g_n = 1 - 0.83^{0.0342} = 0.0063$. Similarly, the relative reduction in the incidence of melanoma is $g_m = 1 - 0.835^{0.0342} = 0.0061$.

Assuming the intervention is applied to males and females equally, we have an expected number of cases prevented of $g_n n_n = 0.0063 \times 13990 = 88.7$ undiscounted cases of NMSC and $g_m n_m = 0.0061 \times 1399 = 8.6$ cases of melanoma. The discounted figures are $k_n = g_n n_{nd} = 19.2$ and $k_m = g_m n_{md} = 1.9$ respectively.

The undiscounted QALY gains are $g_n Q_n = 0.0063 \times 383 = 2.4$ resulting from NMSC cases prevented and $g_m Q_m = 0.0061 \times 8368 = 51.3$ from melanoma. The discounted figures are $E_n = g_n Q_{nd} = 0.53$ and $E_m = g_m Q_{md} = 7.28$ respectively, showing that a programme equivalent to the Turrisi programme could gain $\Delta E = E_n + E_m = 7.81$ discounted QALYs per 100,000 participants.

3.2.3 Completion of the base case analysis for Turrisi

Assuming costs of $c_p = £0.90$ per participant for the intervention, and using the cost savings of $c_m = £3{,}590$ per case of malignant melanoma and $c_n = £1{,}630$ per case of NMSC, we find that the net cost of the Turrisi programme for $N = 100{,}000$ participants is made up of $C_p = Nc_p = £90{,}000$ for running the programme itself less $C_o = k_m c_m + k_n c_n = £(1.9 \times 3590 + 19.2 \times 1630) = £38{,}000$ cost savings for a net total cost of $\Delta C = C_p - C_o = £52{,}000.$ Dividing the net cost by the QALY gain of 7.81 calculated in section 3.2.2 above gives an incremental cost-effectiveness ratio (ICER) of $\frac{\Delta C}{\Delta E} = £6700/\text{QALY}.$

3.2.4 Probabilistic sensitivity analysis for Turrisi

For this analysis, the baseline figures were replaced by numbers drawn from distributions as shown in Table 4. In many instances, the sources give a base case value and a range across which it is varied: unless another distribution is clearly indicated, a uniform distribution has been used to avoid clustering values near the base case.

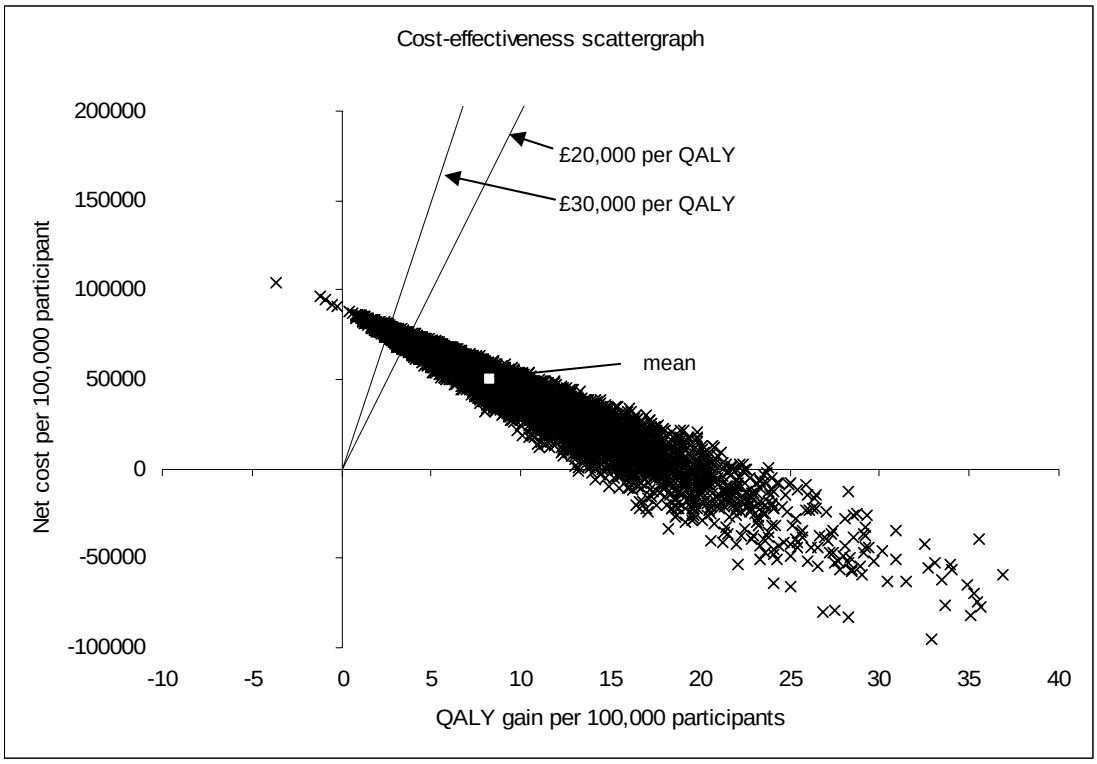
Table 4. Parameter distributions for Probabilistic Sensitivity Analysis based on Turrisi

Parameter	Base case value	Distribution	Mean	Standard deviation	Source
Sunburn frequency (intervention)	0.816	normal	0.816	0.083	Turrisi
(control)	1.74	normal	1.74	0.276	Turrisi

Parameter	Base case value	Distribution	Min	Max	Source
Percent of lifetime UVR under age 18	0.23	Log uniform	0.115	0.46	Kyle
Persistence of behaviour change	2.75	Uniform	1.75	3.75	Kyle
Baseline lifetime UVR	570	Uniform	340	800	See text in section 3.2.2
Expected cases of melanoma	303	Uniform	264	343	CRUK data: see Appendix 2
Cases of NMSC per melanoma	10	Uniform	8	12	Assumption loosely based on CRUK data
Fatality rate for malignant melanoma	0.25	Uniform	0.2	0.3	Assumption loosely based on CRUK data
QALYs lost for case of NMSC	0.027	Uniform	0	0.055	Assumption based on Freedburg
QALYs lost for case of melanoma	0.466	Uniform	0.350	0.581	Assumption based on Freedburg

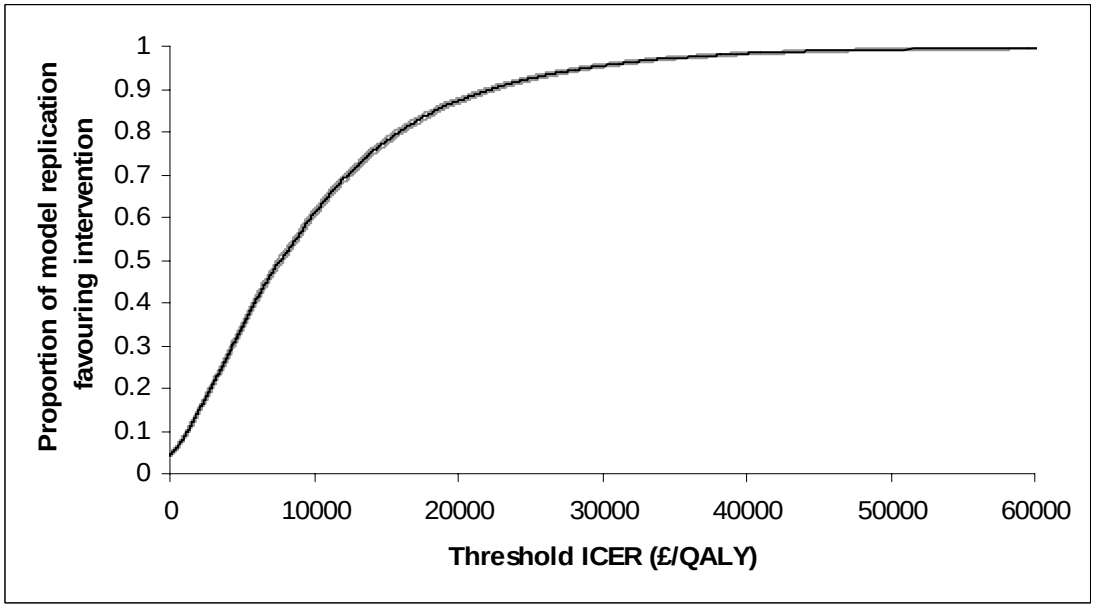
A sample of 10,000 sets of parameters from the above distributions was taken. Figure 2 below shows a plot of the results in terms of costs and effects, together with the mean from all 10,000 replications. Figure 3 shows the cost-effectiveness acceptability curve. On this curve, the vertical axis shows the proportion of model replications which favour the intervention at any given threshold ICER. When a model structure is known to be adequate, and all residual uncertainty is reflected in the parameter distributions, this proportion may be interpreted as the probability that the intervention is cost-effective. However, given the assumptions made throughout this analysis, considerable caution should be taken in applying such an interpretation here.

Figure 2. Results for Turrisi study showing probabilistic analysis from baseline assumptions



Legend: the crosses represent the cost and effectiveness outcomes for each of the 10,000 replications of the model. The two lines show thresholds of £20,000/QALY and £30,000/QALY and the small white square shows the mean based on all 10,000 replications.

Figure 3 Cost-effectiveness acceptability curve for Turrisi study



Legend: the black curve is the estimated cost-effectiveness acceptability curve based on 10,000 replications of the model. The two grey curves are 95% limits reflecting the sampling uncertainty from the finite number of replications and serve no other purpose than to demonstrate that a sufficient number of replications has been made.

The mean differences in cost and QALY outcomes in this analysis are £49,600 and 8.27 QALY respectively, giving an ICER of $\frac{£49,600}{8.27} = £6000/\text{QALY}.$ The proportion of model replications giving results favourable to the intervention at a threshold ICER of £20,000/QALY was 0.87, and at £30,000/QALY, 0.95.

3.2.5 One Way Sensitivity Analysis for Turrisi

A key assumption in the above analysis is that the programme as reported by Turrisi could have the same effect in the United Kingdom as it had in the United States. As noted in the introduction, this may not be the case because the effectiveness of the programme may depend on perceived risk. One way of exploring the importance of this assumption is to introduce a new parameter *p* into the analysis as a multiplier on the number of cases prevented. Taking an arbitrary value of $p = 0.6$ to explain this method, the results from the base case analysis would change so that the QALY gain of $\Delta E = 7.81$ would be replaced by $p\Delta E = 0.6 \times 7.81 = 4.68.$ There would also be an effect on costs. The cost $C_p = £90,000$ for running the programme itself would be unchanged, but the cost savings $C_o = £38,000$ from cases prevented would be replaced by $pC_o = 0.6 \times £38,000 = £22,800$ for a net total cost of $\Delta C = C_p - pC_o = £67,200,$ leading in turn to an ICER of $\frac{\Delta C}{\Delta E} = £14,000/\text{QALY}.$

In the absence of an obvious choice of value for the parameter *p*, results are shown across a range of values from $p = 0.9$ to $p = 0.1.$ Table 5 applies this variation to the results of the base case analysis, and Table 6 to the mean results from the probabilistic sensitivity analysis.

Table 5. One way sensitivity analysis from base case on effectiveness of Turrisi programme

Multiplier	QALYs	Net cost	ICER
1	7.81	52,000	6,700
0.9	7.03	55,800	7,900
0.8	6.25	59,600	9,500
0.7	5.47	63,400	12,000
0.6	4.68	67,200	14,000
0.5	3.90	71,000	18,000
0.4	3.12	74,800	24,000
0.3	2.34	78,600	34,000
0.2	1.56	82,400	53,000
0.1	0.78	86,200	110,000

Table 6 One way sensitivity analysis from mean of probabilistic sensitivity analysis on effectiveness of Turrisi programme

Multiplier	QALYs	Net cost	ICER
1	8.27	49,600	6,000
0.9	7.44	53,700	7,200
0.8	6.61	57,700	8,700
0.7	5.79	61,800	11,000
0.6	4.96	65,800	13,000
0.5	4.13	69,800	17,000
0.4	3.31	73,900	22,000
0.3	2.48	77,900	31,000
0.2	1.65	81,900	50,000
0.1	0.83	86,000	104,000

The next one way analysis is on the relative frequency of sunburn. This parameter in the model is calculated as a ratio of the observed frequencies in the intervention and control groups. For a best estimate of the relative frequency, the observed frequency in the intervention group is taken to its lower 95% limit, and in the control group to its upper 95% limit. For the worst case, the reverse applies. Table 7 shows the results of this analysis applied to the base case, and to the mean results from the probabilistic analysis.

Table 7. One way sensitivity analysis of relative frequency of sunburn

(*a*) Applied to base case results

Relative frequency of sunburn	QALYs	Net cost	ICER
0.287 (best)	11.38	34,600	3,000
0.469 (base)	7.81	52,000	6,700
0.816 (worst)	2.44	78,100	32,100

(*b*) Applied to mean results from probabilistic analysis

Relative frequency of sunburn	QALYs	Net cost	ICER
0.287 (best)	12.30	30,000	2,400
0.469 (base)	8.44	48,800	5,800
0.816 (worst)	2.64	77,100	29,300

Note that the results for using the base case value in the probabilistic analysis differ from the mean results of the full probabilistic analysis, because the effect of varying the relative frequency parameter has been removed.

For the other variables changed in the probabilistic analysis, each in turn was fixed at its minimum and maximum values, retaining the distributions for all other variables. The results of this are shown in Table 8.

