Chapter 3

Human use of sunscreens

Availability

Sunscreen products are available for general public use as a consumer product all over the world. There is thus no constraint on the availability of approved sunscreens, other than cost. Sunscreens are distributed in numerous ways, e.g. in many types of outlets and in pharmacies as over-the-counter products. They are also sold directly by physicians (e.g. in the USA), by hospitals (e.g. in Italy) and by cancer control organizations and cancer charities (e.g. in Australia). In Australia, the availability of sunscreens has been maximized through sales tax exemptions; sunscreens are also available in the work place as part of occupational health and safety programmes; they are widely available in schools, and their use by children is actively promoted. In contrast, in the USA, sunscreens are rarely promoted by schools, in part because of fear of litigation, as these products are classified as drugs.

Regulation

Regulatory control strongly influences the availability of specific sunscreen formulations in most countries. Sunscreens are currently regulated as cosmetics in the European Union (Janousek, 1997), in Japan (Fukuda & Naganuma, 1997), in South Africa, in South America and in Taiwan. Sunscreens are regulated as drugs in Australia, Canada, New Zealand and the USA through procedures specific to each country. Australia and New Zealand maintain a standard for the acceptable method of determining the effectiveness of sunscreens available in those countries (Australian/New Zealand Standards, 1998). Canada's regulation calls for independent evaluation of the safety and effectiveness of sunscreens (Health Canada, 1999). In the USA, several monographs of the Food and Drug Administration (1993, 1998, 1999) list previously approved sunscreens and their active ingredients with acceptable labelling information. The monographs also prescribe detailed methods for determining the effectiveness of each formulation to be marketed, whether or not the active ingredients were previously approved. Furthermore, any new sunscreen active ingredient must fulfil the testing requirements for safety associated with a 'new drug application' before it is approved for marketing in the USA. Of the sunscreen ingredients approved by the Food and Drug Administration, about 15 are still in use, and fewer than half of these account for the bulk of the US market (Murphy, 1997).

Whether they are regulated as cosmetics or drugs, sunscreens are tested toxicologically by the procedures mandated in each country and, in Europe, by the European Commission (1976). Panels of experts and regulatory staff reviewers judge the adequacy of the data on preclinical and clinical safety. The emphasis is usually placed on detecting cutaneous or ocular irritancy or contact sensitivity, but the respective agencies in Canada and the USA anticipate inclusion of data from photocarcinogenesis testing before approval of new sunscreen ingredients (Health Canada, 1999; Food & Drug Administration, 2000).

A directive of the European Commission (2000) mandated that a list of 'full ingredient labelling' in decreasing order of concentration be included on the label of the container of all cosmetics, including sunscreen formulations.

Production

Regrettably, there is no data collection system in place that would make it possible to estimate the total annual use of sunscreen products on a country-by-country basis. The world market for sunscreen formulations and related products was estimated as US$ 3.47 thousand million for the calendar year 1998, the most recent year for which trade journal figures were available. Eight countries accounted for 70% of the consumption in dollar terms: Canada, France, Germany, Italy, Japan, Spain, the United Kingdom and the USA. For the category of sunscreens alone, the European Union and the USA represent about 75% of the world wide market. Table 4 gives estimates of the numbers of units of sunscreen products and the volume of UVR filters sold in 1998.

In the European Union 55% of the market is for sunscreens with a 0–8 labelled SPF, 16% for SPF 9–14 or 15–24, and 13% for SPF > 25. In Germany there is a clear tendency to use of higher-SPF products.

Table 4. Amounts of sunscreen products and UVR filters sold annually worldwide

Area	Estimated number of units (thousands)	Estimated volume of UV filters (t)
USA[a]	163 000	2934
European Union[b]	227 775	4100
Rest of the world[c]	130 225	2164
World	521 000	9198

[a] According to Kline & Co. Inc., the estimated number of units of sunscreen products sold in the USA in 1998 was 163 million. If the average concentration of UV filters is 15%, and the volume/unit is 120 g, the volume sold is 2934 t.

[b] The volume of UV filters was estimated at 4100 t. This results in an estimated number of 227 775 thousand units.

[c] The volume for the rest of the world is estimated by assuming that it represents 25% of world sales.

Sun exposure and protection

Exposure to sunlight

The UVR to which an individual is exposed depends on :

- ambient sunlight,
- the fraction of ambient exposure received on different anatomical sites and
- behaviour and time spent outdoors.

The UVR dose absorbed by the skin is further modified by the use of photoprotective agents such as hats, clothing and sunscreens.

The maximum daily exposure to ambient sunlight under clear summer skies represents about 70 standard erythemal doses (SEDs) in the tropics (10–30°), 60 SED at latitudes approximating those of southern Europe (around 40°) and 45 SED at temperate latitudes (50–60°) (Roy *et al.*, 1996). The SED is a measure of erythemal UVR (Commission Internationale de l'Éclairage, 1998). Just perceptible reddening (minimal erythema) of unacclimatized skin requires exposure to about 1.5 SED for individuals who burn easily and never tan (skin type I) (Lock-Andersen *et al.*, 1998), about 2 SED for people who burn easily but tan minimally (skin type II) and 3 SED for those who burn but tan readily (skin type III) (Weinstock, 1992). Clinical studies have shown no difference in the erythemal response to UVR between children (< 15 years) and adults (Cox *et al.*, 1992).

Sun exposure of adults

Estimates of personal exposure can be obtained in two ways: by direct measurement with UVR-sensitive film badges (Diffey, 1989a) or by independent determination of ambient sunlight, the fraction of ambient exposure received on different anatomical sites and behaviour and time spent outdoors, either by measurement, modelling or a combination of the two (Parisi *et al.*, 2000) (Fig. 15). The results obtained from a number of studies in northern Europe (Challoner *et al.*, 1976; Leach *et al.*, 1978; Larkö & Diffey, 1983; Schothorst *et al.*, 1985; Webb, 1985; Slaper, 1987; Knuschke & Barth, 1996) indicate that indoor workers received an annual exposure of around 200 SED, mainly from exposure during weekends and holidays (Fig. 15) and principally on the hands, forearms and face. This value is approximately 5% of the total ambient sunlight available. It must be stressed, however, that there are large variations in the annual doses received by individuals within a given population group, depending on the propensity for outdoor activities.

Outdoor workers at the same latitudes receive two to three times these doses (Larkö & Diffey, 1983; Webb, 1985), while studies of three groups of outdoor workers on the Sunshine Coast in Queensland, Australia (27° S) wearing film badges suggested that the annual exposure would be considerably higher — certainly in excess of 1000 SED per year (Gies *et al.*, 1995).

Sun exposure of children and adolescents

Few longitudinal studies have been conducted on children's exposure to the sun (Diffey *et al.*, 1996; Gies *et al.*, 1998; Kimlin *et al.*, 1998a; Moise *et al.*, 1999a,b,c; O'Riordan *et al.*, 2000; Parisi *et al.*, 2000), and differences in the methods used in those that were conducted make detailed comparisons problematic. Table 5 summarizes the findings from three of these studies (Diffey *et al.*, 1996; Gies *et al.*, 1998; Moise *et al.*, 1999b). The median dose measured on the chest or shoulder as a percentage of the ambient sunlight is significantly lower for infants and small children than for older children and adolescents, even though the percentage of time spent outdoors between 8:00 and 18:00 is similar. There are two probable reasons for this. The infants were outside between 9:00 and

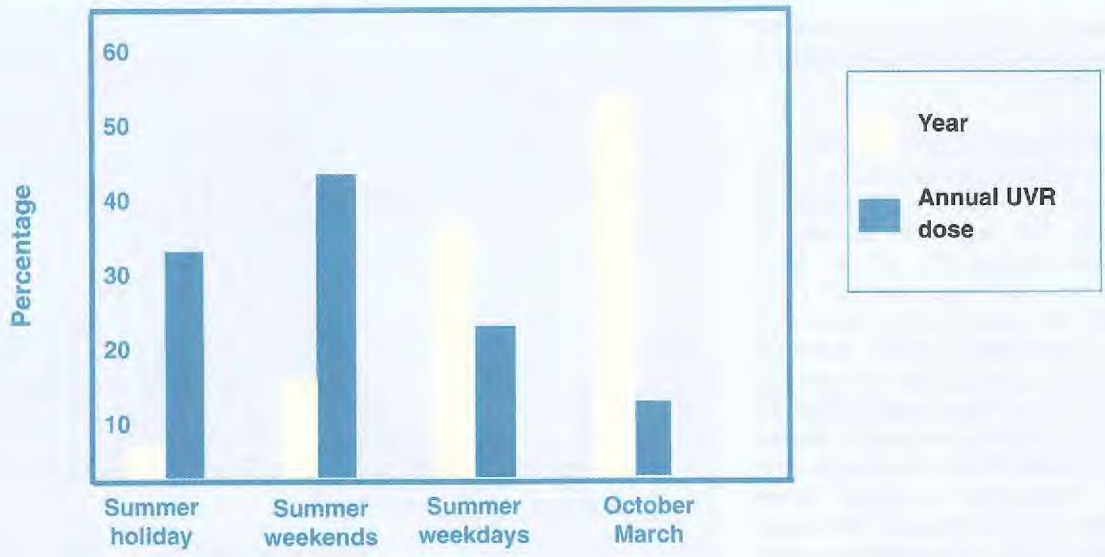

Figure 15 How adult indoor workers in northern Europe are exposed to sunlight (e.g. a 2-week summer holiday, 4% of the year, contributes 30% of the annual dose)

Table 5. Median exposure to UVR (expressed as per cent of ambient) and time spent outdoors between 8:00 and 18:00 for infants, children and adolescents in England and in Queensland, Australia

Age (years)	Location	Season	% ambient UVR	% time ourdoors	Reference
1	Queensland	Spring	0.7	17	Moise *et al.* (1999b)
2	Queensland	Autumn	1.6	25	Moise *et al.* (1999b)
9–10	England	Spring/Summer	6.6	24	Diffey *et al.* (1996)
12	Queensland	Summer	7.0	21	Gies *et al.* (1998)
14–15	England	Spring/Summer	4.5	17	Diffey *et al.* (1996)

16:00, when the UVR intensity is high, for only 5% of the time during weekdays and 9% at weekends; they were therefore exposed most of the time when the ambient UVR intensity was relatively low. Secondly, infants and small children are more likely to be under the supervision of adults than are older children, and such supervision may well involve the use of shade as a means of limiting exposure to UVR.

The annual ambient dose of UVR in England is typically 3000–4000 SED, which is considerably less than that in Queensland where it is 11 000–15 000 SED. Behaviour can be equally, or more, important than the ambient UVR dose in determining an individual's exposure (Diffey & Saunders, 1995; Diffey, 1996). Figure 16 shows the distribution of daily outdoor exposure of English children (1575 child-days) and children in Queensland (568 child-days) to UVR in two of the studies summarized in Table 5 (Diffey *et al.*, 1996; Gies *et al.*, 1998). While the median daily personal exposure in Queensland was twice that received in England, there was a wide overlap between the two distributions: on any one day, the daily exposure of 17% of English children exceeded the median exposure of the children in Queensland, and the exposure of 26% of the

Queensland children was less than the median for the English children (Diffey & Gies, 1998).

Trends in population sun exposure

An important factor that has increased the dose of people living in temperate latitudes has been the increase in overseas holidays (Fig. 17). In recent years the most rapid trends in destinations for foreign holiday travel have been to low-latitude regions where the UVR dose is typically high. For example, holiday visits by British people to the USA (where Florida is the most popular destination) increased 15-fold in the 20 years up to 1997. Participation in outdoor leisure activities has also increased, with consequential increases in exposure to sunlight (Office of National Statistics, 1998).

Anatomical distribution of sunlight

Table 6 shows the mean percentages of ambient UVR relative to the top of the head received at various anatomical sites, as measured on rotating mannekins and living subjects pursuing outdoor activities such as tennis, sailing, swimming, walking, golf and gardening. The shoulders generally receive the greatest relative exposure in all activities (approximately two-thirds of that on the top of the head), with greater variation among the other sites, reflecting differences in posture for the different activities.

Facial exposure to sunlight

The face is particularly prone to solar damage (Fig. 18) because it receives significantly more exposure than other anatomical sites, which are usually covered when outside. A number of workers have used UVR-sensitive film badges to measure the exposure of the face relative to ambient exposure for both human subjects (Holman *et al.*, 1983; Rosenthal *et al.*, 1990; Melville *et al.*, 1991; Rosenthal *et al.*, 1991) and mannekins (Diffey *et al.*, 1977, 1979; Gies *et al.*, 1988; Diffey & Cheeseman, 1992; Gies *et al.*, 1992; Airey *et al.*, 1995; Kimlin *et al.*, 1998b). The data vary considerably, reflecting factors such as positioning of film badges on the face, behaviour of individuals, solar altitude and shade, but representative values for various sites on the face are given in Table 7. The variation is explained partly by the posture or angle at which the head is held. In a study of the effect of head tilt on relative exposure over the face, Airey *et al.* (1995) showed that the exposure of the nose relative to the horizontal dropped from 59% to 11% as the head tilted from 0° to 60° to the normal. Wearing a hat can modify the exposure of

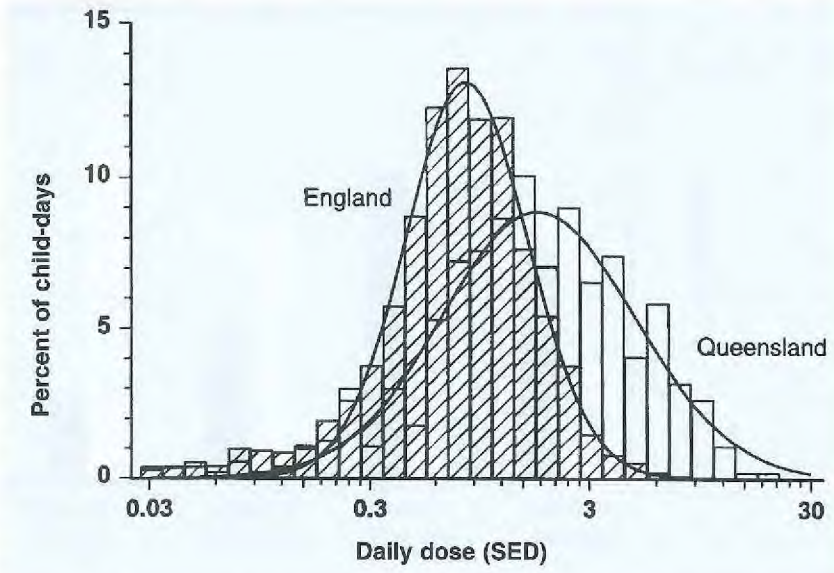

Figure 16 Distribution of daily personal outdoor exposure to UVR of English children and children in Queensland, Australia. Smooth curves are log-normal distributions obtained by regression analysis. SED, standard erythemal dose

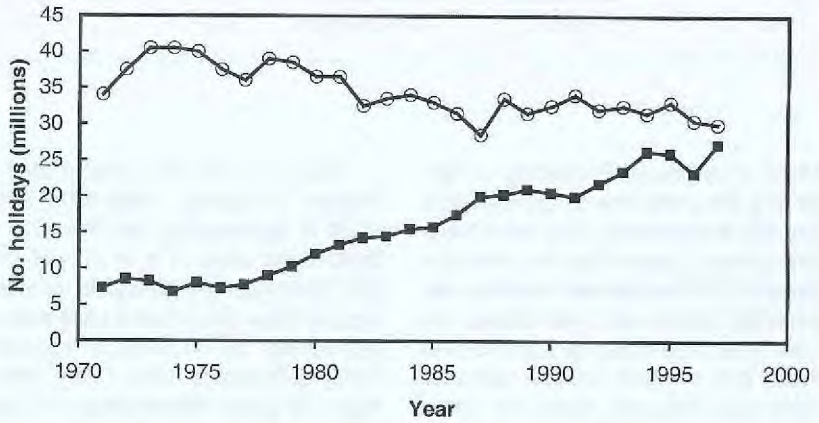

Figure 17 Domestic (open circles) and overseas (closed squares) holidays taken by British residents

Table 6. Exposure to sunlight (relative to 100% on the top of the head) of rotating mannekins and living subjects engaged in tennis, golf, gardening or walking

Site	Mannekin		Living subjects	
	Diffey *et al.* (1977)	Gies *et al.* (1992)	Holman *et al.* (1983)	Herlihy *et al.* (1994)
Cheek	31	24	15	13
Hand	50	–	24	29
Shoulder	75	94	66	43
Back	43	36	58	40
Chest	68	50	44	23
Thigh	33	–	16	25

the face, especially if the hat has a wide brim (Diffey & Cheeseman, 1992; Wong *et al.*, 1996) (Fig. 19).

Influence of clothing on exposure

Most summer clothing provides protection factors against sunburn greater than 10; measurements of over 5000 fabrics submitted for testing to the Australian Radiation Laboratory revealed that 97% of fabrics fell into this category (Gies *et al.*, 1996). More than 85% of fabrics had protection factors of 20 or more. Studies on the spectral transmission of textiles (Robson & Diffey, 1990) showed that many materials absorb more or less uniformly over the solar UVR spectrum. In other words, most clothing, in common with other forms of shade such as trees, canopies and beach umbrellas, provides principally a quantitative rather than a qualitative change in cutaneous exposure to UVR. Factors that affect the protection offered by fabrics against sunlight include weave, colour, weight, stretch and wetness (Gies *et al.*, 1994).

Exposure to the sun and sunscreens

When sunscreens are used to prevent sunburn, how high should the SPF be to satisfy this requirement for the average person? The maximum daily ambient dose of UVR under clear summer skies is about 70 SED in the tropics (10–30°) and about 45 SED in temperate latitudes (50–60°). These maximum ambient doses will not be received, simply because it would be unrealistic to lie in the sun all day without moving. An assiduous sunbather might spend half the time supine and half the time prone, resulting in a maximum exposure on much of the body surface of 50% of the ambient dose. For upright subjects engaging in outdoor pursuits such as gardening, walking or tennis, the exposure relative to ambient on commonly exposed sites such as the chest, shoulder, face, forearms and lower legs ranges from about 20% to 60% (Table 7). Thus, someone who is on holiday in southern Europe would receive a daily exposure of no more than 20 SED over much of the body surface. Since a dose of 2–3 SED is necessary to induce minimal erythema on unacclimatized white skin, a photoprotective device (sunscreen or clothing) need have an SPF of only 10 to prevent sunburn. For exposure to the tropical sun, an SPF of 15 should be adequate for all-day exposure.

If sunscreens of SPF 15 are sufficient to protect against sunburn even with all-day exposure in tropical sunshine, why were people who usually or always used a high-factor (≥ 15) sunscreen more likely to report sunburn than those who rarely or never used sunscreens? Conversely, and not surprisingly, fewer people who usually or always sought shade, wore a hat or wore clothes

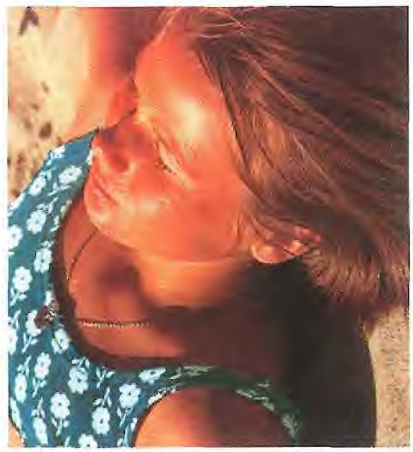

Figure 18 Intentional exposure to the sun for heavy suntanning effect

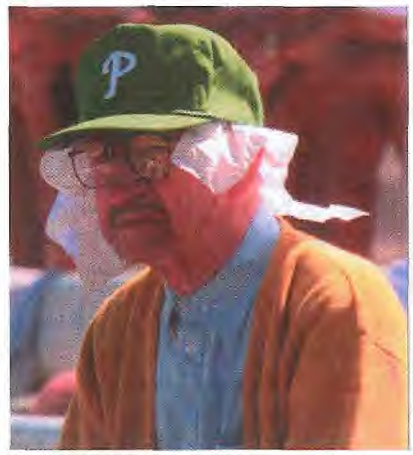

Figure 19 Head protection against the sun

Table 7. Exposure to sunlight on the head in studies on living subjects and mannekins

Site	Relative exposure
Top of head	100
Forehead	20–65
Nose	20–65
Cheek	15–40
Chin	20–35
Back of neck	20–35

got sunburnt than those who rarely or never did so (Dixon *et al.*, 1997). The protection against sunburn conferred by a sunscreen — defined by its SPF — is assessed by phototesting *in vivo* at an internationally agreed application thickness of 2 mg/cm^2 (Fig. 20). Approximately 35 ml of sunscreen would need to be applied to the total body surface of an adult to achieve the SPF quoted on the packaging. Yet, a number of studies have shown that consumers typically apply 0.5–1.5 mg/cm^2 (Stenberg & Larkö, 1985; Bech-Thomsen & Wulf, 1992; Diffey & Grice, 1997; Gottlieb *et al.*, 1997; Azurdia *et al.*, 1999). As application thickness has a significant effect on the degree of protection, most users probably achieve a mean value of 20–50% of that expected from the product label (Stokes & Diffey, 1997b). This problem is compounded by the likely variability of protection over the skin surface due to uneven application (Rhodes & Diffey, 1996). It is difficult to see which parts of the body have been missed when sunscreens are applied. Further, once a sunscreen has been applied to the skin, its adherence may be compromised by factors such as immersion in water (Stokes & Diffey, 1999a) and abrasion by beach sand (Stokes & Diffey, 2000). Therefore, people get sunburnt even when they use high-SPF sunscreens because inadequate amounts of sunscreen are applied, areas of the body are missed, and sunscreens are washed and/or rubbed off. There is some evidence to suggest that the numerical measure of protection indicated on the product pack is generally higher than that achieved in practice (Diffey, 2000), and experience has led consumers to realize that if they want to spend several hours in the sun and avoid sunburn, they must use products labelled with factors of 20, 30 or higher.

Behavioural considerations in sunscreen use

Since 1950, an increasing number of white people have used sunscreens, principally in Australia, Europe and North America. Sunscreen use has also become common among several non-white populations, such as in Japan. In the USA, sunscreen use by adults increased from 35 to 53% between 1986 and 1996 (Robinson *et al.*, 1997a). Between 1989 and 1995, the average yearly increase in sunscreens sold was 17.6% in Japan (Fukuda & Takata, 1997) and 9.6% in the USA. In Germany during the 1990s, sunscreen sales increased by 16.7% per year (Sauermann *et al.*, 1997).