Table 8 One way sensitivity analysis on various parameters

Parameter	Value	QALYs	Net cost	ICER
Percent lifetime UVR under age 18	0.115	3.82	71,400	18,700
Percent lifetime UVR under age 18	0.46	15.21	15,800	1,000
Persistence of behaviour change	1.75	5.26	64,300	12,200
Persistence of behaviour change	3.75	11.24	35,200	3,100
Baseline lifetime UVR	340	4.97	65,700	13,200
Baseline lifetime UVR	800	11.66	33,100	2,800
Expected cases of melanoma	264	7.20	54,800	7,600
Expected cases of melanoma	343	9.35	44,400	4,700
Cases of NMSC per melanoma	8	8.15	56,400	6,900
Cases of NMSC per melanoma	12	8.38	43,100	5,100
Fatality rate for malignant melanoma	0.2	6.91	49,600	7,200
Fatality rate for malignant melanoma	0.3	9.62	49,600	5,200
QALYs lost for case of NMSC	0	7.71	49,600	6,400
QALYs lost for case of NMSC	0.055	8.83	49,600	5,600
QALYs lost for case of melanoma	0.35	8.09	49,600	6,100
QALYs lost for case of melanoma	0.581	8.44	49,600	5,900

Finally with relation to the Turrisi study, we varied the cost of providing the intervention. The base case cost of £0.90 was based on a black and white leaflet. We were quoted a price of £5.00 for a full colour glossy brochure. Table 9 shows the results of varying the cost of the intervention between these limits. Clearly the ICER is highly sensitive to the cost of the intervention.

Table 9 Results of one way sensitivity analysis on cost of Turrisi programme

(*a*) Applied to base case results

Cost per participant	QALYs	Net cost	ICER
£0.90	7.81	52,000	6,700
£1	7.81	62,000	7,900
£2	7.81	162,000	20,700
£3	7.81	262,000	34,000
£4	7.81	362,000	46,000
£5	7.81	462,000	59,000

(*b*) Applied to mean results from probabilistic analysis

Cost per participant	QALYs	Net cost	ICER
£0.90	8.27	49,600	6,000
£1	8.27	59,600	7,200
£2	8.27	159,600	19,300
£3	8.27	259,600	31,000
£4	8.27	359,600	43,000
£5	8.27	459,600	56,000

3.3 Buller (1994)

The study by Buller and colleagues aimed to assess the effectiveness of the Sunshine and Skin Health curriculum, which comprises of five multidisciplinary units, each of which contains lesson material, in-class activities, take-home activities and a student/parent newsletter. Each unit was presented by a school teacher and lasted for approximately one hour. The most significant component of the cost per participant for this intervention is the opportunity cost of the time spent on delivering the sun safety curriculum. To calculate the cost per hour of teaching, we used estimates of the average teachers' pay in the England and Wales published by the Department of Innovation, Universities and Skills (Statistics of Education: School workforce in England). The average salary estimate was multiplied by a factor of 1.4 to represent the annual public sector spending for a teacher. This figure was then divided by the hours of teaching in a year (190 days of 5 hours a day) to estimate the public sector cost for one hour of teaching. To estimate the intervention's cost per pupil, the cost per hour of teaching was divided by the average number of pupils in a primary school class (26), giving a cost per participant of £9.07. Full details of the calculations are in Appendix 3.

As far as the cost of the course materials is concerned, we assume that this is negligible as the same materials can be used by different classes for the purposes of the programme.

In this study, results were reported in terms of changes in various aspects of behaviour. To produce an estimate of the effects of these on overall UV exposure, it is necessary to consider each form of behaviour separately and then combine them.

3.3.1 Assessing the effects of each form of behaviour separately

Individual aspects of behaviour considered by Buller were reported on a scale of 1 (never), 2 (sometimes) and 3 (always), but only mean values are given. Kyle and colleagues (2008) assumed for their baseline analysis that "sometimes" meant 50% of the time, while "always" meant 75% of the time. This assumption can only be applied if the proportions giving each response are available. If group means are to be used, it is necessary to assume that behaviour reported as "always" takes place twice as often as behaviour reported as "sometimes". A reasonable base case assumption compatible with Kyle is to assume that "sometimes" means 40% of the time (and therefore "always" means 80% of the time): this is represented by a parameter *t* with base case value 0.4, to be varied in sensitivity analysis between 0.3 and 0.5. Then (in the base case) a mean score of 1, 2, or 3 respectively corresponds to mean behaviour occurring 0, 40%, or 80% of the time. Mean scores in between can be interpreted by linear interpolation: for example a mean score of $s = 1.5$ corresponds to mean behaviour occurring 20% of the time. This can be calculated as $t(s-1) = 0.4 \times (1.5-1) = 0.2$. Similarly, a mean score of 2.5 would be interpreted as behaviour occurring 60% of the time.

The first aspect of behaviour for which Buller and colleagues report a significant positive outcome is sunscreen use in winter, for which they report a mean score of $s_{1i} = 1.455$ for the intervention group and $s_{1c} = 1.29$ for the control group. This is interpreted to mean that sunscreen is applied $p_{1i} = t(s_{1i} - 1) = 0.4 \times 0.455 = 0.182$ of the time in the intervention group, and $p_{1c} = t(s_{1c} - 1) = 0.4 \times 0.29 = 0.116$ of the time in the control group. Following Kyle et al (2008), we assume that the sunscreen used has a nominal sun protection factor (SPF) of 15, but that it is applied at a quarter of the

recommended thickness. Therefore (since protection is assumed to depend exponentially on thickness) there is an effective SPF of 2. If sunscreen with an effective SPF of $f = 2$ is applied for $p_{1i} = 0.182$ or 18.2% of the time, then the exposure to sunlight is halved for that 18.2% of the time, and is therefore a fraction $v_{1i} = 1 - p_{1i}\left(1 - \frac{1}{f}\right) = 1 - 0.182 \times \left(1 - \frac{1}{2}\right) = 0.909$ of the exposure that would occur had no sunscreen been applied at all. Similarly for the control group, we have $v_{1c} = 1 - p_{1c}\left(1 - \frac{1}{f}\right) = 1 - 0.116 \times \left(1 - \frac{1}{2}\right) = 0.942,$ which gives us a relative exposure of $\frac{v_{1i}}{v_{1c}} = 0.965.$ Thus the relative reduction in exposure for this factor is

$$u_1 = 1 - \frac{v_{1i}}{v_{1c}} = 0.035.$$

For the behavioural outcome "lie out in the sun to get a tan", we have mean scores of $s_{2i} = 1.57$ in the intervention group and $s_{2c} = 1.93$ in the control group. Since this is risk-taking rather than protective behaviour, the relative reduction in exposure is calculated simply as $u_2 = 1 - \frac{s_{2i} - 1}{s_{2c} - 1} = 0.387.$

Two other behavioural outcomes reported by Buller could be included in the analysis. For wearing protective clothing in summer, we have mean scores of $s_{3i} = 1.71$ and $s_{3c} = 1.34$ for intervention and control groups respectively. Applying the same methods as for sunscreen in winter, but assuming a sun protection factor of 25 for protective clothing (Kyle et al, 2008), we have $u_3 = 0.175.$ Similarly for lip balm, we have $s_{4i} = 1.925,$ $s_{4c} = 1.73,$ and assuming a sun protection factor of 2, we obtain $u_4 = 0.110.$

Two other factors were reported with significant outcomes by Buller. The first of these was wearing sandals in summer. It was not clear whether this was protective behaviour (compared to going barefoot) or risk-taking behaviour (compared to wearing shoes). The second was general sunscreen use, where significant effects were

reported by different age groups, but the effects went in opposite directions. Accordingly, it was decided to omit both these effects from the analysis.

3.3.2 Combining the various behavioural outcomes

To obtain an estimate for overall exposure from the results in section 3.3.1, it is necessary to combine these results in some way. The simplest way of doing this is to assign weights to each of the factors and produce a weighted average. Where no significant difference was reported by Buller, the assumed effect is zero, and this is included in the weighting given to "other factors". This method allows for unequal importance of the various factors but does not take into account interactions (positive or negative) between them. Table 10 shows the weightings used for the base case analysis: these were varied in sensitivity analysis.

Table 10. Weightings for the factors extracted from Buller (1994)

Factor *i*	Weighting w_i
Use sunscreen in winter	0.05
Lie out in sun to get a tan	0.25
Wear protective clothing in summer	0.25
Lip balm	0.05
Other factors (assumed no effect)	0.40
Total	1.00

Applying the weightings to the relative reductions in exposure from Section 3.3.1, we have an overall (short term) reduction in exposure of $u = w_1u_1 + w_2u_2 + w_3u_3 + w_4u_4$

$= 0.05 \times 0.035 + 0.25 \times 0.387 + 0.25 \times 0.175 + 0.05 \times 0.110 = 0.148.$

As in Section 3.2.1, the overall lifetime relative reduction in exposure can then be calculated as $a_r = \frac{s}{18} \times \frac{P}{100} \times u = \frac{2.75}{18} \times 0.23 \times 0.148 = 0.0052.$

3.3.3 Completion of base case analysis for Buller (1994)

Following the same methods as in Section 3.2.2, the lifetime relative reduction in exposure to UVR converts into a (discounted) reduction of 8.36 cases of NMSC and

0.81 cases of melanoma for every 100,000 children enrolled in the programme. This in turn leads to a saving of 3.39 QALYs.

Costing teaching time for the programme at £9.07 per pupil means a total cost for running the programme of £907,000 for 100,000 pupils. Offset against this is a cost saving of £16,500, leading to a net cost of £890,500. Thus we have a base case ICER for this programme of $\frac{£890,500}{3.39} = £260,000/\text{QALY}$.

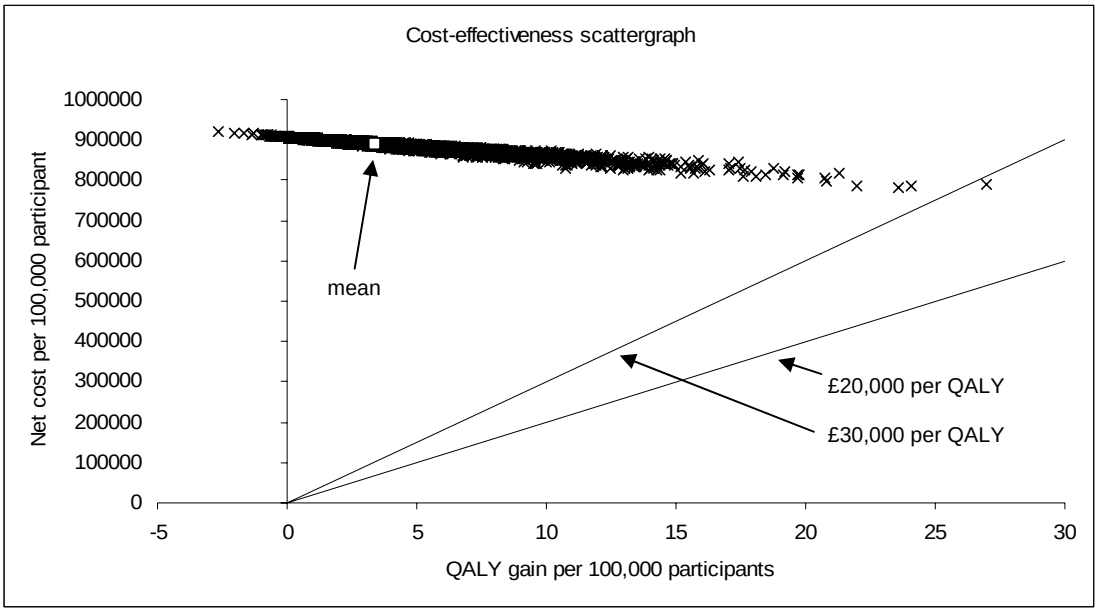
3.3.4 Probabilistic sensitivity analysis for Buller (1994)

For the probabilistic analysis of this programme, it is necessary to make some estimate of the uncertainty around the reported behaviour measures. All that is reported is that they are significant at the 5% level. As a reasonable approximation, the figure for the control group was treated as fixed, while the figure for the intervention group in each case was taken to be normally distributed using the base case value as the mean and taking the standard deviation to be half the difference between the base case values for the intervention and control group. This gives a relative exposure figure that is just significant at the 5% level.

The effective sun protection factor for the three different protective behaviours is taken to follow a log uniform distribution between 50% and 200% of the base case value, with independent sampling for the three separate behaviours. The weights attached to the different behavioural factors $(w_1, w_2, w_3, w_4, w_5)$ were sampled from a Dirichlet distribution with parameters $(1,5,5,1,8)$: this gives maximum variability while preserving the base case means and avoiding the risk of U-shaped marginal distributions.