Sunscreen use is included in 'sun-related behaviour', i.e. any behaviour that increases or decreases the exposure of the skin or eyes to sunlight (Hill *et al.*, 1993). Sun-related behaviour other than sunscreen use includes wearing protective clothing, hats or sunglasses (Fig. 21), seeking or remaining in the shade, scheduling activity or work to be indoors around solar noon and minimizing the time spent outdoors at high and low latitudes and in sunny seasons. Since cloud cover reduces UVR intensity at ground level, modulating outdoor activity to take into account local prevailing weather conditions is also sun-related behaviour.

While the purpose of sunscreens is to reduce the amount of UVR that reaches the epidermis, the underlying reasons that people use them include: to reduce the risk for skin cancer, to prevent sunburn, to promote suntanning by avoiding burns that blister, to protect the skin from photoageing, to take part in outdoor activities or simply to comply with the expectations of others. The motivations of other populations may be quite different. For instance, in Japan, sunscreen use is often based on a desire to prevent 'disgraceful' pigmented spots, and sunscreens are used frequently during daily activities (Fukuda & Takata, 1997).

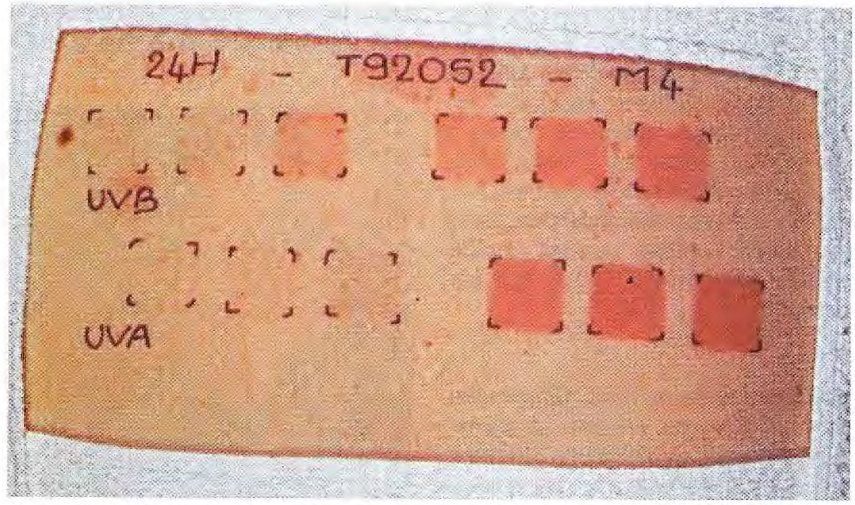

Figure 20 Both UVA and UVB induce erythema. The reactions, reproduced indoors by exposure of a volunteer to solar-simulated light attenuated by cut-off filters, are used to determine sun protection factors.

Figure 21 Sun-protective behaviour on the beach

Except for people who may use sunscreen routinely as a component of makeup, moisturizers and other anti-ageing products, sunscreen use (like other sun-related behaviour) is a contingent rather than a habitual behaviour. That is to say, it is contingent upon certain situations, such as a warm, sunny day. It therefore makes little sense to draw conclusions about an individual's predisposition to sun protection unless the prevailing conditions, in particular UVR intensity, can be estimated at the same time as the sun-related behaviour is recorded.

Another complication in the study of sun-related behaviour is that it is an alternative. It is false to conclude that people who do not use sunscreens are not interested in sun protection. Some of the studies considered in this section are open to the criticism that they assume that sunscreen use *per se* can be used as an indicator of a predisposition to sun protection or that it is valid to add sunscreen use as an item in scales that include other sun-related behaviour. Someone who remains indoors needs neither a sunscreen, a hat, nor clothing to be protected from UVR, even if it is midday at the equator.

Two types of exposure to the sun can be distinguished, during which sunscreen may be applied on uncovered parts of the skin. The primary purpose of intentional exposure to the sun is to achieve a biological response, such as a tan. During intentional exposure, significant portions of the trunk and limbs are frequently uncovered. Sunbathing is the most typical such behaviour. Intentional exposure to sources of UVR other than the sun has become popular with the increasing availability of artificial tanning devices. The randomized trial of the effect of use of sunscreens with different SPFs on duration of exposure (Autier *et al.*, 1999), described on p. 61, was conducted in situations of intentional exposure. Unintentional exposure to the sun occurs during daily life, with no specific intention to acquire a tan or to stay in the sun. Unintentional exposure to UVR sources other than the sun may occur at the workplace. During unintentional exposure to the sun, the uncovered body parts are generally the face, ears, neck and hands. The forearms and legs (especially of women) may also be uncovered, but the trunk is usually covered. The randomized trials of the ability of sunscreens to prevent non-melanocytic sun-induced lesions (Thompson *et al.*, 1993; Naylor *et al.*, 1995; Green *et al.*, 1999a,b; Gallagher *et al.*, 2000) were conducted in situations of unintentional exposure, with sunscreens (or placebo lotion) applied essentially on the face, ears, neck and hands.

A serious concern is that use of sunscreens, which reduces the most immediate adverse effect of the sun (sunburn), may actually increase total exposure to sunlight and therefore the risk for harm (Autier *et al.*, 1999). It is therefore important to understand both the behavioural consequences and the behavioural causes of sunscreen use.

It is difficult to assess actual sunscreen application from direct observation, and sunscreen use patterns have been assessed prospectively in few studies. Most of the data come from surveys in which people were asked directly whether they used a sunscreen when in the sun or about their knowledge about the properties of sunscreens. As sunscreen use has become a socially desirable behaviour which is widely promoted by cancer prevention campaigns and commercial advertising, it must be borne in mind that assessment of sunscreen use through questionnaires is subject to bias and over-reporting. There may be considerable discrepancy between knowledge about sun protection methods, self-reported sun protection and actual sun protection (von Schirnding *et al.*, 1991/92; Zinman *et al.*, 1995; Buller & Borland, 1999; Dixon *et al.*, 1999). The declared motives for using a sunscreen must be noted with caution, as they are likely to be influenced by the perception subjects have about the right answer (Buller & Borland, 1999). For these reasons, studies based only on knowledge of the properties of sunscreens have not been considered in this section.

What is known about the behavioural aspects of sunscreen use can be found in the answers to the following questions:

- Who uses sunscreens?
- Where and when do they use them?
- Why do they use them?
- How do they use them?
- What is their experience of using them?
- Which strategies to increase sunscreen use are effective?
- What effect does sunscreen use have on other sun-related behaviour, particularly the timing and scheduling of outdoor activities?

Who uses sunscreens and when and where they use them

There is great variation in the use of sunscreens by white-skinned populations, according to their natural susceptibility to the sun, socioeconomic status, attraction to sunlight, holiday habits, perception of skin cancer risk and background sun irradiation. Table 8 shows the sunscreen use reported by European subjects in two epidemiological studies conducted between 1988 and 1992, and the sunscreen use of European children as reported by parents in 1995–96. A South to North gradient in the proportion of children and adult sunscreen users is noticeable, paralleling the South to North gradient in natural susceptibility to sunlight prevailing in Europe. Sunscreen use is particularly high in Scandinavian countries, with use rates as high as 86–90% among Norwegian and Swedish adolescents (Wichstrom, 1994; Boldeman *et al.*, 1996).

The prevalence of sunscreen use in various samples, including summer and winter/snow settings, was reported in 79 studies (see Tables 9 and 10). Unfortunately, no standard metric has been used to quantify use, and in a number of studies in which data on sunscreen use were collected they were not reported separately because the authors' focus was on indices of sun protection, into which prevalence of sunscreen use was merged. There is thus considerable variation in the way in which the data were reported. In some studies, a point prevalence of use is reported; for instance people interviewed on the beach were asked "Are you using a sunscreen now?" and people in a telephone survey were asked "Were you using a sunscreen between 11:00 and 15:00 yesterday?" A question about typical use is often asked, such as "In summer, how often do you use a sunscreen when out of doors?" For simplicity of presentation and ease of comparison, only the highest category of typical use, or the sum of the two highest categories, is taken to indicate 'use' (for instance, the sum of 'always' and 'frequently'). The few studies in which only 'ever used' was reported have been excluded.

The prevalence of sunscreen use has been reported for populations and subpopulations in 15 countries covering latitudes ranging from 60° to 18°, but for very few specific locations, except the beach. Women are far more likely to use sunscreens than men, regardless of age, country, location or whether use is reported as habitual or at a specific time. In all the studies in which sex differences were reported, use was greater among female than male subjects. In 16 of these, the difference was ≥ 10%, and in eight it was ≥ 20% . Another noteworthy feature is the consistency of reported use by age group within studies. In all studies in which use on young children and adults was compared, the children's use was higher. In three studies in which adolescents were compared with adults, use by adolescents was lower. The mean prevalence of regular use (in studies of the prevalence of use always/frequent/often) was 60% (18 estimates in 12 studies) on children up to the age of 13, 32% (19 estimates in 12 studies) for adolescents and 44% (37 estimates in 22 studies) for adults.

Sunscreens are most often used during intentional exposure to the sun (Fig. 22). The mean prevalence of usual use in studies in which precautions at the beach and/or sunbathing were recorded expressly was 65% in children (five studies), 68% in adolescents and young adults (three studies) and 48% in adults (six studies). Studies of the prevalence of sunscreen use conducted at the beach tended to give higher use rates than those in other or unspecified

Table 8. Latitude and sunscreen use by European children in 1995–96 and by European adults in 1988–92

Country (city)	Children aged 6–7 years (%)		Adults who ever used sunscreen (%)
	Often/always use sunscreen when in the sun[a]	% of sunscreens with SPF ≥ 15[a]	
Sweden (Lund)	–	–	71[b]
Germany (Bochum)	69	63	62[c]
Belgium (Brussels)	62	69	50[c]
France (Lyon)	42	74	48[c]
Italy (Rome)	45	51	–

[a] From Autier *et al.* (1998)
[b] From Westerdahl *et al.* (1995), control subjects ≥ 15 years old
[c] From Autier *et al.* (1995), control subjects ≥ 20 years old

Table 9. Prevalence of sunscreen use in summer (who uses them and where they use them)

Reference	PP or H	Location of study	Year	Location of use	Study population and prevalence of sunscreen use	Other comments
Australia						
Hill *et al.* (1984)	H	Australia, Victoria	1982		Adult volunteers, recruited in workplaces, average 37 years When on vacation 53% When at work 37% On weekends 43%	Self-report 'Very often/always' use sunscreen
Hill *et al.* (1992)	PP	Australia, Victoria	1987–88	When outdoors	Melbourne residents, 14–69 years All 21% Males 16% Females 25%	Self-report Had applied a sunscreen (55% of sunscreens used were SPF ≥ 15)
Baade *et al.* (1996)	PP	Australia, Queensland	1988–89 and 1991–92	Summer weekends on Sunday while outside between 11:00 and 15:00	Residents 14–69 years 1988–89 25% 1991–92 33%	Self-report Used sunscreen on Sunday
Hill *et al.* (1993)	PP	Australia, Victoria	1988–90 (only 1990 data reported here)	When outdoors on the previous summer weekend between 11:00 and 15:00	Melbourne residents, 14–69 years Males / Females 14–29 years 16% / 24% 30–39 years 18% / 39% 40–69 years 9% / 26% Skin type (sensitivity) High 24% / 32% Medium 12% / 30% None 11% / 17%	Self-report Used sunscreen
Hill & Boulter (1996)	PP	Australia, Victoria	1988–95	11:00–15:00 on previous Sunday	Victorians 1988 1989 1990 1992 1995 19% 25% 24% 27% 34%	Self-report Used sunscreen
Pincus *et al.* (1991)	PP	Australia	1989 March	Queensland beach between 12:00 and and 14:30 (average temperature, 27 °C)	Beachgoers 2–78 years All 70% < 10 years (n = 8) 50% 10–19 years 57% 20–29 years 79% 30–39 years 62% ≥ 40 years 64%	Self-reports; parent proxy reports for children < 10 years 'Applied sunscreen on the day of survey'

Table 9. (Contd)

Reference	PP or H	Location of study	Year	Location of use	Study population and prevalence of sunscreen use	Other comments
Pincus *et al.* (1991) (contd)					Skin type: fair 76% medium 68% olive/dark 63%	
Bennetts *et al.* (1991)	PP	Australia	1989	Two Victorian beaches, temperature 30–37 °C	Children 8–12 years Observed to apply sunscreen 'when arrived at beach' 75% Reported they had used 'a SPF ≥ 15 sunscreen' 48%	Self-report and observation
Martin (1995)	H	Australia	1989 December	Adelaide	Patients ≥ 16 years 74%	Self-reports 'Used sunscreen'
Pratt & Borland (1994)	PP	Australia, Victoria	1990–91	On a surf beach between 11:30 and 16:00 on days > 25 °C	Adolescents, 15–20 years 74%	Self-report 'Wearing sunscreen on at least some parts of their body at time of interview'
Foot *et al.* (1993)	PP	Australia	1991	Beach	All 69% Children < 15 years ~85% Adults 15–29 years ~55% Adults ≥ 30 years ~60%	Parent proxy reports, self-reports 'SPF 15+ applied to at least one body region' (approximations from bar chart)
Green *et al.* (1999a)	H	Australia	1992	Nambour	Residents in sunscreen treatment group 75%	Self-reported compliance with 'Daily sunscreen application' at 12 months: head neck arms and hands 3–4 days per week
Whiteman *et al.* (1994)	PP	Australia, Northern Territories	1992 August–October	When sitting in the sun 11:00–13:00 at the Darwin markets	Non-Aboriginal people 3–76 years All 17% Past history of skin cancer 44% No history of skin cancer 11% NT residents 14%	Self-report interview 'Had applied' sunscreen
Watts *et al.* (1993)	H	Australia	1992 Summer	Adelaide	Survey participants 83% Males 73% Females 92%	'Used' sunscreen to avoid sunburn or getting too much sun

Table 9. (Contd)

Reference	PP or H	Location of study	Year	Location of use	Study population and prevalence of sunscreen use		Other comments
Segan *et al.* (1999)	H	Australia, Victoria	1993 November	When outside for > 15 min between 10:00 and 14:00 while on holiday in Queensland	Tourists, ≥ 17 years	90%	Self-report 'Always/usually or sometimes' used SPF ≥ 15 sunscreen
Whiteman *et al.* (1997)	H	Australia	1994		Queensland children 10–21 years at interview When on holiday Melanoma cases ≤ 15 years Controls ≤ 15 years When at school Melanoma cases ≤ 15 years Controls ≤ 15 years	 64% 54% 21% 13%	Children's retrospective self-reports 'Often/always' use sunscreen
Broadstock *et al.* (1996)	H	Australia, Victoria	1994	When outside for ≥ 1 h in summer between 11:00 and 15:00	Secondary students 12–17 years	27%	'Always' use SPF ≥ 15 sunscreen
Dobbinson *et al.* (1999)	H	Australia, Victoria	1995–96		Lifesavers When sunny VIC lifesavers NSW lifesavers When no sun VIC lifesavers NSW lifesavers	 97% 85% 76% 54%	'Regularly' use sunscreen on patrol
Pruim *et al.* (1999)	H	Australia, Nambour	1996	When in sun	Residents ≥ 29 years	36%	Self-report 'Usually' wore sunscreen in last 3 months (of those who used sunscreen, 61% reapplied it)
Dixon *et al.* (1999)	H	Australia, Victoria	1996–97 mid-spring	On sunny days when outside	Melbourne primary school-children 'Always/mostly/wear sunscreen on exposed areas (parent's report) Used sunscreen (children's report)	 72% 86%	Parents' proxy and children's reports, observation

Table 9. (Contd)

Reference	PP or H	Location of study	Year	Location of use	Study population and prevalence of sunscreen use	Other comments
Canada						
Campbell & Birdsell (1994)	H	Canada, Alberta	1987	When exposed to sun	Adults 35–64 years Males 15% Females 35%	Self-report 'Usually use' sunscreen
Rivers & Gallagher (1995)	H	Canada	1991–93		General public attending screening programme 1991–93 Age group: Males / Females 0–19: 70% / 94% 20–39: 61% / 79% 40–64: 61% / 78% ≥ 65: 54% / 69% All: 60% / 78%	Self-report 'Usually use' sunscreen
Zinman *et al.* (1995)	PP H	Canada	1993	When child played outdoors in the sun for > 30 min	Children attending hospital emergency department Had 'used sunscreen at least once in previous 2 months' 84% Would apply an SPF ≥ 15 sunscreen 74%	Parents proxy reports
Lovato *et al.* (1998)	H	Canada	1996 June-August		Children 'Always/often' used sunscreen on body < 12 years 76% 6–12 years 68% ≤ 5 years 84% 'Always/often' used sunscreen on face < 12 years 76% 6–12 years 67% ≤ 5 years 84%	Parent proxy reports
Gooderham & Guenther (1999)	H	Canada, Ontario	1998 April and May	When outdoors in summer	Primary students Summer pre-test 'Always' use/plan to use/using sunscreen 41% When using sunscreen, 'always' use/plan to use/ using a SPF ≥ 15 sunscreen 69%	Self-report

Table 9. (Contd)

Reference	PP or H studY	Location of	Year	Location of use	Study population and prevalence of sunscreen use	Other comments
Denmark						
Stender *et al.* (1996a)	PP	Denmark	1994 July	At a beach, park, swimming-pool in Copenhagen after bathing	Used sunscreen on day of interview Sunbathers 65% Males 52% Females 73% Reapplied sunscreen ≥ 10 years 43% ≤ 10 years 11%	Self-report interviews
Stender *et al.* (1996b)	PP	Denmark, eastern	1994	4 beaches, 1 park July (summer; $n = 805$) May (early spring; $n = 100$)	Sunbathers (average, 28 years) All 67% Males 52% Females 73%	Self-report; parent proxy report for children < 8 'Used sunscreen' on day of study
France						
Grob *et al.* (1993)	H	France, Marseilles	1989 April–May		Children 3 years 85% Adolescents 13–14 years 48%	Mothers' proxy reports for children aged 3 years; adolescents, self-reports Sunscreen 'used'
France & Switzerland						
Autier *et al.* (1999)	H	France & Switzerland	1997	Before study, during sunny holidays or leisure times in sun	Swiss & French participants in a sunscreen trial, 18–24 years SPF 10 57% SPF 30 55%	Self-report 'Always/often' use sunscreen
Greece						
Kakourou *et al.* (1995)	H	Greece	1993 September–November		Mothers & children ≤ 12 years attending outpatient department 'Used' sunscreen last summer Mothers 80% Children 84% 'Always' used sunscreen when at the beach Mothers 52% Children 64%	Mothers' reports of self and children

Table 9. (Contd)

Reference	PP or H	Location of study	Year	Location of use	Study population and prevalence of sunscreen use		Other comments
Israel							
Harth *et al.* (1995)	H	Israel	1993		Habitual use (at least 1 year after excision)		
					Patients treated for BCC	64%	
					Controls	36%	
					After swimming		
					Patients treated for BCC	48%	
					Controls	33%	
Japan							
Kawada *et al.* (1989)	H	Japan	1988		Outpatients 15–68 years		Self-report 'Sunscreen use'
					All	27%	
					Females	57%	
					Males	18%	
					< 30 years	39%	
					> 30 years	42%	
					Japanese skin type: 1	53%	
					Japanese skin type: 2	36%	
					Japanese skin type: 3	40%	
New Zealand							
McGee & Williams (1992)	H	New Zealand	1991		Students 13–15 years		Self reports 'Often/always' used sunscreen last summer
					All	54%	
					Males	49%	
					Females	59%	
McGee *et al.* (1995)	PP	New Zealand	1994	Summer weekends	Adults 15–65 years		Self reports 'Used a sunscreen when outside on the weekend (Of those who used sunscreen, 89% reported using SPF ≥ 15)
					Respondents outdoors	32%	
McGee *et al.* (1997)	PP	New Zealand	1994 January–March	Sunny summer weekend	Children ≤ 10 years 1 day on weekend:		Parents' proxy reports 'Were wearing' sunscreen
					Saturday	49%	
					Sunday	52%	
					Both days	37%	

Table 9. (Contd)

Reference	PP or H	Location of study	Year	Location of use	Study population and prevalence of sunscreen use	Other comments
Norway						
Wichstrom (1994)	H	Norway	1992		High-school students Very often/always' use sunscreen Males 20% Females 35% Use SPF ≥ 6 Males 28% Females 24%	Self-report
South Africa						
von Schirnding *et al.* (1991/92)	H & PP	South Africa	1989	At the beach	Whites, ≥ 1 years: 'Most/all' the time use sunscreens 72% At time of interview use sunscreen 50% Using sunscreen lotion Males 49% Females 74% Using SPF ≥ 15 on body 6% Using SPF ≥ 7 on body 15% Using SPF > 7 on face Males 18% Females 43%	Self-reports
Sweden						
Jerkegren *et al.* (1999)	H	Sweden	1995	Habitual use	University students ~ 24 years When sunbathing Females Males 51% When sunbathing in a southern country 79% When sunbathing 11–15 h 50% When skin starts to turn red 50% Every day 7%	Self-report 'Always/very often' used sunscreen 70%

Table 9. (Contd)

Reference	PP or H	Location of study	Year	Location of use	Study population and prevalence of sunscreen use		Other comments
United Kingdom							
Hughes *et al.* (1993)	H	United Kingdom	1990	On holiday:	Children 12–16 years Warmer country United Kingdom Elsewhere	 78% 41% 52%	Self-report Wearing a sunscreen 'when it was sunny'
Bourke *et al.* (1995)	H	United Kingdom	1992	On sunny days	People in city ≥ 15 years When at home Males Females People aware of melanoma People unaware When 'abroad' Males Females People aware of melanoma People unaware	 12% 32% 27% 13% 73% 54% 71% 46%	Self-report 'often/always' use sunscreen
Bourke & Graham-Brown (1995)	H	United Kingdom	1993		Children ≤ 14 years Sunny day at home Abroad	 53% 88%	Parents' proxy reports Frequently/always ensure children use sunblock (of these, 32% said they used SPF ≥ 15)
USA							
Michielutte *et al.* (1996)	H	USA, North Carolina	1994		Women > 20 years When sunbathing Spring/summer	 48% 33%	Self-report interviews at health care clinic 'Always' use sunscreen
Putnam & Yanagisako (1982)	H	USA, Hawaii	1980–81 December–February	Before receiving educational package	Hawaii Kai residents ≥ 18 years 'Use' sunscreen 'Use' SPF 8–15	 34% 19%	Self-reported changes