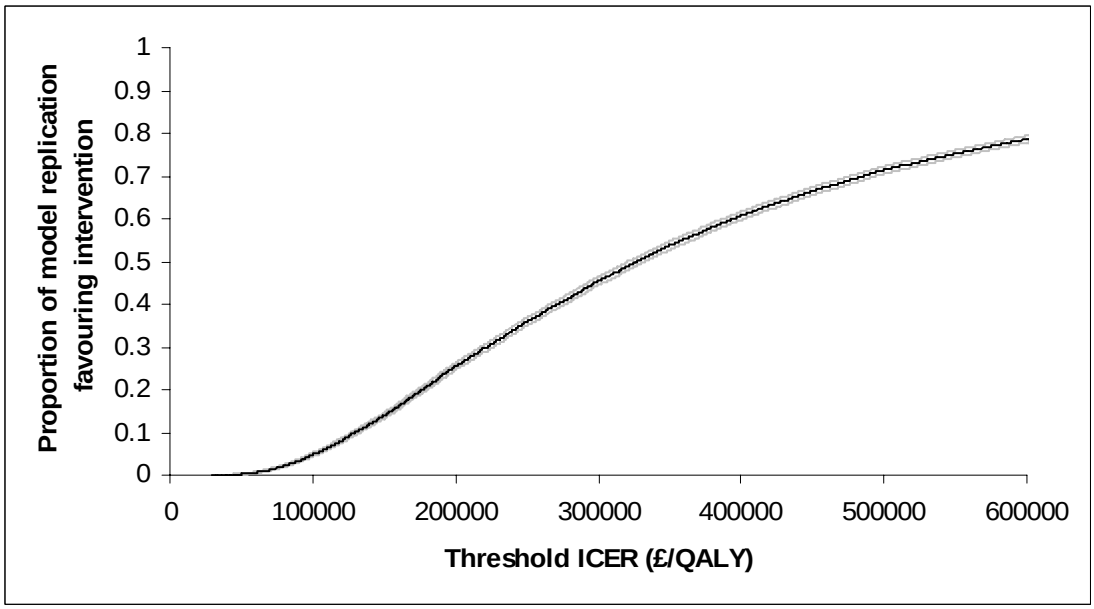
The other parameters were given the same distributions as for Turrisi (see Section 3.2.4). Figures 4 and 5 show respectively the cost-effectiveness scattergraph and cost-effectiveness acceptability curve. The cautionary comments from Section 3.2.4 apply equally to the interpretation of these graphs.

Figure 4. Results for Buller (1994) study showing probabilistic analysis from baseline assumptions



Legend: the crosses represent the cost and effectiveness outcomes for each of the 10,000 replications of the model. The two lines show thresholds of £20,000/QALY and £30,000/QALY and the small white square shows the mean based on all 10,000 replications.

Figure 5 Cost-effectiveness acceptability curve for Buller (1994) study



Legend: the black curve is the estimated cost-effectiveness acceptability curve based on 10,000 replications of the model. The two grey curves are 95% limits reflecting the sampling uncertainty from the finite number of replications and serve no other purpose than to demonstrate that a sufficient number of replications has been made.

The mean differences in cost and QALY outcomes in this analysis are £890,000 and 3.42 QALY respectively, giving an ICER of $\frac{£890,000}{3.42} = £260,000/\text{QALY}$. No model replications gave results favourable to the intervention at a threshold ICER of £20,000/QALY and only one replication out of 10,000 at £30,000/QALY.

3.3.5 One Way sensitivity analysis for Buller (1994)

Given the extremely unfavourable results from the base case and probabilistic analysis, no one way analysis was deemed necessary.

3.4 Jackson (2006)

The intervention assessed by Jackson and colleagues involved a 35 minute group session on skin cancer and photoaging, targeted sun protection and sunbathing norms. Each group comprised of 8 participants on average. The cost of the intervention cost to the public sector consists of the presenters' opportunity cost due to time spent on delivering the intervention. Assuming that in the UK the most appropriate health professional to deliver the intervention would be a community nurse, the cost of a 35 minute educational session was estimated at £2.115 (Curtis, 2008). Both intervention and control groups were given a free sunscreen sample. The cost of the sunscreen sample was not considered in this analysis, as the results have been adjusted for the changes in behaviour in the control group.

3.4.1 Base Case Analysis

For this programme, there are two measures of protective behaviour that appear suitable for analysis, namely sun protection (face index) and sun protection (body index). These are measured on a scale from 1 to 7. Only mean scores are available, so it is necessary to assume that the scale has interval properties. Point 1 on the scale is defined as "never" and so can be taken as no protection. Point 7 is defined as "always". In line with the assumptions in Section 3.3, this will be interpreted in the base case as providing 80% protection. Values are available for intervention and control groups both pretest and at two week follow up. Means for pretest are given both for the whole group tested, and for those retained at follow up. The latter figures are more directly comparable with the follow up figures and therefore have been used for analysis.

Consider first the sun protection (face index). In the intervention group, the pretest and follow up figures are respectively $s_{11i} = 3.66$ and $s_{12i} = 4.39.$ Taking $t = 0.8,$ representing the protection at a "perfect" score of 7, these can be interpreted as exposure levels $1 - \frac{t}{6}(s_{11i} - 1) = 1 - \frac{0.8}{6} \times (3.66 - 1) = 0.645$ and $1 - \frac{t}{6}(s_{12i} - 1) = 1 - \frac{0.8}{6} \times (4.39 - 1) = 0.548$ respectively. Thus the relative exposure is $r_{1i} = \frac{1 - \frac{t}{6}(s_{12i} - 1)}{1 - \frac{t}{6}(s_{11i} - 1)} = \frac{0.548}{0.645} = 0.849.$ Similarly in the control group we have $s_{11c} = 3.91$ and $s_{12c} = 3.97$ for protective behaviour pretest and at follow up respectively. These give a relative exposure (controlling for the effect of the sunscreen sample given to both groups) of $r_{1c} = \frac{1 - \frac{t}{6}(s_{12c} - 1)}{1 - \frac{t}{6}(s_{11c} - 1)} = 0.987.$ Thus the relative reduction in exposure due to the intervention can be estimated as $u_1 = 1 - \frac{r_{1i}}{r_{1c}} = 1 - \frac{0.849}{0.987} = 0.140.$

Similarly, for sun protection (body index), we have a change in the intervention group from $s_{21i} = 2.95$ to $s_{22i} = 3.61,$ and in the control group from $s_{21c} = 2.69$ to $s_{22c} = 2.88.$ Applying the same process gives $u_2 = 0.089.$

To combine these, we can use the information from Cancer Research UK (2009d). For females, 14% of malignant melanoma is on the face, 79% is on other parts of the body, and 7% is unspecified. We therefore take weights of $w_1 = \frac{14}{93} = 0.15$ and $w_2 = \frac{79}{93} = 0.85$ for the contributions of face and body protection to the overall effect, giving $u = w_1 u_1 + w_2 u_2 = 0.15 \times 0.140 + 0.85 \times 0.089 = 0.097$ as the overall relative reduction in (short term) UVR exposure.

Now to find the achievable reduction in lifetime exposure. It is reasonable to suppose that behaviour taught at age 22 will persist slightly longer than that taught at age 12, so an effective persistence of behaviour of $s = 4$ years is used in the base case. This must be expressed as a fraction of the percentage of exposure received after the age of 18. Life expectancy for 18-year-old females in the UK is approximately 64 years (Government Actuary's Department, 2009), and we sustain the assumption that the percentage of lifetime exposure before the age of 18 is 23%, so we now take $P = 77$

for the percentage of lifetime exposure after the age of 18. Then the estimate for achievable reduction in lifetime exposure from the programme is

$$a_r = \frac{s}{64} \times \frac{P}{100} \times u = \frac{4}{64} \times 0.77 \times 0.097 = 0.0047.$$

To estimate the final outcomes, the methods of Section 3.2.2 are again used. However, the figures from Table 1 (in Section 3.1) for females aged 22 are substituted for the figures for children aged 12.

Following these methods, the lifetime relative reduction in exposure to UVR converts into a (discounted) reduction of 10.80 cases of NMSC and 1.05 cases of melanoma for every 100,000 women enrolled in the programme. This in turn leads to a saving of 4.52 QALYs.

Costing the programme at £2.115 per participant means a total cost for running the programme of £211,500 for 100,000 women. Offset against this is a cost saving of £21,400, leading to a net cost of £190,100. Thus we have a base case ICER for this programme of $\frac{£190{,}100}{4.52} = £42{,}000/\text{QALY}.$

3.4.2 Probabilistic sensitivity analysis for Jackson

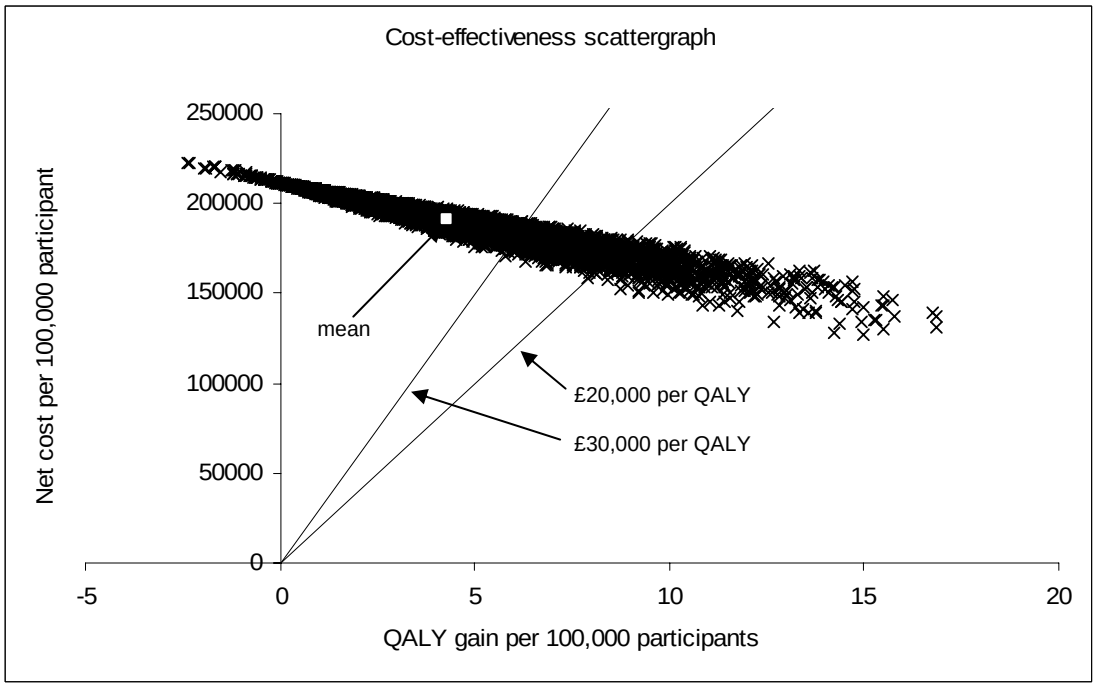
For the outcome variables, Jackson reported an *F* statistic relating to the difference between intervention and control groups at follow up. The (one-tailed) *P* value for this *F* statistic has been taken as a measure of the statistical significance of the ratio of the behaviour variables and used to set the standard deviation for a lognormal distribution of that ratio. (This is at least less arbitrary than simply assuming that the difference is only just significant at the 5% level as was done for Buller (1994) in Section 3.3.)

For the contribution of face effects to total reduction in UVR exposure, this was taken to follow a Beta distribution with parameters $\left(1, \frac{79}{14}\right)$, following similar principles to those used in Section 3.3, to give the same mean as the base case, with maximum variability without a U-shaped distribution.

For the expected number of cases of malignant melanoma, this was set to a uniform distribution between 381 and 494 cases, to preserve the correct mean for participants aged 22, but with the same relative variability as was used in Sections 3.2 and 3.3.

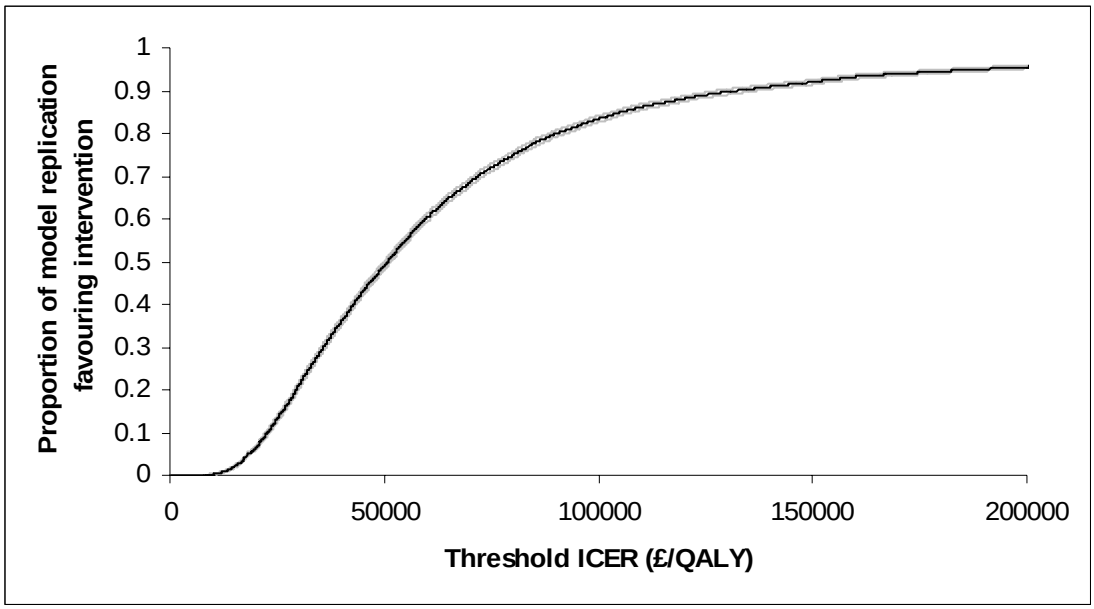
The other parameters were given the same distributions as for Turrisi (see Section 3.2.4). Figures 6 and 7 show respectively the cost-effectiveness scattergraph and cost-effectiveness acceptability curve. The cautionary comments from Section 3.2.4 apply equally to the interpretation of these graphs. The mean differences in cost and QALY outcomes in this analysis are £191,000 and 4.29 QALY respectively, giving an ICER of $\frac{£191{,}000}{4.29} = £45{,}000/\text{QALY}$. The proportion of model replications giving results favourable to the intervention at a threshold ICER of £20,000/QALY was 0.065, and at £30,000/QALY, 0.021.

Figure 6. Results for Jackson study showing probabilistic analysis from baseline assumptions



Legend: the crosses represent the cost and effectiveness outcomes for each of the 10,000 replications of the model. The two lines show thresholds of £20,000/QALY and £30,000/QALY and the small white square shows the mean based on all 10,000 replications.