Table 9. (Contd)

Reference	PP or H	Location of study	Year	Location of use	Study population and prevalence of sunscreen use	Other comments
Robinson (1992)	H	USA	1983–87	At baseline 1 year after surgery	NMSC patients (average age, ~ 60 years) Use SPF < 15 32% Use SPF ≥ 15 1% Use 'when sun exposure was expected 32% Use 'daily' 0%	Self-report (prior to education)
Berwick *et al.* (1992)	H	USA, Connecticut	1988 May		Subjects attended community skin cancer screening Used sunscreen at least once last summer 75% 'Almost always' used sunscreen 42%	
Ross & Sanchez (1990)	H & PP	USA, Puerto Rico	July 1988–January 1989		Beachgoers ≥ 18 years Habitual use Tourist group 82% Peurto Rican residents 38% While at the beach Tourist group 77% Puerto Rican residents 50%	Interviews
Banks *et al.* (1992)	H	USA	1989 April–June	In early part of sunny season before they acquire a tan	Paediatric patients 12–19 years 26%	Self-reports Used sunscreen on 'more than half the days of sun exposure'
Mermelstein & Riesenberg (1992)	H	USA, Chicago	1990		High-school students Used sunscren 'at least most of the time' Males 8% Females 17% High-risk skin type 17% Low- risk skin type 7% 9th grade 12% 10th grade 14% Usual sunscreen used was SPF ≥ 15 Males 14% Females 20% High-risk skin type 21% Low-risk skin type 12%	Self-reports

Table 9. (Contd)

Reference	PP or H	Location of study	Year	Location of use	Study population and prevalence of sunscreen use	Other comments
Vail-Smith & Felts (1993)	H	USA, Southeast	1990 autumn	When exposed to sun for ≥ 30 min	University students Use SPF ≥ 15 sunscreen 9% 'Usually' use SPF ≥ 15 sunscreen at beach All 17% Males 15% Females 16%	Self reports
Hourani & LaFleur (1995)	H	USA, southern California	1990 &1992		Residents attending community screening, ≥ 17 years 50% Males / Females 17–35 years 26% / 41% 36–50 years 35% / 31% ≥ 51 years 39% / 29%	Self-reports 'Regularly' use sunscreen
Foltz (1993)	H	USA	1991		Parents at paediatric clinic aged 23–49 years 'Sometimes/always' wear sunscreen 67% 'Sometimes/aways' ensure child has sunscreen on Beach 77% Garden 47%	Parent proxy reports
Mawn & Fleischer (1993)	H	USA, North Carolina	1991	Samples from cruise ship, shopping mall, social function	White adults ≥ 15 years 40%	Self-reports 'Almost always/very often' use sunscreen
Maducdoc *et al.* (1992)	PP	USA, Texas	1991 July 10:00–15:00	Galveston beach	Parents using sunscreen on children ≤ 12 years 51%	Had 'used' sunscreen on their children
Koh *et al.* (1997)	H	USA	1991 July–September	Aquatic recreational areas	Sunbathers > 16 years All 47% Males 36% Females 53% Low education 38% Middle education 53% High education 55%	Self-report 'Always/often' use sunscreen (55% of regular sunscreen users and 25% overall sunbathers used SPF ≥ 15 sunscreen)

Table 9. (Contd)

Reference	PP or H	Location of study	Year	Location of use	Study population and prevalence of sunscreen use	Other comments
Leary & Jones (1993)	H	USA	1991 September	When in the sun	White undergraduates 17–23 years 7%	'Used' sunscreen regularly
Rodriguez *et al.* (1993)	H	USA, Puerto Rico	November 1991–March 1992	San Juan beach	Adolescents (white Puerto Ricans) All 68% 13–15 years 67% 16–18 years 71% High-risk skin type 20% Low-risk skin type 11%	Self-report 'Always' used sunscreen
Rossi *et al.* (1994)	PP	USA, Rhode Island	1991–92 Summer	Beach	Beachgoers 81%	Individuals accepted free sunscreen
Nguyen *et al.* (1994)	PP	USA, New Jersey	1992	Beaches	Beachgoers All 78% Males 70% Females 84% 13–18 years 72% 19–25 years 78% 26–40 years 81% 41–87 years 82% Skin type I & II 87% Skin type III & IV 78% Skin type V & V 61%	'Number using sunscreen' (of those who used sunscreen, 87% provided detail on SPF used: 35% used SPF ≥ 16; 17% used ≥ 4)
Hall *et al.* (1997)	H	USA	1992	When outside on a sunny day for > 1 h	Whites ≥ 17 years All 32% Males 22% Females 41%	Self-reports 'Very likely" to use sunscreen
Friedman *et al.* (1995)	H	USA, Houston, Texas	1992 May	Worksite	Hospital employees (average, 44 years) 64%	Self-report 'Very/extremely likely to use sunscreen
Buller *et al.* (1995)	H	USA	1993		Children < 14 years 76% Parents 19–56 years 42%	Parents/proxy Use 'most or all of the time' in summer
Marlenga (1995)	H	USA	1993		Dairy farmers, average, 51 years 'Frequently/always' use sunscreen 8% 'Never' use sunscreen 54%	Self-reports

Table 9. (Contd)

Reference	PP or H	Location of study	Year	Location of use	Study population and prevalence of sunscreen use		Other comments
Hoegh *et al.* (1999)	H	USA, California	1993–95	When outside > 15 min	Non-Hispanic white residents ≥ 18 years:		Self-report on 'use of sunscreen'
					Males	13%	'Always' use sunscreen (regular use)
					Females	31%	
					High-school graduates	23%	
					Non-graduates	11%	
					Fair skin	27%	
					Medium/dark skin	18%	
Newman *et al.* (1996)	H	USA, San Diego	1994		Adults 18–65 years:		Self-report?
					When suntanning last summer		
					'Always/sometimes' used sunscreens on face	39%	
					'Always/sometimes' used sunscreen on body	39%	
					While in the sun for recreation last summer		
					'Always/sometimes' used sunscreen on face	59%	
					'Always/sometimes used sunscreen on body	51%	
Robinson *et al.* (1997b)	H	USA, Midwest	1994	When outside in summer	Adolescents		Self report
					'Every day'	26%	
					'About once a week'	23%	
					'A few times each summer	49%	
					'Daily use'		
					11–13 years	23%	
					14–16 years	31%	
					17–19 years	23%	
					Males	17%	
					Females	35%	
					Skin type I, II	33%	
					Skin type III, IV	29%	
					Skin type V, VI	–	
Reynolds *et al.* (1996)	PP	USA, Southeastern states	1994		Average, 11 years		
					On Saturday	29%	'Used sunscreen'
					On Sunday	21%	
					On the weekend		
					Males	11%	
					Females	21%	

Table 9. (Contd)

Reference	PP or H	Location of study	Year	Location of use	Study population and prevalence of sunscreen use	Other comments
Miller *et al.* (1999)					Children < 13 years When outside < 6 years 36% 6–13 years 33% When at the beach < 6 years 85% 6–13 years 65% With continuous exposure for 6 h < 6 years 47% 6–13 years 35%	Proxy reports by parents 'Usually' wear sunscreen
Rosenman *et al.* (1995)	H	USA	1995	When outside for more than 1 h	Farmers & spouses ≥ 40 years Males 13% Females 42%	Self-report 'Very likely to use a sunscreen'
Glanz *et al.* (1997)	H	USA, Hawaii	1995	When outdoors	General public 65%	Self-report questionnaire 'Always/usually' use sunscreen
Zitser *et al.* (1996)	PP	USA, Connecticut	1995	When at beach (three beaches) 9:30–15:30	Beachgoers Using sunscreen 56% Males 48% Females 60% Using SPF > 14 sunscreen 25%	Self-report interviews
Glanz *et al.* (1998a)	H	USA, Hawaii	1995 Summer	Four summer programmes, one swimming-pool	Parents 61% Children 68% Staff 51%	Self-report, proxy reports of parents 'Use' sunscreen (at baseline)
Martin *et al.* (1999)	H	USA, Florida	1996	Subtropical climate	Students 9–13 years Boys 17% Girls 20%	'Often/very often used sunscreen in past month'
Robinson & Rademaker (1998)	PP	USA, Michigan	1996	Beach at Lake Michigan	Beachgoers: Males 46% Females 71% Children ≤ 10 years 76%	Observation Applied sunscreen at the beach

Table 9. (Contd)

Reference	PP or H	Location of study	Year	Location of use	Study population and prevalence of sunscreen use		Other comments
Glanz *et al.* (1999)	H	USA, Hawaii	1996 mid-June	Summer recreation programmes	Children Use sunscreen Use before going to beach Parents Use sunscreen Use before going outside Staff Use sunscreen Use before going outside	 39% 81% 36% 57% 29% 59%	Parents' proxy reports & self-report 'Usually or always'
Robinson *et al.* (1998b)	H	USA	1996		*Parents* magazine readers Regularly apply sunscreen to their children when at beach *Seventeen* magazine readers 12–19 years 'Always/often' use sunscreen when outdoors Males Females	 68% 30% 40%	
Donavan & Singh (1999)	H	USA, Kansas	1997		Primary-school students 'Always use sunscreen' 'Thought sunscreen only important in summer months'	 29% 51%	
McCarthy *et al.* (1999)	PP	USA, Texas	1997	Galveston Island beach	Beachgoers 16–59 years	76%	Self-report, observation Used sunscreen
Glanz *et al.* (1998b)	H	USA, Hawaii	1997	When in bright sun	Children 6–8 years, participating in prevention programme 'Usually used sunscreen (formative research) Parents 'Always' used sunscreen Staff 'Usually/always' used sunscreen	 62% ~1/3 60%	

Year, the year data were collected, if reported, otherwise year of publication less 2 years
PP, point prevalence (i.e. at a specific time) or H, habitual (i.e averaged over many observations or what people say they typically do); BCC, basal-cell carcinoma; NMSC, non-melanoma skin cancer; VIC, Victoria State; NSW, New South Wales; NT, Northern Territories

Table 10. Prevalence of sunscreen use in winter or in the snow

Reference	PP or H	Location of study	Year	Location of use	Study population and prevalence of sunscreen use		Other comments
Gooderham & Guenther (1999)	H	Canada, Ontario	1998 April & May	During winter	Primary-school students Before test After test 1 After test 2	 2% 14% 12%	Self-report 'Always' use/plan to use/using sunscreen when going outdoors in winter
Harth *et al.* (1995)	H	Israel	1993	Winter	BCC patients and controls average age, 54 years Patients Controls	 51% 39%	Self-report after treatment Used sunscreen in winter
Jerkegren *et al.* (1999)	H	Sweden	1995	When skiing in sunny weather	University students ~ 24 years	50%	'Always/very often' used sunscreen
Buller *et al.* (1995)	H	USA	1993	In winter	Adults 19–56 (with children):	23%	Self-report 'At least some of the time' use sunscreen
Michielutte *et al.* (1996)	H	USA, North Carolina	1994	When outdoors	Women > 20 years Autumn Winter	 10% 8%	Self-report (face-to-face interviews at a health care clinic) 'Always use'
Buller *et al.* (1998)	H	USA	1996–97	Winter	Skiers and boarders 'Wearing a sunscreen' Adults Children SPF ≥ 15 'Use of sunscreen lip balm' Adults Children	 89% 13% 90% 64% 85%	Self-report

PP, point prevalence (i.e. at a specific time) or H, habitual (i.e averaged over many observations or what people say they typically do); BCC, basal-cell carcinoma
Year, the year data were collected, if reported, otherwise year of publication less 2 years

Figure 22 Intentional exposure to the sun on a beach

settings, probably because frequent beachgoers are more likely to use sunscreens and to be overrepresented in beach surveys. There is little doubt that the setting in which sunscreens are most commonly used is the beach and/or during sunbathing. The mean point prevalence of sunscreen use in 10 studies of beachgoers and one of sunbathers was 66%, and that in the studies in which sex differences were reported was about one-third times higher in women than in men. In five studies, the mean point prevalence of sunscreen use in people who were not beachgoers or sunbathers when out of doors in summer was 30%.