Figure 7. Cost-effectiveness acceptability curve for Jackson study



Legend: the black curve is the estimated cost-effectiveness acceptability curve based on 10,000 replications of the model. The two grey curves are 95% limits reflecting the sampling uncertainty from the finite number of replications and serve no other purpose than to demonstrate that a sufficient number of replications has been made.

3.4.3 One Way sensitivity analysis for Jackson

The first variable considered for one way analysis is the persistence of improved sun protective behaviour. In the base case, this was set to 4 years. Table 11 below shows the effect of changing this from the base case analysis, while Table 12 changes this to a range of fixed values in the probabilistic analysis, preserving the distributions for all other parameters.

Table 11. Varying persistence of effect of Jackson study from base case

Persistence in years	QALYs	Net cost	ICER
2	2.26	201,000	89,000
3	3.39	195,000	58,000
4	4.52	190,000	42,000
5	5.65	185,000	33,000
6	6.78	179,000	26,000
8	9.03	169,000	19,000
10	11.28	158,000	14,000
12	13.53	148,000	11,000

Table 12. Varying persistence of effect of Jackson study from probabilistic analysis

Persistence in years	QALYs	Net cost	ICER
2	2.15	201,000	93,000
3	3.23	196,000	61,000
4	4.30	191,000	44,000
5	5.38	186,000	35,000
6	6.45	181,000	28,000
8	8.60	170,000	20,000
10	10.74	160,000	15,000
12	12.88	150,000	12,000

Note that the results in Table 12 for a persistence of 4 years differ from the mean results of the probabilistic analysis reported in Section 3.4.2 because of the removal of the variability in this parameter.

For the other parameters varied in the sensitivity analysis, each in turn was changed to its lower and upper limits. For the parameters with lognormal and beta distributions, these were taken at the 2.5 and 97.5 percentiles: for other parameters, the minimum and maximum values were used. The results are shown in Table 13.

Table 13. One way sensitivity analysis on various parameters in Jackson study

Parameter	Value	QALYs	Net cost	ICER
Ratio of exposure (face)	0.761	4.97	188,000	38,000
Ratio of exposure (face)	0.973	3.55	194,000	55,000
Ratio of exposure (body)	0.838	7.11	177,000	25,000
Ratio of exposure (body)	0.990	1.30	205,000	158,000
Proportion of exposure on face	0.0045	3.97	192,000	49,000
Proportion of exposure on face	0.480	5.02	187,000	37,000
Percent lifetime UVR under age 18	0.115	5.06	187,000	37,000
Percent lifetime UVR under age 18	0.46	3.09	197,000	64,000
Baseline lifetime UVR	340	2.55	199,000	78,000
Baseline lifetime UVR	800	6.00	183,000	30,000
Expected cases of melanoma	381	3.73	194,000	52,000
Expected cases of melanoma	494	4.84	188,000	39,000
Cases of NMSC per melanoma	8	4.23	194,000	46,000
Cases of NMSC per melanoma	12	4.34	188,000	43,000
Fatality rate for malignant melanoma	0.2	3.58	191,000	53,000
Fatality rate for malignant melanoma	0.3	5.00	191,000	38,000
QALYs lost for case of NMSC	0	4.00	191,000	48,000
QALYs lost for case of NMSC	0.055	4.57	191,000	42,000
QALYs lost for case of melanoma	0.35	4.20	191,000	45,000
QALYs lost for case of melanoma	0.581	4.37	191,000	44,000

3.5 Other studies

For all other studies, we have conducted a threshold analysis. The methods described above to convert a lifetime reduction in UVR exposure to cases prevented and QALYs gained have been applied across a range of different levels of relative reduction in exposure. Then the cost per participant c_p required to achieve a given threshold ICER T can be calculated as $c_p = \frac{C_o + T\Delta E}{100{,}000}$, where C_o and ΔE are respectively the cost savings (from cases prevented) and QALYs gained from applying the intervention to 100,000 participants.

Figures 8 to 10 show the results of this analysis applied to populations at age 12, 22, and 42, respectively, representing children, young adults, and a general adult population. In each case thresholds for cost saving and cost-effective at £20,000/QALY and £30,000/QALY are shown. Studies with a full analysis are shown on the appropriate graphs.

Figure 8. Threshold analysis for population aged 12 years old

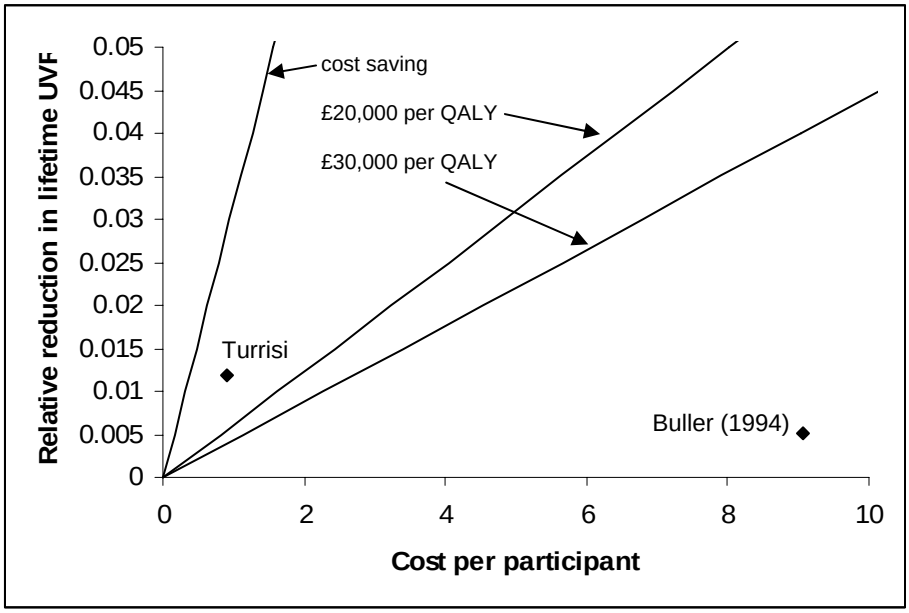


Figure 9. Threshold analysis for population aged 22 years old

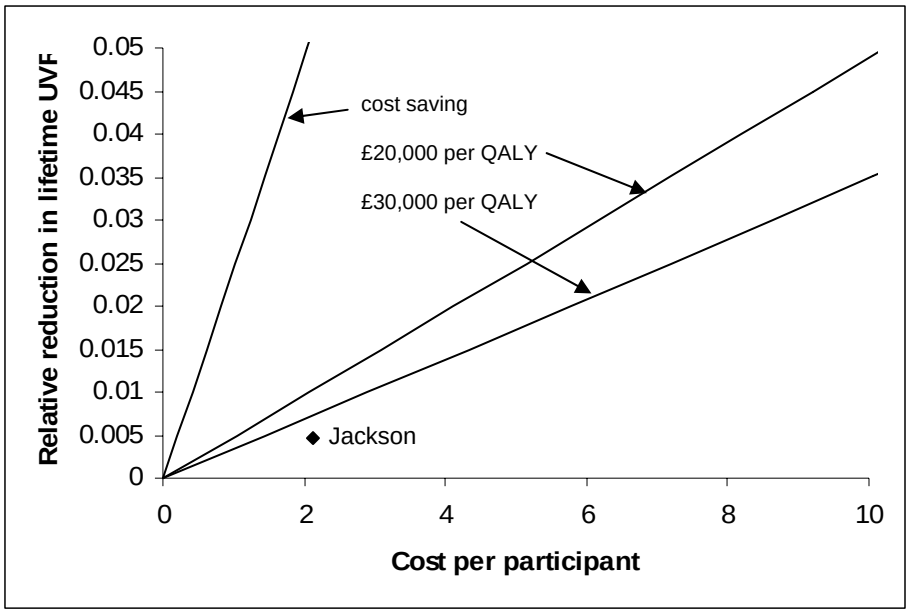
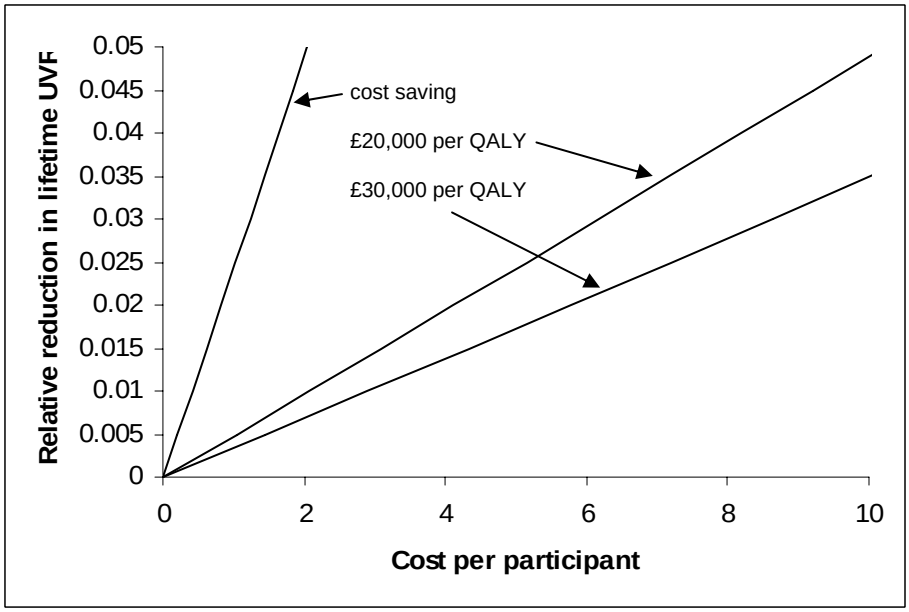


Figure 10. Threshold analysis for population aged 42 years old



The studies where complete modelling has not been possible, but it has been possible to estimate a cost per participant, are described in Table 14. Then Table 15 gives for each of these studies the relative reduction in lifetime UVR that would be necessary to achieve each possible threshold ICER.

Table 14. Description of studies for threshold analysis

Study	Intervention type	Description of intervention
Buller (1997)	Verbal advice	An interactive sun safety fair, featuring a number of activity stations (a life-size board game quiz, a puppet show, sunblock display, a presentation about sun overexposure and a game about sun safe clothes), video presentation, a presentation of the ultraviolet light using prisms and a presentation on skin type and skin-self examination. The intervention took place in three public elementary schools.
Buller (2006)	Verbal advice	Six 50-minute lessons based on the Sunny Days Healthy Ways curriculum. The aim of the lessons was to teach the following skills: selecting and applying sunscreen; selecting sun protective clothing, hats and sunglasses; using shade and minimizing time in the sun.
Bauer (2005)	Printed material	The intervention involved participating parents receiving an initial educational session and an educational letter three times yearly with more detailed information on proper sunscreen use and sun protection, as well as receiving brochures from public melanoma prevention campaigns with detailed information.
Prochaska (2005)	Printed material	The intervention involved mailing participants three computer generated reports at 0, 6 and 12 months. Each report was three to five pages long and was divided into sections about change and readiness to change behaviour, pros and cons of changing behaviour, feedback on participants' use of up to six change processes relevant to their stage of change, feedback on how to enhance self efficacy and strategies for taking small steps to progress to the next stage.
Borland (1991)	Mass media and printed	The assessed intervention was targeted at outdoor staff working in Telecom company. It involved distributing a

Study	Intervention type	Description of intervention
	material	set of materials for each depot (posters and video) and a folder of materials for each worker (brochure introducing the campaign, a letter from management, various brochures about sun protection and skin cancer). These resources were complimented by input from occupational health nurses.
Mayer (1997)	Verbal advice and printed material	The intervention included an ultraviolet reduction curriculum presented at poolside by YMCA aquatics instructors and home-based activities for children and their parents.

Table 15. Results of threshold analysis

Study	Age group	Cost per participant	Relative reduction in lifetime UVR for		
			£30k/QALY	£20k/QALY	Cost saving
Buller (1997)	children	£6.32	0.028	0.039	0.210
Buller (2006)	children	£9.07	0.040	0.057	0.309
Bauer (2005)	children	£3.80	0.017	0.024	0.123
Prochaska (2005)	adults	£1.51	0.005	0.006	0.029
Borland (1991)	adults	£3.18	0.010	0.014	0.061
Mayer (1997)	children	£5.76	0.025	0.036	0.190

4. Discussion

Chapter 3 of this report includes results from detailed modelling for three studies assessing verbal advice interventions. No other types of intervention have been modelled in full due to the absence of suitable behavioural outcomes. The results suggest that if an intervention applied to a population of UK children could obtain outcomes equivalent to those observed in the Turrisi (2004) study, at a similar level of cost, such an intervention could be highly cost-effective by comparison with the standards normally applied by NICE. However, even in this case the results are highly sensitive to the cost of the intervention. Further, the analysis does not include potential harms. The number needed to treat to obtain a gain of 1 QALY is over 10,000 for the base case analysis, and does not fall below 2,500 for the most optimistic analysis considered. Even a fairly small amount of harm could be enough to give this intervention a net QALY loss.

Interventions such as the school based programmes analysed by Buller (1994, 2006), if costed according to the public sector perspective of accounting for teachers' time in delivering the intervention, seem highly unlikely to achieve the effects necessary to be cost-effective by UK standards.

The only intervention applied to adults that was fully analysed was the verbal advice intervention given to young women and reported by Jackson (2006). The cost-effectiveness of this intervention depends heavily on the persistence of behaviour, which in this case was measured only over a period of two weeks, and then adjustment had to made for the fact that both intervention and control groups had received free sunscreen samples. Again, the analysis does not include potential harms.

Other types of intervention have not been analysed in full. However, a complete analysis of such interventions would require the same outcome measures as those used in the modelling of verbal advice. A threshold analysis has been conducted which shows the relationship between the cost of the intervention and the reduction in lifetime exposure to ultraviolet radiation that would be necessary to make the

intervention cost-effective at recognised thresholds. Where it has been possible to estimate the cost per participant of providing an intervention, the reduction needed has been calculated. Whether any of the interventions considered are capable of achieving such a reduction in exposure is highly unclear, given the nature of the outcomes measured and reported in the effectiveness studies. From a cost-effectiveness point of view, the nature of the intervention is unimportant in itself. What matters is whether a given outcome can be achieved (by any type of intervention) for a given cost.

4.1 Limitations of the analysis

The analysis is limited by the paucity of studies with behavioural outcomes. Even where such studies exist, the outcomes are measured on scales which are not well suited to economic analysis. It has been necessary to make a substantial number of assumptions in order to complete the analysis.

The analysis of necessity highly speculative, and should be taken as indicative of the type of analysis that can be carried out given appropriate data. At many stages of the calculation, it has been assumed that data can be transferred beyond the context in which it was collected. Also, we have often had to use group mean values to infer behaviour about the group as a whole and thus may miss effects where distribution matters.

A particular point where substantial assumptions have been necessary relates to the persistence of improved behaviour. The assessment of lasting effects has been based on studies with very limited follow up periods.

4.2 Recommendations for further research

There is a clear need for effectiveness evidence before any intervention can be regarded as cost-effective in a UK context. Such evidence will need to be collected through a study carried out in a setting that may be regarded as equivalent to a UK setting, in terms both of climate and culture. It is also important that any new primary research in this area is designed with economic analysis in mind. This means both a sufficient follow up period to allow assessment of the persistence of behaviour change, and use of appropriate measures of behaviour change.

There is also a need for resolution of the substantial uncertainty in the process of converting short-term outcome measures relating to behaviour change.

5. Appendices

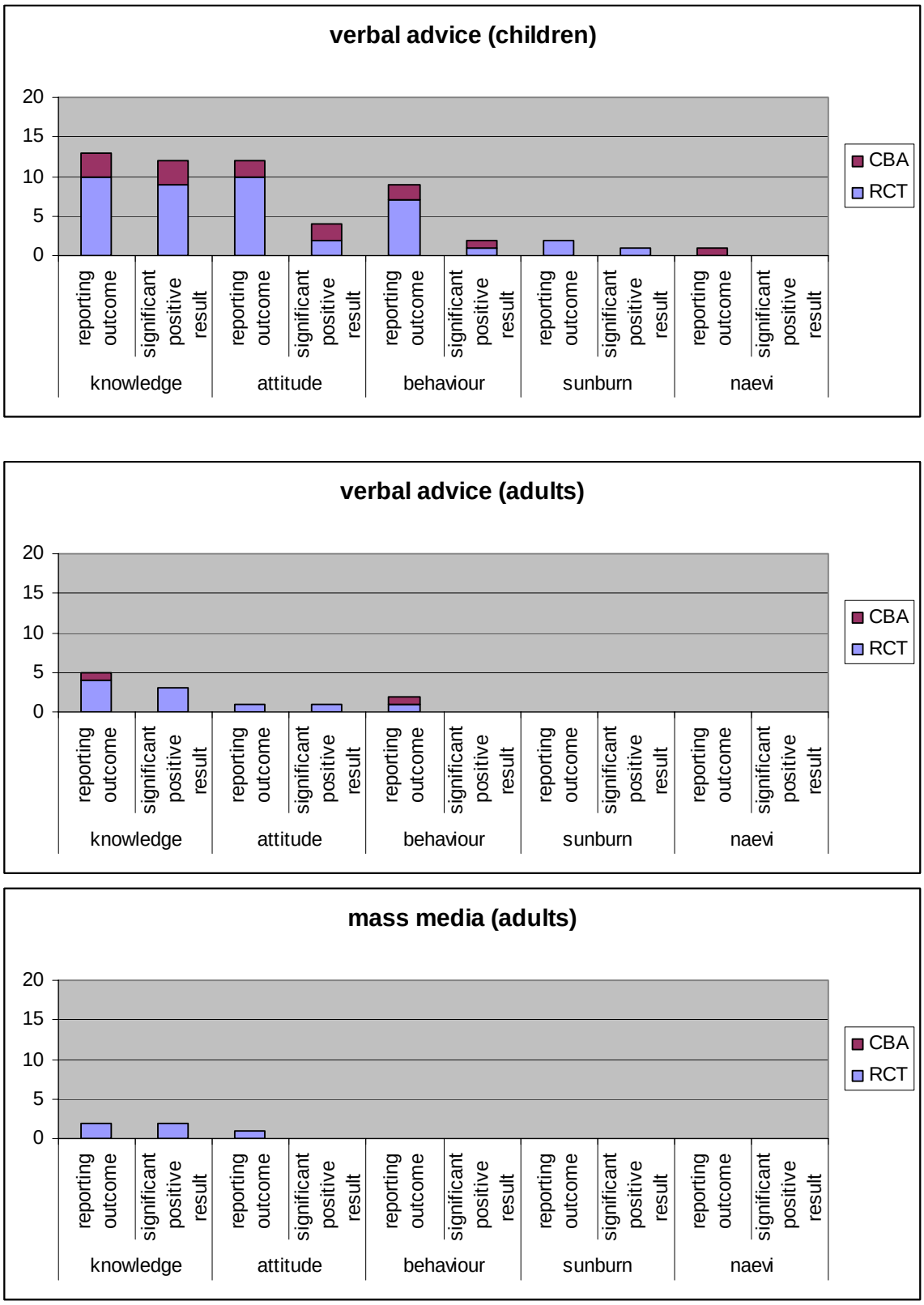
Appendix 1. Number of studies showing outcomes

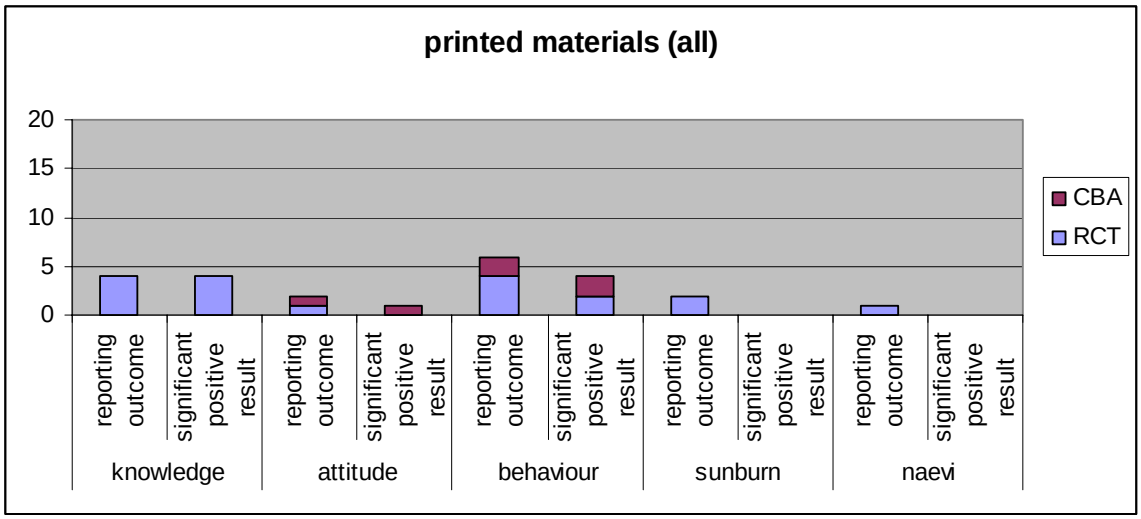
The graphs in Figure 11 below show the number of randomised controlled trials (RCTs) and controlled before and after studies (CBAs) found in each category, both in terms of reporting an outcome and significant positive results. They were compiled using the following principles:

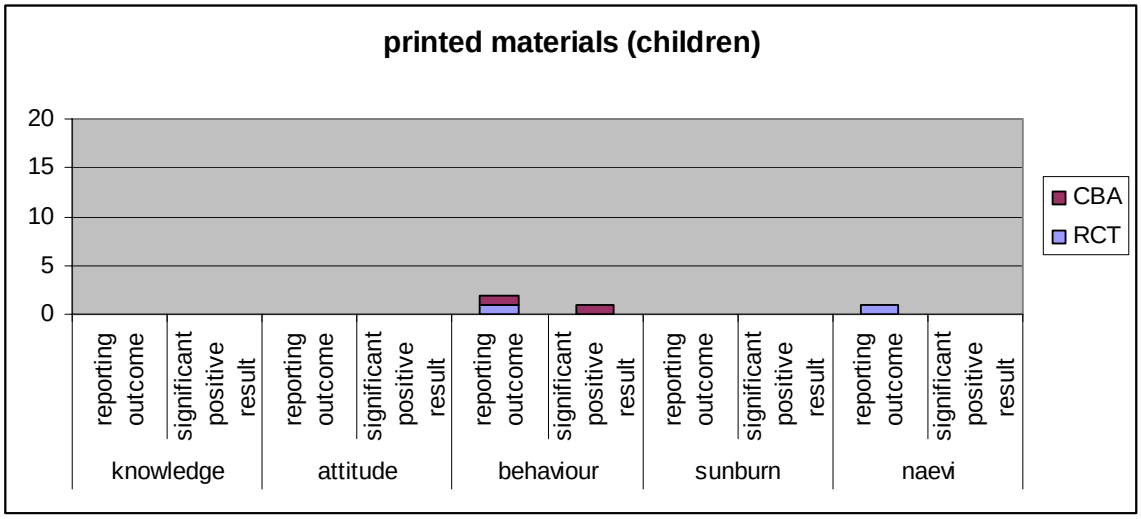
- where appropriate, all studies of a particular type are shown first, followed by separate graphs for interventions aimed at children only and adults only;
- studies that do not report results for study arms (but for example as regression analysis) are not included;
- when a study reports the same outcome using two measures, significant positive result counted only if study shows an increase at least in one outcome;
- one study (verbal advice, children) showed an increase in one age group and a decrease in another; it was included as not significant;
- when only significance for items within scales is reported, significant positive result only if an increase can be observed in more than 50%;
- if not significant at first post-test and significant at second, treated as significant positive result;
- if a study uses more than one intervention group of a given type, results are counted as positive if they are positive for at least one of the intervention groups;
- studies were not distinguished by setting.

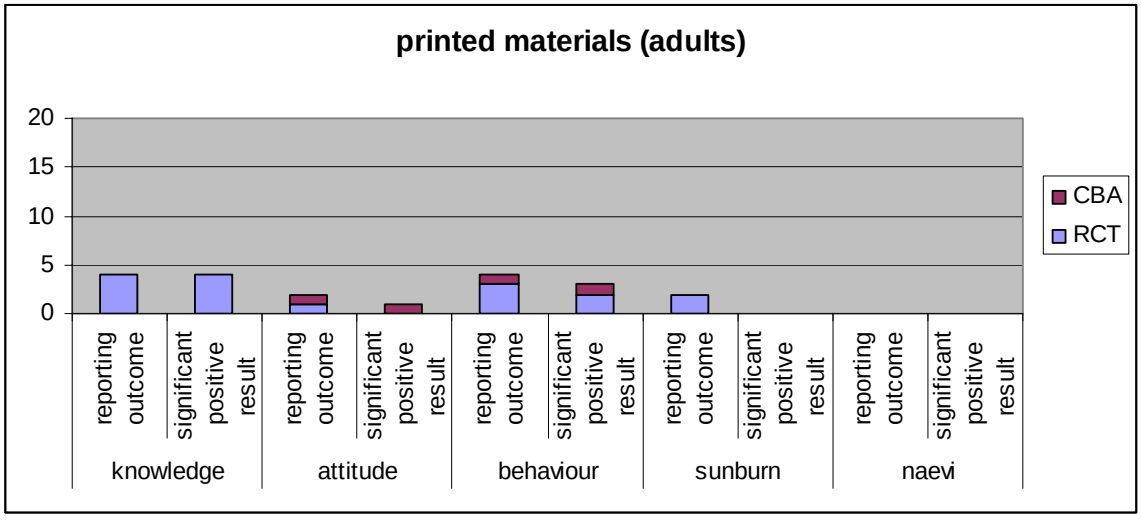
Where no studies of a particular type are shown on a chart, that means none were found in the review.