In two studies (Foltz, 1993; Jerkegren *et al.*, 1999) in which sunscreen use was compared in various settings, sunscreens were used more often at the beach than in any other setting. Four studies in northern Europe (Hughes *et al.*, 1993; Bourke & Graham-Brown, 1995; Bourke *et al.*, 1995; Jerkegren *et al.*, 1999) reported greater use of sunscreens when 'abroad' (presumably on summer vacations) than at home.

Some studies suggest that sunscreen use in sunny climates is more strongly associated with intentional than with unintentional exposure to the sun. In northern Australia, 71% of women and 68% of men on beaches applied a sunscreen (Pincus *et al.*, 1991). In contrast, less than 20% of fair-skinned adults at a market were found to have applied a sunscreen to uncovered areas of the skin (Whiteman *et al.*, 1994). In a case–control study of childhood melanoma in Queensland (the area of the world with highest incidence of melanoma), 83% of control children had used sunscreen when on holiday as compared with 44% when at school (Whiteman *et al.*, 1997).

The self-reported usual sunscreen use of the same respondents in seasons other than summer was contrasted in only five studies. In Arizona, USA (Buller *et al.*, 1995), 23% of 19–56-year-old parents used sunscreen 'at least some of the time' in winter, whereas 42% 'almost always' used sunscreen in summer. Of women in North Carolina, USA (Michielutte *et al.*, 1996), 10% 'always' used sunscreens in the autumn, 8% in winter, 33% in spring and summer and 48% when sunbathing. Before a skin cancer education programme in Ontario, Canada (Gooderham & Guenther, 1999), 41% of primary-school students reported 'always' using, or planning to use, a sunscreen in summer, but only 2% did so in winter. In Sweden (Jerkegren *et al.*, 1999), 50% of a sample of university students 'always or very often' used sunscreens when skiing in sunny weather and 79% did so when sunbathing abroad. A study in Colorado, USA (Buller *et al.*, 1998), showed that 89% of adults used sunscreen on the snowfields.

How people use sunscreens

Few published data are available on how people use sunscreens, although cosmetics companies have probably collected much relevant information in the course of product development and testing. This lack of detailed published information, which would have to be based on unobtrusive observation and measurement, is a significant limitation. The literature on how people use sunscreens is thus heavily biased towards aspects of use that respondents can readily describe. The three main themes are application before exposure and reapplication during exposure, SPF strengths used and the parts of the body to which sunscreens are applied.

In several studies, respondents were asked if they routinely applied sunscreen, as recommended, 30 min or so before going out into the sun. Among adolescents and adults, application before exposure was reported by 65% in Denmark (Stender *et al.*, 1996a), by 13% in Greece (Kakourou *et al.*, 1995), by 87% in New Zealand (McGee *et al.*, 1995) and by 2% in the USA (Robinson & Rademaker, 1998). Among parents, application on their children before exposure was reported by 20% in Greece (Kakourou *et al.*, 1995) and by 12% (Foltz, 1993) and 89% (Glanz *et al.*,

1999) in the USA. It cannot be determined whether this highly variable pattern reflects true differences among the population groups or artefacts of measurement.

Among adolescents and adults, reapplication was reported by 61% (Pincus *et al.*, 1991) and 62% (Pruim *et al.*, 1999) in Australia, by 43% in Denmark (Stender *et al.*, 1996a), by 82% in France (Grob *et al.*, 1993), by 9% in Greece (Kakourou *et al.*, 1995), by 30% in Puerto Rico (Rodriguez *et al.*, 1993) and by 8% in the USA (Banks *et al.*, 1992). Among children, parents and/or children, the prevalence of sunscreen reapplication was 11% in Denmark (Stender *et al.*, 1996a), 54% in France (Grob *et al.*, 1993), 10% in Greece (Kakourou *et al.*, 1995) and 45% in the USA (Foltz, 1993). Again, the high variability suggests that much of it is due to measurement artefact, and no generalization can be made about the prevalence of reapplication among sunscreen users from these data.

The choice of SPF level may vary according to the stage of tan acquired or desired (Vail-Smith & Felts, 1993; Wichstrom, 1994; Newman *et al.*, 1996), skin sensitivity (Zitser *et al.*, 1996), parental supervision (McGee *et al.*, 1997) and regularity of use (Koh *et al.*, 1997), but there are too few studies for conclusions to be drawn about common patterns of choice. Reported sunscreen use in the absence of details of SPF rating is likely to be highly ambiguous, and the reported numbers may include people using the most effective sunscreens as well as those who have deliberately chosen low-SPF formulations expressly to permit greater exposure to UVR. A number of studies do, however, indicate the proportion of sunscreen users using a high-SPF product on a specific occasion. The proportion reporting use of sunscreens with an SPF ≥ 15 was 48% (Bennetts *et al.*, 1991), 47% (Pincus *et al.*, 1991), 55% (Hill *et al.*, 1992), 84% (Foot *et al.*, 1993) and 27% (in adolescents; Broadstock *et al.*, 1996) in Australia; 89% in New Zealand (McGee *et al.*, 1995); 6% in South Africa in 1989 (von Schirnding *et al.*, 1991/92); and 48% (Nguyen *et al.*, 1994), 45% (Zitser *et al.*, 1996), 90% (in snow fields; Buller *et al.*, 1998), 60% (Glanz *et al.*, 1998a,b) and 47% (McCarthy *et al.*, 1999) in the USA. The results of these studies indicate that a little over half of self-identified 'sunscreen users' use high-SPF products.

The SPF of sunscreens used on children appears to be higher than that of adults: in Europe in 1995–96, 50% of children who had ever received a sunscreen had a product of higher SPF than that used by their parents (Autier *et al.*, 1998). Table 6 suggests that the South to North gradient observed in Europe for sunscreen use by children also exists for the SPF. In general, users were more likely to apply sunscreen to the face than to other parts of the body and to use a sunscreen with a higher SPF on the face.

The patterns of sunscreen use by families on an inland beach in the USA were measured by a combination of observational and interview methods (Robinson *et al.*, 1998b). Women were most likely to provide and apply sunscreens to others, particularly children, and the median delay in application of sunscreen between arrival at the beach and application to the last family member was 51 min.

Why people use sunscreens

Table 11 lists the reasons why adults, adolescents and children use or do not use effective sunscreens (people deliberately using ineffective products were considered not to be using sunscreens). When significant associations between skin type and sunscreen use were found, it was assumed that knowledge about a propensity to burn was the reason for sunscreen use. In some studies, associations with sunscreen use were not sought, and people were simply asked why they used or did not use them. Reasons can be inferred from such studies even if a link with behaviour was not demonstrated.

The commonest reason for using sunscreens among adults, adolescents and children was having a sensitive skin type. Self-perception of risk, previous experience of skin cancer and a family history of skin cancer were also frequently related to sunscreen use, particularly by adults. Two studies showed that sunscreen use was relatively more common among adults who knew people who had had skin cancer. Compliance with social norms was identified as another reason for using sunscreens.

A large majority of the studies of the role of knowledge about the dangers of exposure to the sun found that this predicted sunscreen use. Studies of adults and adolescents confirmed that sunscreens are used to prevent sunburn, and generally, positive attitudes to use of sunscreens and sun protection (measured variously) were related to sunscreen use.

Both positive and negative attitudes to suntanning have been found to be associated with sunscreen use by adults, and a positive attitude to a tan has been related to sunscreen use by adolescents, consistent with the results of behavioural studies, which show that sunscreen use increases with increasing exposure to UVR, and with those of epidemiological studies, in which skin cancer/melanoma was positively correlated with sunscreen use (see p. 69). Three studies of adolescents and two of adults have shown that sunscreen use is part of deliberate sunbathing, and other studies suggest that one motive for sunscreen use is to permit additional time in the sun. These conclusions raise concern that sunscreen use may result in unintended, additional, hazardous exposure to UVR.

Table 11 also presents reasons that people give for not using sunscreens, most of which are inferred, since often only non-users were asked their reasons. Those identified included finding them redundant (having skin that does not burn easily or is already tanned, not

Table 11. Reasons given for using or not using effective sunscreens

Reason	Adults		Adolescents		Children	
	Yes	No	Yes	No	Yes	No
Reason to use						
Previously had skin cancer	Whiteman *et al.*, 1994; Harth *et al.*, 1995; Rademaker *et al.*, 1996; Hall *et al.*, 1997	Pruim *et al.*, 1999				
Have skin that is fair/burns easily	Kawada *et al.*, 1989; Miller *et al.* 1990; Ross & Sanchez, 1990; Berwick *et al.*, 1992; Hill *et al.*, 1992; Leary & Jones, 1993; Campbell & Birdsell, 1994; Newman *et al.*, 1996; Stender *et al.*, 1996b; Zitser *et al.*, 1996; Hall *et al.*, 1997; Glanz *et al.*, 1999; Hoegh *et al.*, 1999; Pruim *et al.*, 1999		Fritschi *et al.*, 1992; Mermelstein & Riesenberg, 1992; Wichstrom, 1994; Broadstock *et al.*, 1996; Reynolds *et al.*, 1996	Banks *et al.*, 1992 Boldeman *et al.*, 1996	Zinman *et al.*, 1995; Robinson & Rademaker, 1998; Glanz *et al.*, 1999; Miller *et al.*, 1999	
Perception of being at high risk for melanoma/ skin cancer	Pincus *et al.*, 1991; Berwick *et al.*, 1992; Friedman *et al.*, 1995; Hall *et al.*, 1997; Robinson *et al.*, 1997a	Leary & Jones, 1993	Mermelstein & Riesenberg, 1992			
Perception by parents that children are at high risk for melanoma/skin cancer					Buller *et al.*, 1995; Miller *et al.*, 1999	
Family history of skin cancer	Hourani & LaFleur, 1995					
Know people who had skin cancer	Keesling & Friedman, 1987; Leary & Jones, 1993					

Table 11. (Contd)