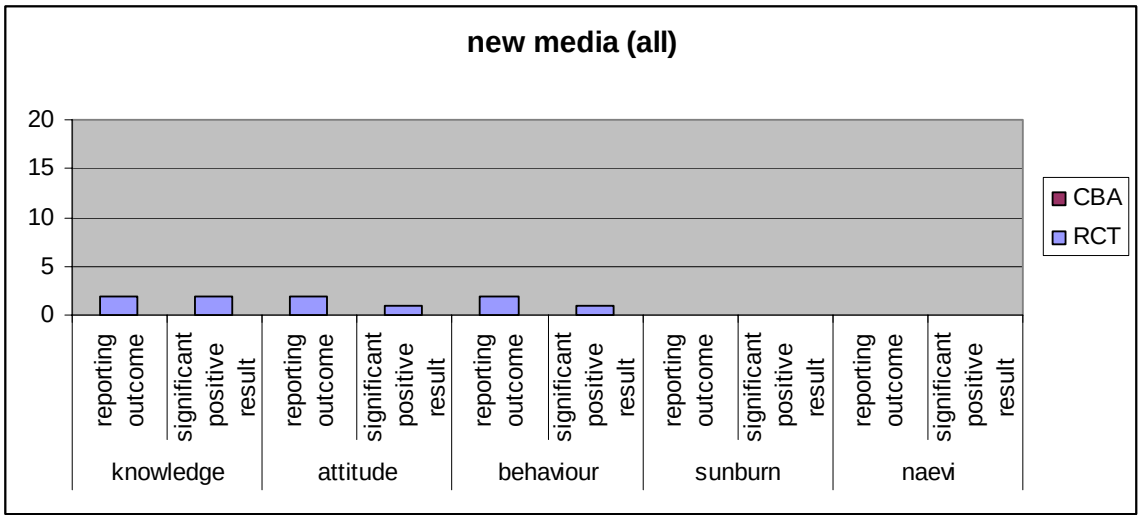
Figure 11. Numbers of studies in each category reporting different types of outcome

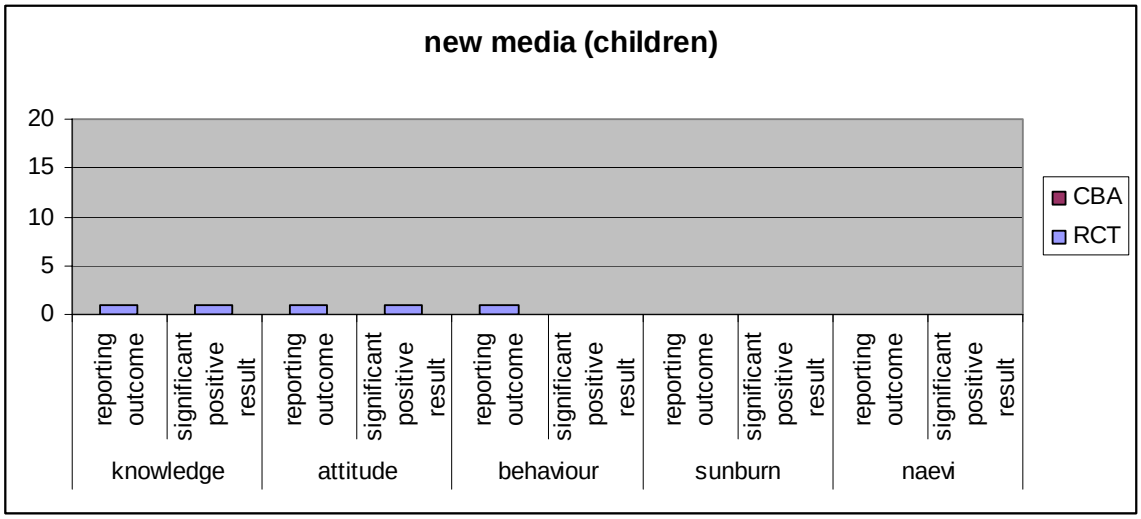


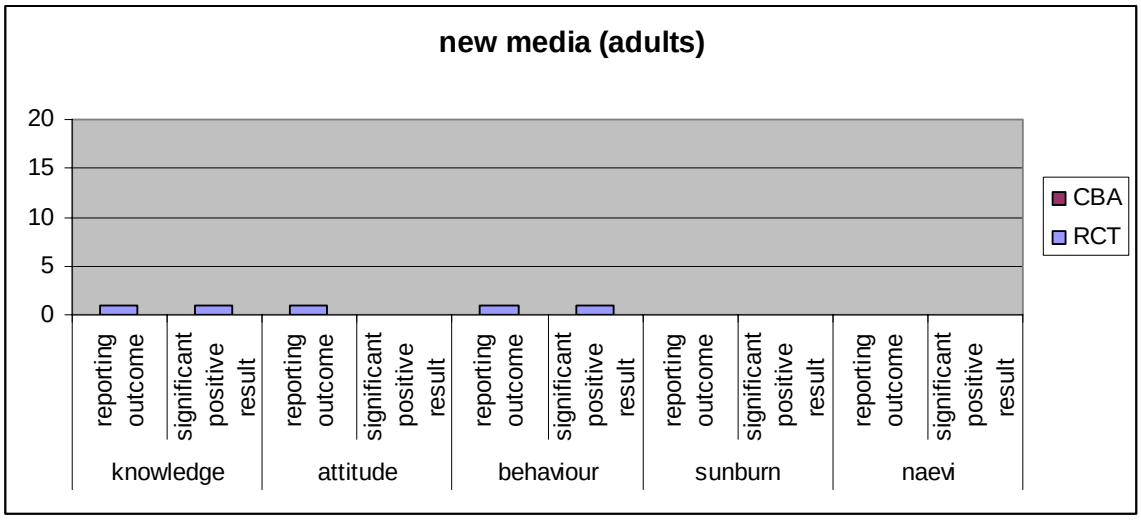

printed materials (all)
20
15
10
5
0
CBA
RCT
reporting outcome
significant positive result
knowledge
attitude
behaviour
sunburn
naevi

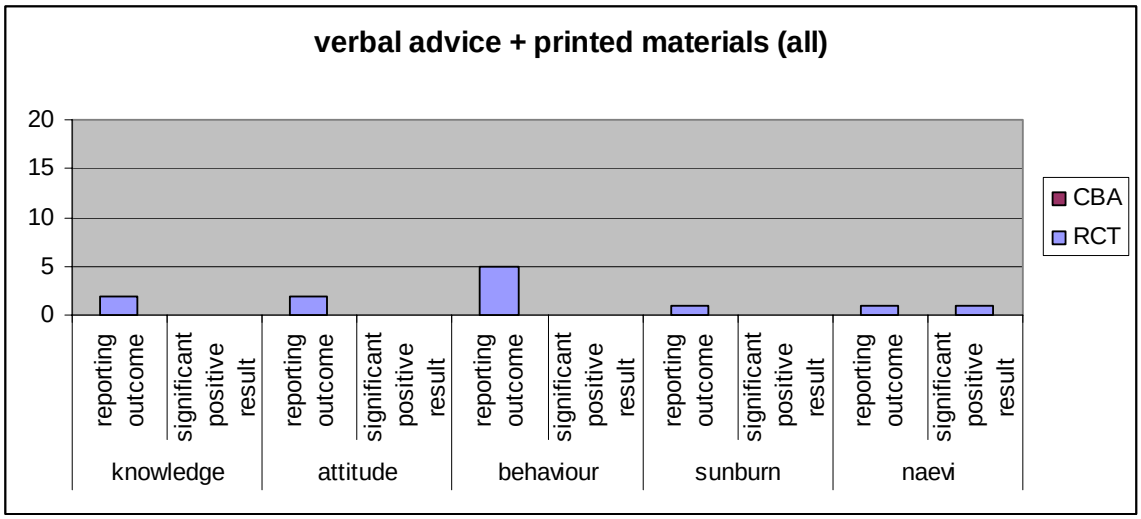

printed materials (children)
20
15
10
5
0
CBA
RCT
reporting outcome
significant positive result
knowledge
attitude
behaviour
sunburn
naevi

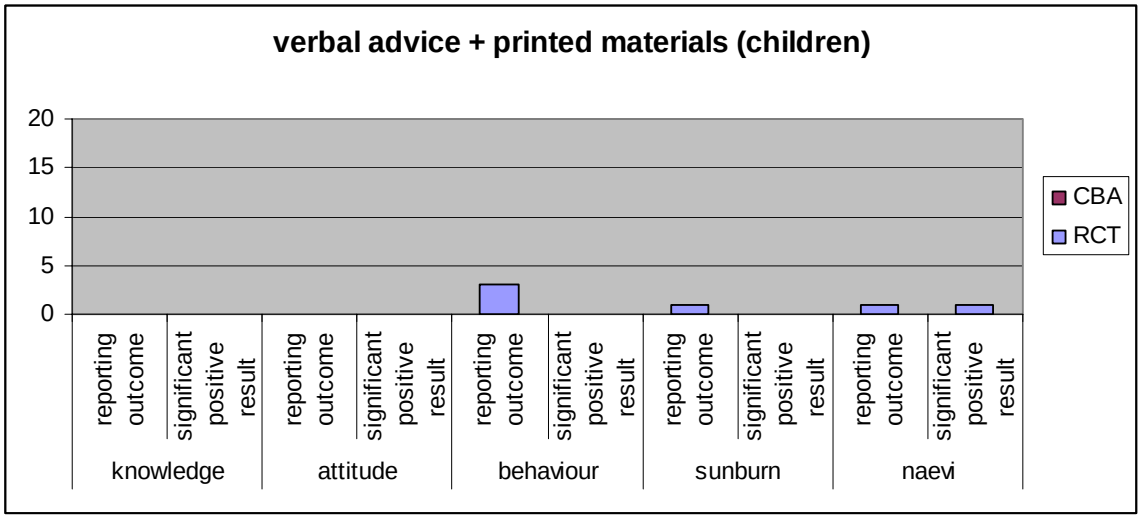

printed materials (adults)
20
15
10
5
0
CBA
RCT
reporting outcome
significant positive result
knowledge
attitude
behaviour
sunburn
naevi

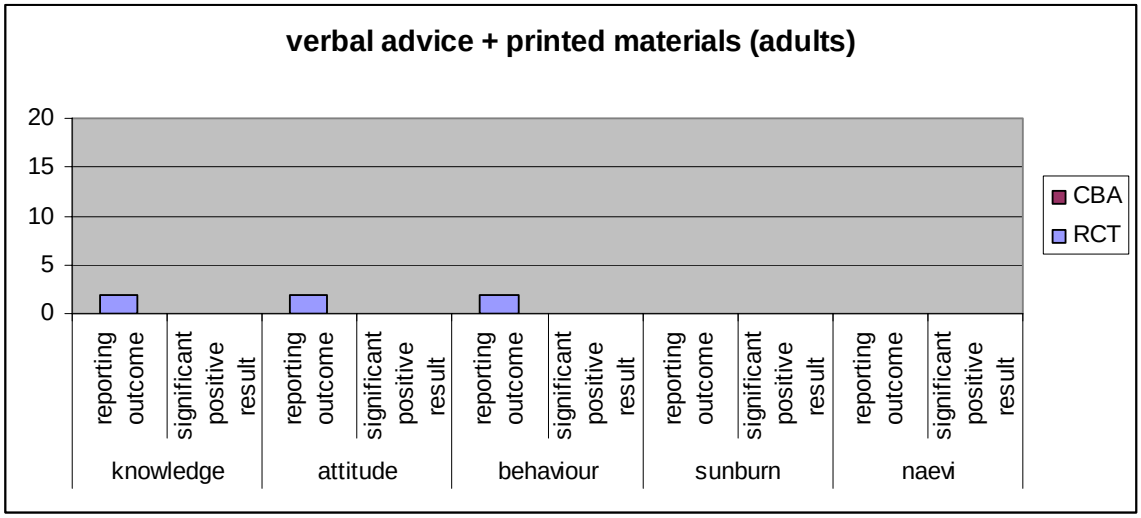

new media (all)
20
15
10
5
0
reporting outcome
significant positive result
knowledge
attitude
behaviour
sunburn
naevi
CBA
RCT

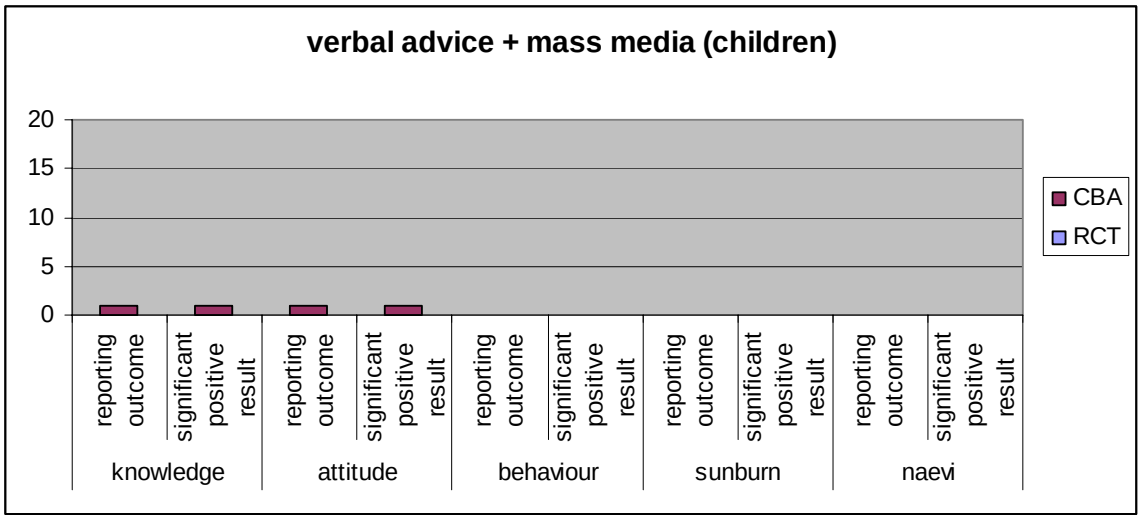

new media (children)
20
15
10
5
0
reporting outcome
significant positive result
knowledge
attitude
behaviour
sunburn
naevi
CBA
RCT