Reason	Adults		Adolescents		Children	
	Yes	No	Yes	No	Yes	No
Know dangers of exposure to sun	Hill *et al.*,1984; Keesling & Friedman, 1987; Kawada *et al.*, 1989; Berwick *et al.*, 1992; Vail-Smith & Felts, 1993 (I); Bourke *et al.*, 1995; Buller *et al.*, 1995; Michielutte *et al.*, 1996; Newman *et al.*, 1996; Glanz *et al.*, 1999	Leary & Jones, 1993; Hillhouse *et al.*, 1996	Banks *et al.*, 1992; Hughes *et al.*, 1993; Wichstrom, 1994			
Parents know dangers of sun exposure					Grob *et al.*, 1993 (I); Bourke & Graham-Brown, 1995; Zinman *et al.*, 1995; Glanz *et al.*, 1999	Maducdoc *et al.*,1992; Buller *et al.*, 1995
Children know dangers of sun exposure					Rademaker *et al.*, 1996 (I); Donavan & Singh, 1999	Kubar *et al.*, 1995; Boldeman *et al.*, 1996
Positive attitude to sunscreen/sun protection	Hillhouse *et al.*, 1996; McGregor & Young, 1996 (I)		Grob *et al.*, 1993 (I); Hughes *et al.*, 1993		Donavan & Singh, 1999; Martin *et al.*, 1999	
Prevent sunburn	Hill *et al.* 1984; Kawada *et al.*, 1989; Vail-Smith & Felts, 1993 (I)		Grob *et al.*, 1993 (I)		Maducdoc *et al.*, 1992; Grob *et al.*, 1993 (I)	
Knowledge about sunscreen product (e.g., reapplication)	Kawada *et al.*, 1989; Pruim *et al.*, 1999	Leary & Jones, 1993				
Negative attitude to tan	Newman *et al.*, 1996					
Compliance with social norms or peer group	Kawada *et al.*, 1989; Hillhouse *et al.*, 1997		Banks *et al.*, 1992; Wichstrom, 1994		Rademaker *et al.*, 1996 (I); Martin *et al.*, 1999	
Part of deliberate sunbathing/assist tanning	Hill *et al.*, 1984 Vail-Smith & Felts, 1993 (I)		Grob *et al.*, 1993 (I); Wichstrom, 1994; Eiser *et al.*, 1995			

Table 11. (Contd)

Reason	Adults		Adolescents		Children	
	Yes	No	Yes	No	Yes	No
Allows more burn-free hours in sun	Pincus *et al.*, 1991; Autier *et al.*, 1999 (I)		Grob *et al.*, 1993 (I)			
Positive attitude to tanning	McGregor & Young (1996) (I)	Berwick *et al.*, 1992	Wichstrom, 1994			
Parents insist on sunscreen use			Banks *et al.*, 1992			
Parents remind children to use sunscreen					Donavan & Singh, 1999	
Parents practise prevention (use sunscreen)					Foltz, 1993; Buller *et al.*, 1995; Zinman *et al.*, 1995; McGee *et al.*, 1997; Robinson & Rademaker, 1998; Glanz *et al.*, 1999; Miller *et al.*, 1999	
Reasons not to use						
Have skin that does not burn easily	Stender *et al.*, 1996a (I)					
Already have protective tan	McGee *et al.*, 1995 (I)					
Not outdoors enough to warrant use	Berwick *et al.*, 1992 (I); McGee *et al.*, 1995 (I); Stender *et al.*, 1996a (I)					
Use other sun protection instead	Berwick *et al.*, 1992 (I); McGee *et al.*, 1995 (I)					
Judged that sun too mild to need sunscreen	McGee *et al.*, 1995 (I)					
Sunscreen retards desired tan	Kawada *et al.*, 1989; Berwick *et al.*, 1992 (I), Robinson, 1992; Gerbert *et al.*, 1996		Robinson *et al.*, 1997b			
Negative attitude to sunscreen	Hill *et al.*, 1984; Hillhouse *et al.*, 1996					
Sunscreens a nuisance	Berwick *et al.*, 1992; Gerbert *et al.*, 1996; Hill *et al.*, 1984					

Table 11. (contd)

Reason	Adults		Adolescents		Children	
	Yes	No	Yes	No	Yes	No
Reason not to use						
Sunscreens too expensive	Gerbert *et al.*, 1996; Vail-Smith & Felts, 1993 (I)	Stender *et al.*, 1996a (I)				
Sunscreens greasy or have an odour	Gerbert *et al.*, 1996; Vail-Smith & Felts, 1993 (I)	Stender *et al.*, 1996a (I)				
Forget	Marlenga, 1995; McGee *et al.*, 1995					
Not masculine	Hill *et al.*, 1984					
Is 'dorky' or 'uncool'	Lowe *et al.*, 1993 (I) (especially males); Nguyen *et al.*, 1994 (I)					

'Yes', studies in which significant associations were reported between reason and sunscreen use or in which an association was inferred (I) because a proportion of the sample stated the reason for use
'No', studies in which the stated reason for use was tested but not found

being outdoors long enough or the sun not being strong enough to warrant use) and using an alternative form of protection. The most clearly articulated reason for not using sunscreens was that they retard the acquisition of a sought-after tan. A generally negative attitude to sunscreens was found to predict no use. A number of studies identified the objections to sunscreens as considering them a nuisance, expensive, greasy, have an odour and easy to forget. One study reported that men who found sunscreens 'unmasculine' were less likely to use them (Hill & Boulter, 1996). In two studies, adolescents perceived sunscreens as 'uncool' or 'dorky' (Lowe *et al.*, 1993; Nguyen *et al.*, 1994)

It might be expected that subjects with a history of skin cancer (other than melanoma) would be more inclined to use sunscreens than the average population (Whiteman *et al.*, 1994; Harth *et al.*, 1995; Hall *et al.*, 1997), but two studies in Queensland, Australia, do not support that assumption (Green *et al.*, 1999a,b; Pruim *et al.*, 1999). It might also be expected that patients with conditions that require protection from the sun would use sunscreens. Yet, sunscreen use was reported by less than 50% of British renal transplant recipients, who are at higher risk for non-melanoma skin cancer (Seukeran *et al.*, 1998), and only 50% of Puerto Rican patients with systemic lupus erythematosus, a disease that may be exacerbated by sunlight, reported sunscreen use (Vila *et al.*, 1999).

Children's sunscreen use was predicted by the parents' use of sunscreens and other solar protection, the parents' perception of their child's risk of melanoma/skin cancer and parental reminders. While there is evidence of a strong parental effect on sunscreen use among children, little evidence is available concerning the children's own knowledge and attitudes.

Strategies to increase sunscreen use

A number of interventions have been conducted to promote sun protection in general and sunscreen use in particular, in which the effect on sunscreen use was measured. These programmes can be broadly classified as targeted to particular population groups (Tables 12 and 13) or to the community as a whole (Table 14). Studies were excluded if they addressed formative research only, had no data on sunscreen use or did not report the impact on sunscreen use. A study in children in which drawing was used at interview after a test was also excluded.

Interventions were conducted in a variety of settings. School programmes were the most common (11 studies), and the results of programmes at beaches and pools (five studies) and other recreational settings were also reported. Work sites and clinical settings were less often targeted for intervention. Two localized community interventions were also considered to be targeted interventions: one in which an educational brochure was available for general use and another targeted to households in one suburb. The targeted interventions were generally short-term programmes aimed at improving sun protection behaviour among specific high-risk groups, including children, adolescents, beachgoers, outdoor workers and patients with non-melanoma skin cancer. The programmes incorporated a range of strategies, from brief educational presentations or packages aimed at increasing knowledge or specific recommendations for sunscreen use, to integrated programmes with multiple components to promote sustainable behavioural change by developing supportive social and physical environments for sun protection.

Most programmes incorporated some educational elements designed to increase awareness about skin cancer and the benefits of sunscreen use (Fig. 23). Strategies designed to influence social norms for sunscreen use were commonly directed at children and included peer-led programmes, role modelling and parental involvement or home activities. A few promoted strategies for sustainable change by encouraging the development of policies on sun protection in organizations such as schools, recreational programmes and lifesaving clubs. Programmes were led by medical experts in a few settings.

Twenty-one of the 28 studies reported at least some measure of outcome with regard to sunscreen use, although proxies for behaviour were used in some studies. For example, two studies measured intention to use sunscreen rather than actual use.

Nine of the 16 targeted interventions were successful in increasing sunscreen use. The designs of the more targeted interventions were generally adequate, involving either quasi-experimental or randomized controlled trials, although a few had weaker designs, with either no control group or no or a limited pre-intervention test, and few reported the impact on sunscreen use. The interventions were successful across a range of settings, including schools, beaches or pools, recreation sites, clinics and households. Two others changed factors that are precursors to behaviour, i.e. beachgoers' intention to use sunscreen (Detweiler *et al.*, 1999) and care-givers prompting use of sunscreens by youths (Parrott *et al.*, 1999).

The intensity and duration of the targeted intervention appeared to affect the success of programmes. Thus, successful programmes tended to be longer, have multiple components or be supported by broader community-based programmes. Two brief, school-based programmes consisting of only one class session had no impact on behaviour (Mermelstein & Riesenberg, 1992; Buller *et al.*, 1997) even though they included some interactive components such as discussions, worksheets and take-home bags to involve parents. The duration of the intervention did not appear to improve sunscreen use in two studies, a 4-month educational package for schoolchildren (Hughes *et al.*, 1993) and a 41-day intervention at swimming pools with role models, incentives and free sunscreen (Lombard *et al.*, 1991), but an Australian study (Girgis *et al.*, 1993) provides some evidence that solar protection scores were increased after school-based interventions of longer duration with more interactive learning techniques.

Distributing educational brochures has had mixed success. Detweiler *et al.* (1999) found that brochures could promote the intention to use sunscreens. Moreover, brochures with specific reco-mmendations for sunscreen use appeared to be more effective than general recommendations for sun protection. A comic book brochure with specific recommendations for using sunscreens SPF ≥ 8 was successful in changing the use of sunscreens by Hawaiian householders (Putnam & Yanagisako, 1982). A brochure promoting general awareness of sun protection and, specifically, a 'SunSmart Siesta' to holiday-makers had no effect on their sunscreen use, although sun avoidance during peak UV radiance increased (Segan *et al.*, 1999).