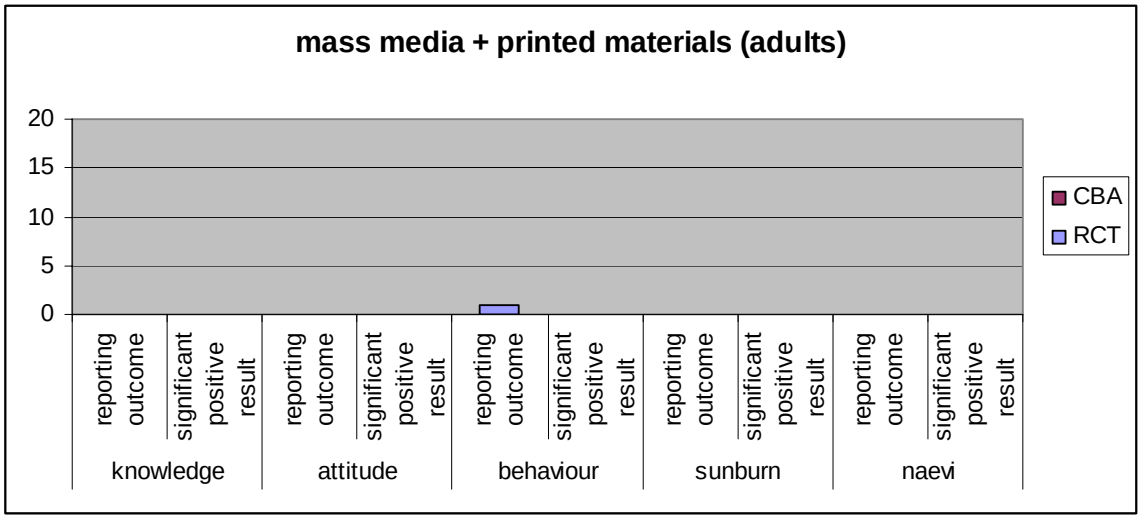

new media (adults)
20
15
10
5
0
reporting outcome
significant positive result
knowledge
attitude
behaviour
sunburn
naevi
CBA
RCT

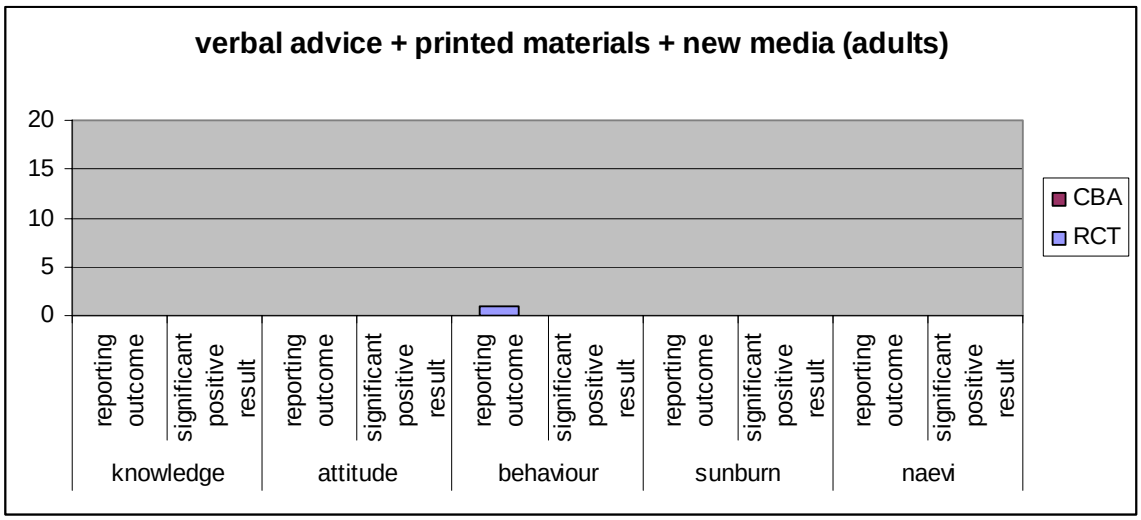

verbal advice + printed materials (all)
20
15
10
5
0
reporting outcome
significant positive result
knowledge
attitude
behaviour
sunburn
naevi
CBA
RCT


verbal advice + printed materials (children)
20
15
10
5
0
reporting outcome
significant positive result
knowledge
attitude
behaviour
sunburn
naevi
CBA
RCT


verbal advice + printed materials (adults)
20
15
10
5
0
reporting outcome
significant positive result
knowledge
attitude
behaviour
sunburn
naevi
CBA
RCT







Legend: CBA = controlled before and after study, RCT = randomised controlled trial, naevi = melanocytic naevi

Appendix 2. Background calculations

Before considering individual interventions, the background effects of skin cancer need to be calculated in a form that is suitable for economic evaluation. Cancer Research UK (2009b) provides incidence data for malignant melanoma in 5 year age bands for males and females separately, from which it seems sensible to perform the relevant calculations in those groups. It is necessary to make some assumptions concerning relative incidence of malignant melanoma to non-melanoma skin cancer (NMSC) and fatality of skin cancers. Cancer Research UK (2009c) report over 9,500 cases of malignant melanoma each year, and over 2,300 deaths from skin cancer. For NMSC, they report: "More than 72,000 cases of non-melanoma skin cancer are registered each year but it is estimated that the actual number is at least 100,000 cases in the UK each year." From these figures, and in the absence of age-dependent incidence of NMSC, it is assumed in the base case that the incidence of NMSC is 10 times that of melanoma, and that the fatality rate is approximately 2300/9500, that is one quarter, of the incidence rate of melanoma. (The figures used here differ from the ones quoted in the scope for this project, but have been used in preference because they are more recent and provide a common source for incidence and mortality data.)

For sensitivity analysis, the lower limit for the ratio of cases of NMSC to melanoma can be taken as 8 (72,000/9,500 rounded to the nearest integer) and therefore it makes sense to set an upper limit of 12. For the fatality rate, a range from 0.2 to 0.3 was selected.

Strictly speaking, separate fatality rates should be applied to NMSC and melanoma. However, in the absence of reliable data, it is a reasonable approximation to apply a fatality rate of 0.25 per case of melanoma (see above) and 0 per case of NMSC. The important thing in the analysis is to give a fair estimate of the number of deaths which can be prevented by reducing the incidence. This will be achieved, since the proportionate reductions in incidence of the two types of cancer are approximately equal.

Table 16. Background calculations for malignant melanoma – males aged 12

A Age	B Survivors from 100,000 live births to given age	C Life expectancy (years) from given age	D Survival rate from age 12 to given age	E Incidence per 100,000 at given age	F Expected number of cases in five year age band	G Expected cases discounted at 3.5% back to age 12	H Expected fatalities in five year age band	I Expected life years lost	J Expected fatalities discounted to age 12	K Life expectancy discounted to age at death	L Expected life years lost discounted to age 12
12	99277.1	65.99	1.000	0.1							
17	99170.7	61.06	0.999	1.3	6.644	5.594	1.661	101.417	1.398	19.693	27.540
22	98871.9	56.24	0.996	2.7	13.198	9.356	3.299	185.557	2.339	19.164	44.823
27	98522.9	51.43	0.992	4.7	23.248	13.876	5.812	298.909	3.469	18.572	64.427
32	98111.0	46.63	0.988	6.9	34.312	17.244	8.578	399.996	4.311	17.906	77.194
37	97562.2	41.88	0.983	10.1	49.434	20.918	12.358	517.572	5.229	17.159	89.731
42	96862.6	37.16	0.976	13.1	63.896	22.765	15.974	593.590	5.691	16.310	92.823
47	95831.6	32.53	0.965	13.5	65.348	19.603	16.337	531.440	4.901	15.351	75.231
52	94240.7	28.04	0.949	18.2	86.590	21.870	21.648	606.997	5.468	14.273	78.036
57	91766.7	23.72	0.924	27.5	127.001	27.008	31.750	753.115	6.752	13.062	88.192
62	88058.3	19.61	0.887	30.3	134.294	24.046	33.574	658.378	6.011	11.710	70.395
67	82221.6	15.81	0.828	38.1	157.799	23.789	39.450	623.699	5.947	10.240	60.903
72	73711.3	12.33	0.742	46.7	173.474	22.020	43.369	534.735	5.505	8.658	47.660
77	61279.2	9.29	0.617	49.7	153.408	16.396	38.352	356.291	4.099	7.040	28.856
82	44548.8	6.81	0.449	56.3	126.362	11.371	31.591	215.132	2.843	5.517	15.684
87	26031.4	4.90	0.262	57.2	74.970	5.680	18.742	91.838	1.420	4.193	5.954
92	10829.4	3.45	0.109	57.2	31.188	1.990	7.797	26.900	0.497	3.084	1.534
97	2681.6	2.41	0.027	57.2	7.723	0.415	1.931	4.653	0.104	2.225	0.231
				sum	1329	264	332	6500	66		869

Legend: more detailed explanation in text

Table 17. Background calculations for malignant melanoma – females aged 12

A Age	B Survivors from 100,000 live births to given age	C Life expectancy (years) from given age	D Survival rate from age 12 to given age	E Incidence per 100,000 at given age	F Expected number of cases in five year age band	G Expected cases discounted at 3.5% back to age 12	H Expected fatalities in five year age band	I Expected life years lost	J Expected fatalities discounted to age 12	K Life expectancy discounted to age at death	L Expected life years lost discounted to age 12
12	99416.2	70.13	1.000	0.2							
17	99345.9	65.18	0.999	2.4	11.929	10.044	2.982	194.377	2.511	20.103	50.477
22	99221.4	60.26	0.998	6.5	32.589	23.103	8.147	490.953	5.776	19.609	113.258
27	99079.7	55.34	0.997	11.3	56.091	33.480	14.023	776.016	8.370	19.058	159.515
32	98898.3	50.44	0.995	13.0	64.895	32.614	16.224	818.329	8.154	18.441	150.359
37	98630.1	45.57	0.992	15.3	76.024	32.169	19.006	866.108	8.042	17.748	142.733
42	98210.9	40.75	0.988	17.7	87.219	31.074	21.805	888.547	7.769	16.966	131.802
47	97548.3	36.01	0.981	20.1	98.429	29.527	24.607	886.110	7.382	16.085	118.730
52	96464.5	31.39	0.970	21.9	106.022	26.778	26.506	832.009	6.695	15.092	101.037
57	94811.0	26.89	0.954	25.2	120.210	25.564	30.053	808.112	6.391	13.968	89.272
62	92355.7	22.53	0.929	28.1	130.461	23.359	32.615	734.822	5.840	12.692	74.123
67	88517.5	18.39	0.890	31.9	142.094	21.422	35.524	653.279	5.355	11.264	60.324
72	82647.8	14.51	0.831	33.2	138.027	17.520	34.507	500.692	4.380	9.679	42.394
77	73324.6	11.01	0.738	39.9	147.075	15.719	36.769	404.824	3.930	7.985	31.380
82	59006.5	8.04	0.594	39.4	116.820	10.512	29.205	234.808	2.628	6.298	16.551
87	39961.4	5.65	0.402	42.4	85.310	6.464	21.327	120.500	1.616	4.731	7.644
92	19911.6	3.85	0.200	42.4	42.507	2.712	10.627	40.913	0.678	3.400	2.305
97	5903.4	2.71	0.059	42.4	12.603	0.677	3.151	8.538	0.169	2.479	0.419
				sum	1468	343	367	9259	86		1292
				MF mean	1399	303	350	7880	76		1081

Legend: more detailed explanation in text

The calculations for malignant melanoma are based on applying the intervention to a 12-year-old and are shown in Table 16 (males) and Table 17 (females). Explanation of the tables is as follows. Columns B and C are extracted from life tables (Government Actuary's Department, 2009) and show respectively the expected number of survivors to the given age from 100,000 live births and the life expectancy remaining. Column D is calculated from column B and shows the probability of a 12-year-old surviving to the given age.

Column E shows age-dependent incidence data (Cancer Research UK, 2009b) per 100,000, and then 5 times the product of the numbers in columns D and E gives column F, the expected number of cases within a five-year age range for 100,000 12-year-olds. Column G discounts the values in column F at 3.5% back to age 12. Column H is the expected number of fatalities based on a 25% fatality rate and column I is obtained by multiplying the numbers in columns C and H to give the undiscounted life years lost due to skin cancer. For discounted values, column J discounts the values from column H back to age 12, and then column K discounts the life expectancy back to the age of death. Multiplying these columns together gives us (column L) the expected life years lost, correctly discounted back to age 12.

Summing the relevant columns and assuming that the intervention is applied to equal numbers of boys and girls, we find that for every 100,000 12-year-olds, the expected lifetime number of cases of malignant melanoma is 1,399 (303 discounted at 3.5%), the expected number of cases of NMSC is 13,990 (3,030 discounted), the expected number of skin cancer deaths is 350 (76 discounted) and the expected number of life years lost is 7,880 (1,080 discounted). Note that discounting has a heavier impact on the life years lost than on other figures, because life years lost are potentially later in life than onset of a cancer. These numbers were used for the base case analysis. For sensitivity analysis, the values calculated for males and females separately were taken as limits of a uniform distribution.

Tables 18 to 21 show equivalent calculations for ages 22 and 42.

Table 18. Background calculations for malignant melanoma – males aged 22

A Age	B Survivors from 100,000 live births to given age	C Life expectancy (years) from given age	D Survival rate from age 22 to given age	E Incidence per 100,000 at given age	F Expected number of cases in five year age band	G Expected cases discounted at 3.5% back to age 22	H Expected fatalities in five year age band	I Expected life years lost	J Expected fatalities discounted to age 22	K Life expectancy discounted to age at death	L Expected life years lost discounted to age 22
22	98871.9	56.24	1.000	2.7							
27	98522.9	51.43	0.996	4.7	23.343	19.654	5.836	300.134	4.914	18.572	91.253
32	98111.0	46.63	0.992	6.9	34.453	24.424	8.613	401.636	6.106	17.906	109.336
37	97562.2	41.88	0.987	10.1	49.636	29.627	12.409	519.693	7.407	17.159	127.093
42	96862.6	37.16	0.980	13.1	64.157	32.243	16.039	596.023	8.061	16.310	131.472
47	95831.6	32.53	0.969	13.5	65.616	27.765	16.404	533.618	6.941	15.351	106.555
52	94240.7	28.04	0.953	18.2	86.945	30.977	21.736	609.484	7.744	14.273	110.529
57	91766.7	23.72	0.928	27.5	127.521	38.253	31.880	756.201	9.563	13.062	124.913
62	88058.3	19.61	0.891	30.3	134.845	34.058	33.711	661.076	8.515	11.710	99.706
67	82221.6	15.81	0.832	38.1	158.445	33.695	39.611	626.255	8.424	10.240	86.262
72	73711.3	12.33	0.746	46.7	174.185	31.188	43.546	536.926	7.797	8.658	67.505
77	61279.2	9.29	0.620	49.7	154.037	23.222	38.509	357.751	5.806	7.040	40.872
82	44548.8	6.81	0.451	56.3	126.880	16.105	31.720	216.014	4.026	5.517	22.215
87	26031.4	4.90	0.263	57.2	75.277	8.045	18.819	92.214	2.011	4.193	8.434
92	10829.4	3.45	0.110	57.2	31.316	2.818	7.829	27.010	0.705	3.084	2.173
97	2681.6	2.41	0.027	57.2	7.755	0.588	1.939	4.672	0.147	2.225	0.327
				sum	1314	353	329	6239	88		1129

Legend: more detailed explanation in text

Table 19. Background calculations for malignant melanoma – females aged 22

A Age	B Survivors from 100,000 live births to given age	C Life expectancy (years) from given age	D Survival rate from age 22 to given age	E Incidence per 100,000 at given age	F Expected number of cases in five year age band	G Expected cases discounted at 3.5% back to age 22	H Expected fatalities in five year age band	I Expected life years lost	J Expected fatalities discounted to age 22	K Life expectancy discounted to age at death	L Expected life years lost discounted to age 22
22	99221.4	60.26	1.000	6.5							
27	99079.7	55.34	0.999	11.3	56.201	47.320	14.050	777.539	11.830	19.058	225.454
32	98898.3	50.44	0.997	13.0	65.023	46.096	16.256	819.936	11.524	18.441	212.513
37	98630.1	45.57	0.994	15.3	76.174	45.467	19.043	867.808	11.367	17.748	201.734
42	98210.9	40.75	0.990	17.7	87.391	43.919	21.848	890.291	10.980	16.966	186.285
47	97548.3	36.01	0.983	20.1	98.623	41.732	24.656	887.849	10.433	16.085	167.809
52	96464.5	31.39	0.972	21.9	106.230	37.848	26.558	833.642	9.462	15.092	142.802
57	94811.0	26.89	0.956	25.2	120.446	36.131	30.112	809.699	9.033	13.968	126.174
62	92355.7	22.53	0.931	28.1	130.717	33.016	32.679	736.264	8.254	12.692	104.762
67	88517.5	18.39	0.892	31.9	142.373	30.277	35.593	654.562	7.569	11.264	85.260
72	82647.8	14.51	0.833	33.2	138.298	24.763	34.574	501.675	6.191	9.679	59.918
77	73324.6	11.01	0.739	39.9	147.364	22.216	36.841	405.619	5.554	7.985	44.352
82	59006.5	8.04	0.595	39.4	117.049	14.858	29.262	235.269	3.714	6.298	23.393
87	39961.4	5.65	0.403	42.4	85.477	9.135	21.369	120.737	2.284	4.731	10.804
92	19911.6	3.85	0.201	42.4	42.591	3.833	10.648	40.994	0.958	3.400	3.257
97	5903.4	2.71	0.059	42.4	12.627	0.957	3.157	8.555	0.239	2.479	0.593
				sum	1427	438	357	8590	109		1595

Legend: more detailed explanation in text

Table 20. Background calculations for malignant melanoma – males aged 42

A Age	B Survivors from 100,000 live births to given age	C Life expectancy (years) from given age	D Survival rate from age 42 to given age	E Incidence per 100,000 at given age	F Expected number of cases in five year age band	G Expected cases discounted at 3.5% back to age 42	H Expected fatalities in five year age band	I Expected life years lost	J Expected fatalities discounted to age 42	K Life expectancy discounted to age at death	L Expected life years lost discounted to age 42
42	96862.6	37.16	1.000	13.1							
47	95831.6	32.53	0.989	13.5	66.977	56.393	16.744	544.687	14.098	15.351	216.421
52	94240.7	28.04	0.973	18.2	88.749	62.916	22.187	622.127	15.729	14.273	224.491
57	91766.7	23.72	0.947	27.5	130.167	77.695	32.542	771.888	19.424	13.062	253.707
62	88058.3	19.61	0.909	30.3	137.642	69.174	34.410	674.789	17.294	11.710	202.510
67	82221.6	15.81	0.849	38.1	161.732	68.436	40.433	639.246	17.109	10.240	175.204
72	73711.3	12.33	0.761	46.7	177.799	63.346	44.450	548.064	15.836	8.658	137.107
77	61279.2	9.29	0.633	49.7	157.232	47.166	39.308	365.172	11.792	7.040	83.013
82	44548.8	6.81	0.460	56.3	129.512	32.711	32.378	220.495	8.178	5.517	45.120
87	26031.4	4.90	0.269	57.2	76.838	16.340	19.210	94.127	4.085	4.193	17.130
92	10829.4	3.45	0.112	57.2	31.966	5.724	7.991	27.571	1.431	3.084	4.413
97	2681.6	2.41	0.028	57.2	7.915	1.193	1.979	4.769	0.298	2.225	0.664
				sum	1167	501	292	4513	125		1360

Legend: more detailed explanation in text

Table 21. Background calculations for malignant melanoma – females aged 42

A Age	B Survivors from 100,000 live births to given age	C Life expectancy (years) from given age	D Survival rate from age 42 to given age	E Incidence per 100,000 at given age	F Expected number of cases in five year age band	G Expected cases discounted at 3.5% back to age 42	H Expected fatalities in five year age band	I Expected life years lost	J Expected fatalities discounted to age 42	K Life expectancy discounted to age at death	L Expected life years lost discounted to age 42
42	98210.9	40.75	1.000								
47	97548.3	36.01	0.993	20.1	99.637	83.892	24.909	896.984	20.973	16.085	337.341
52	96464.5	31.39	0.982	21.9	107.323	76.084	26.831	842.220	19.021	15.092	287.070
57	94811.0	26.89	0.965	25.2	121.685	72.633	30.421	818.030	18.158	13.968	253.642
62	92355.7	22.53	0.940	28.1	132.062	66.370	33.016	743.840	16.592	12.692	210.600
67	88517.5	18.39	0.901	31.9	143.838	60.865	35.960	661.296	15.216	11.264	171.394
72	82647.8	14.51	0.842	33.2	139.721	49.779	34.930	506.837	12.445	9.679	120.450
77	73324.6	11.01	0.747	39.9	148.880	44.661	37.220	409.793	11.165	7.985	89.159
82	59006.5	8.04	0.601	39.4	118.253	29.868	29.563	237.689	7.467	6.298	47.027
87	39961.4	5.65	0.407	42.4	86.357	18.365	21.589	121.979	4.591	4.731	21.719
92	19911.6	3.85	0.203	42.4	43.029	7.705	10.757	41.416	1.926	3.400	6.548
97	5903.4	2.71	0.060	42.4	12.757	1.923	3.189	8.643	0.481	2.479	1.192
				sum	1154	512	288	5289	128		1546

Legend: more detailed explanation in text

Appendix 3. Details of costing calculations

Buller (1994)

The study by Buller and colleagues aimed to assess the effectiveness of the Sunshine and Skin Health curriculum, which comprises of five multidisciplinary units, each of which contains lesson material, in-class activities, take-home activities and a student/ parent newsletter. Each unit was presented by a school teacher and lasted for approximately one hour.

The most significant cost component for this intervention is the opportunity cost of teachers' time spent on delivering the sun safety lessons instead of the standard curriculum. To estimate this cost, we calculated a school teacher's annual salary plus overhead costs at £44,800 (Average salary on March 2004= £27,820 inflated to 2008 multiplied by a factor of 1.4 to account for overheads). Assuming there are on average 26 students in a class and 950 hours of teaching per year the cost per student for the five lessons was estimated to be:

$$\text{Cost per student} = \frac{(£47.16\,(\text{cost of teachers time for a one hour lesson}) \times 5\,\text{lessons})}{26\,\text{students}}$$

= £9.07.

Buller (1997)

The intervention considered in this report is an interactive sun safety fair, featuring a number of activity stations (a life-size board game quiz, a puppet show, sunblock display, a presentation about sun overexposure and a game about sun safe clothes), video presentation, a presentation of the ultraviolet light using prisms and a presentation on skin type and skin-self examination. The intervention took place in three public elementary schools. Each class of students spent between 45 and 60 minutes attending the fair.

We assumed that in the UK this intervention would require the input of 5 community nurses. Estimates of the per hour cost of community nurse services to NHS (£29) were obtained by Curtis (2008). Assuming each class spent on average 68 minutes on attending the fair and comprised of 26 students, we calculated cost per student attending the fair as follows: Cost per student = (£29 × 5 nurses × 1.13 hours) / 26

students. This gave a cost of £6.32 per student. The per student cost of the material used for the fair (board game quiz, puppet show etc) is considered negligible as the material can be re-used many times for the purposes of the intervention.

Buller (2006)

The intervention involved six 50-minute lessons based on the Sunny Days Healthy Ways curriculum. The aim of the lessons was to teach the following skills: selecting and applying sunscreen; selecting sun protective clothing, hats and sunglasses; using shade and minimizing time in the sun.

The most significant cost component for this intervention is the opportunity cost of teachers' time spent on delivering the sun safety lessons instead of the standard curriculum. To estimate this cost, we calculated a school teachers' annual salary plus overhead costs at £44,800. (Average salary on March 2004= £27,820 inflated to 2008 multiplied by a factor of 1.4 to account for overheads.) Assuming there are on average 26 students in a class and 950 hours of teaching per year the cost per student for the six lessons was estimated to be:

$$\text{Cost per student} = \frac{(£39.30\,(\text{cost of teachers time for a 50 minutes lesson}) \times 6\,\text{lessons})}{26\,\text{students}}$$

= £9.07. (This cost is of course equal to the cost per participant in the 1994 study, because the total teaching time is the same.)

The per student cost for the Sunny Days Health Ways material is considered negligible as the material can be re-used many times for the purposes of the intervention.

Bauer (2005)

The intervention involved participating parents receiving an initial educational session and an educational letter three times yearly with more detailed information on proper sunscreen use and sun protection, as well as receiving brochures from public melanoma prevention campaigns with detailed information.

In the UK setting, we assumed that the initial educational session would delivering by a community nurse. Given that 25 participants attended the initial session, the cost of delivering the session to the public sector is estimated at:

$$\frac{\text{£29 (community nurse salary per hour obtained by Curtis (2008)}}{\text{25 participants}}$$

= £1.16 per participant.

The cost of a 3 page letter posted to participants three times a year is estimated according at £0.47, including to actual cost of the letter (£0.11 according to University of Birmingham Central Printing Unit) and postage cost (£0.36 for a 1st class- letter stamp). The cost of the 20 page brochure was estimated at £1.24, including the actual cost of the brochure (£0.72) and postage cost (£0.52 for a 1st class- large letter stamp). The total cost per participant cost of the intervention was estimated as:
Total cost per participant = £1.16 + (£0.47 × 3) + £1.24 = £3.80

Prochaska (2005)

The intervention involved mailing participants three computer generated reports at 0, 6 and 12 months. Each report was three to five pages long and was divided into sections about change and readiness to change behaviour, pros and cons of changing behaviour, feedback on participants' use of up to six change processes relevant to their stage of change, feedback on how to enhance self efficacy and strategies for taking small steps to progress to the next stage.

The cost of the intervention comprises of the cost of 3 three to five page letter and the postage cost of sending such letters. Assuming that the letter would be on average 4 page long, its actual cost was estimated at £0.14. Postage cost is £0.36 per letter.

The cost per participant (for one year) was estimated at:
Cost per participant = £0.14 (cost of letter) + £0.36 (postage cost) × 3 letters per year = £1.51

Borland (1991)

The assessed intervention was targeted at outdoor staff working in Telecom company. It involved providing a set of materials (posters and video) to each depot and a folder

of materials to each worker (brochure introducing the campaign, a letter from management, various brochures about sun protection and skin cancer). These resources were complimented by input from occupational health nurses.

The cost of providing material for this intervention, as estimated and reported in the Hocking (1991) study, was AU$3 per person in 1991. This cost was estimated at £2.22 by converting it into 2008 prices by using exchange and inflation rates obtained from the Bank of England.

The cost per participant of the input provided by an occupational health nurse, was calculated at £0.96 by using estimates of the per hour wage of an occupational health nurse from Curtis (2008). The total per participant cost of the intervention was estimated as follows:
Total cost per participant= £2.22 (cost per participant for material) + £0.96 (cost of occupational nurse input per participant) = £3.18

Mayer (1997)
The intervention assessed in this study involved a UV reduction curriculum presented in 4 five-minute classes at poolside by YMCA aquatics instructors and home-based activities for children and their parents.

The cost of this intervention consists of the opportunity cost of the presenter's time spent on the curriculum. Assuming an average salary of £9.10 per hour for YMCA instructors (US $13) and aquatics class size ranging from 2 to 7 children (average 4 children) the cost per children for the 4 five-minute presentation is estimated at £0.76. The materials' cost for the home based activities was estimated at £5 per children, resulting in a total cost of £5.76 per participating children.

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