Other components of successful strategies involve increasing the perception of risk for developing skin cancer. An intervention in which adolescents were shown computerized photo-images of their own faces with superimposed ageing and skin lesions was successful in improving both the frequency of sunscreen use and application of sunscreen (Novick, 1997). Education about skin cancer risk and specific recommendations for sun protection in a medical

Figure 23 Educational brochure aimed at improving sun-exposure behaviour

Table 12. Impact of targeted interventions on sunscreen use

Reference	Location	Study design and setting	Sample size	Population group	Duration of intervention	Strategy	Sunscreen use outcome	Other outcomes
Australia								
Dobbinson *et al.* (1999)	Australia, Victoria, 1997, 1989	Beaches Cross-sectional/ post-test comparison with control group	n = 129 VIC & n = 134 NSW lifesavers	Lifesavers on patrol	10 years	Incentives provided to clubs to develop sun protection policies and comply with adequate protection while on patrol. Awareness training for juniors	Sunscreen use in VIC greater than in NSW Regular use in sun 97% vs 85%, $p < 0.001$ When no sun, 76% vs 54%, $p < 0.001$	More VIC than NSW lifesavers used hats, shirts, and shelter/shade in sun. (No difference in shirt use when not in sun)
Segan *et al.* (1999)	Australia, Victoria, November 1993	Tourism in Queensland Randomized controlled trial	21 flights to Queensland on Saturdays & Sundays n = 373	Tourists aged ≥ 17	Pre-flight test Post-holiday test (most < 2 weeks)	Brochure provided information and sun protection recommendations, e.g., 'SunSmart Siesta Plan'	Sunscreen use not significantly different from control group	Fewer mean days spent outside between 11:00 and 14:00 (controls, 3.7, intervention 3.2, $p < 0.001$) Hats, clothing, shade use not signifcant
Canada								
Gooderham & Guenther (1999)	Canada, London, Ontario, 1998	Schools pre-/post-test	35 schools (pre-test n = 244)	Grade 4 students 9–11 years	1 month before intervention 1-h class, 35-min slide show, worksheets. Post-test Follow-up at 1 month	Interactive 'sun awareness' class session, slide presentations, (incidence, risks and prevention), activity book	Increase in 'always' use of sunscreen SPF > 15 (T1 69%, T2 88%, $p < 0.001$) Increase in winter and summer use	Significant increase in use of hats, long-sleeved shirts, trousers, sunglasses
United Kingdom								
Hughes *et al.* (1993)	England, 1990	7 schools, post-test only (intervention and control groups)	n = 543 (262 matched tests 1 & 2)	School students 12–16 years	Educational package May–June Post test in July Follow-up test in September	Workbook with sun protection tips; education on UVR and skin cancer Components assessed Workbook and either video, poster design, homework or discussion	No impact on sunscreen use	No impact on other sun behaviour

Table 12. (contd)

Reference	Location	Study design and setting	Sample size	Population group	Duration of intervention	Strategy	Sunscreen use outcome	Other outcomes
USA								
Putnam & Yanagisako (1982)	USA, Hawaii. October 1981	Community Pre-/post-intervention Repeated cross-sectional samples	n = 304	Residents of suburb (reporting for household) ≥ 18 years	Pre-test December 1980–February 1981 Package distributed to households. Post-test (October 1981) 4 months after distribution	Comic book emphasized increased risk for skin cancer among whites and gave recommendations for sun protection (use of SPF ≥ 8, protect skin during peak UVR), education on how to check skin and when to seek medical advice	38.5% of readers changed their use of SPF ≥ 8 sunscreen after reading book Readers significantly more likely than non-readers to use sunscreen ($p < 0.0005$) but not other sun protection	44% of readers changed their avoidance of sun exposure 10:00–14:00 30% of readers wore protective clothing
Robinson (1992)	USA, Chicago 1983–89	Medical Longitudinal (no control group)	n = 1022	NMSC patients Not reported	Phase 1:2 weeks and 6 months before operation Phase 2 annual follow-up with written material	Recommended daily sunscreen use, ceasing tanning, minimizing time outside peak UVR	Daily SPF ≥ 15: Before operation, 0; 1 year, 12%; 2–6 years, 25%	Decreased tanning after 1 year Increased clothing use with increased outdoor activity after 2–6 years
Robinson *et al.* (1998b)	USA, Chicago, May 1990–September 1991	Medical Pre-/post-intervention	178 pairs	Patients and helpers 30–60 years	NMSC patients & helpers surveyed pre- and post-intervention (~ 1 year after surgery)	Education and recommendations provided in brochure and verbally by staff. Emphasizing ceasing tanning, avoiding outdoor activities 10:00–14:00, wearing protective clothing, using SPF ≥ 15 sunscreen	Increased sunscreen use ($p = 0.01$ for patients, $p = 0.013$) for helpers	Helpers ($p = 0.018$) and patients ($p = 0.02$) decreased hours spent outside. Helpers ($p = 0.001$) also decreased use of indoor tanning devises
Lombard *et al.* (1991)	USA, Virgina, 1991	Pools Pre/post	2 private swimming pools	Public 1–16 years ≥ 16 years	Pre: 15 days Intervention phase. 41 days of observation	Sun protection competition and feedback, posters, fliers Lifesaver role modelling Provision of free sunscreen	No change in mean quantity of sunscreen used at either pool	Increase in children's use of protective behaviour (6.5% to 27%) Increase in adults' sun protection (22% to 38%)

Table 12. (contd)

Reference	Location	Study design and setting	Sample size	Population group	Duration of intervention	Strategy	Sunscreen use outcome	Other outcomes
Mermelstein & Riesenberg (1992)	USA, Chicago, 1992	10 schools Randomized controlled trial	*n* = 1703	Students 14–17 years	Pre-test. Intervention, 1 session. Post-test	Education video, discussion of barriers to sun protection, work sheet to assess personal risk for skin cancer	No effect on intention (likelihood) to use sunscreen	No effect on intention (liklihood) to use other sun protection behaviour
Buller *et al.* (1997)	USA, Tucson, Arizona, 1993	3 schools Quasi-experimental	*n* = 318	Grade 4 students	Pre-test, brief 2 x 1-day intervention (1 h curriculum & fair). Post-test and 3-month follow-up test	Interactive learning activities	Neither intervention affected children's intention to use sunscreen	Neither intervention affected intention to use hats or lip balm
Glanz *et al.* (1998b)	USA, Hawaii, 1995	Recreational settings for children (three YMCAs, one summer fun site, one pool) Pre/post intervention	Parents	Children 6–8 years and staff	Base-line 4-week intervention Follow-up	Staff given manual on activities, sun protection, policy development guidelines. Programme provided sunscreen and sun protective environment. Children given activities for home and incentives for sun protection. Monitoring and feedback on children's sun protection behaviour. Parents given educational brochures	Increase in sunscreen use: parents 61% to 63%, children 68% to 75%	Compositve sun protection scores significantly improved for parents and children, not staff. Shade use increased: parents 46% to 58%, children 23% to 38%
Detweiler *et al.* (1999)	USA, New England, 1996	Public beach Pre-/post-intervention (no control group/ randomly assigned to treatment)	*n* = 217	Beachgoers (76% women) 18–79 years	Beachgoers completed pre-test questions before reading brochure and post-test questions (in sealed section) after reading brochure	Prospect theory: message framing	Beachgoers who read brochures highlighting potential 'gains' are more likely than those reading brochures highlighting potential 'losses' to use and reapply sunsunscreen and request free sunscreen	Not measured

Table 12. (contd)

Reference	Location	Study design and setting	Sample size	Population group	Duration of intervention	Strategy	Sunscreen use outcome	Other outcomes
Weinstock *et al.* (1988)	USA, 1996	Public beach Randomized controlled trial	$n = 2324$	Beachgoers	Baseline, 12- and 24-month follow-up	Intervention: pamphlet, free sunscreen, sun damage and skin sensitivity checks	Difference between intervention and control group, $p = 0.02$ at 12 months increasing at 24 months	Sun protection index, $p = 0.001$ Sun avoidance, $p = 0.004$ at 12 months At 24 months, hat use also significant, $p = 0.03$
Novick (1997)	USA, Long Island, New York, 1997	2 day camps Randomized controlled trial	$n = 30$	Female students 13–28 years	5 weekly tests included logs of sunscreen application and measured weight of supplied sunscreen. Intervention images shown on 2 days in week 4	Subjects shown computerized photographic images of themselves. Two intervention groups shown altered images: either aged only or aged and disfigured with lesions	Increased use of sunscreen and more thorough application of sunscreen post-test	No change in mean time spent outside
Dietrich *et al.* (1998)	USA, New Hampshire, 1998	Public beaches Part of multi-component community randomized controlled trial	10 towns randomly assigned	Children aged 2–11 years at beach	Baseline and 1-year follow-up	Educational materials: avoid sun, cover up (hats, clothes), use SPF > 15, encourage family/friends to use	Increase in intervention towns from 0.56% pre-test to 0.76% post-test (mean; applied to at least one body part)	No change in clothing or shade use, children with any protection increased from 0.53% to 0.74% Change in control group was from 0.66% to 0.72%.
Parrott *et al.* (1999)	USA, Georgia, 1999	8 youth soccer participants Pre-/post intervention	$n = 12$ coaches, $n = 50$ parents, $n = 61$ players	Coaches 33–64 years Parents 31–56 years Youths 8–14 years	Pre-test: curriculum manual presented to coaches during focus group meeting. Post-test	Education on skin cancer, and how to protect skin (including how to choose and use sunscreen)	More parents prompting youths to wear sunscreen and role modelling More coaches preceiving they were able to encourage youths to wear sunscreen	No change in wearing of other sun protection items

VIC, Victoria State, NSW, New South Wales State; NMSC, non-melanoma skin cancer

Table 13. Targeted interventions in which effect on sunscreen use was not reported separately

Reference	Location	Study design and setting	Sample size	Population group	Duration of intervention	Strategy	Sunscreen use outcome	Other outcomes
Australia								
Girgis *et al.* (1993)	Australia, New South Wales, 1993	School Randomized controlled trial/ diary	11 schools $n = 612$	School-children 9–11 years	4-week curriculum. 1 x 30-min lecture. Control group	Curriculum: interactive Lecture: didactic 'Skin Safe' booklet distributed to both groups	Not reported	Significant ($p < 0.01$) difference in protection score at post-test Increased sun protection in curriculum group
Girgis *et al.* (1994)	Australia, New South Wales, 1994	One electrical supply company (12 depots) Randomized controlled trial	$n = 142$	Outdoor workers 22–63 years (mean, 40)	Pre-test 1-week intervention Post-test at 1 month	30-min lecture and presentation; brochure included education on increased risk of outdoor workers for skin cancer; sun protective clothing available at workplace	Sunscreen use not reported separately	Solar protection scores increased in intervention group ($p < 0.02$) and remained stable in control group ($p = 1.0$). Group difference at post-test was significant ($p = 0.04$)
USA								
Lawler (1989)	USA, 1989	Community Process evaluation only		General population	Available through American Cancer Society	Education booklet on sunscreen products and prevention strategies		
Reding *et al.* (1995)	USA, Wisconsin, 1991–92	School Quasi-experimental	$n = 401$	Third-grade students	Pre-test. Two 30–40 min presentations ~ 1 week apart on how and when to protect. Post-test & 6-month follow-up test	Education only	No sunscreen use measures	Increased knowledge No sun protection behaviour measured

Table 13. (contd)

Reference	Location	Study design and setting	Sample size	Population group	Duration of intervention	Strategy	Sunscreen use outcome	Other outcomes
Friedman *et al.* (1995)	USA, Texas, 1992	Worksite Longitudinal	$n = 324$	Hospital employees average, 41 years	Pre-test before clinical screening (May 1992). 4–7 month follow-up surveys	5-min screening and 15-min educational video on prevention, early detection and treatment	Analysis of predictors of intention to use sunscreen. Change in intention after test not reported	
Grant-Petersson *et al.* (1999)	USA, New Hampshire, 1997–99	Multi-component community-wide intervention in small towns (population 4000–12 000) Process evaluation from randomized controlled trial	24 elementary schools, 31 child-care centres	School-children 2–9 years	Schools, 2-year intervention Child-care centres, 1–2 year intervention	Schools held ~3 h of class lessons. Child-care centres held two 'SunSafe' theme days. Materials included 'SunSafe' manual (activities, reading lists, etc), cartoon video, cover-up video. ABCs guidelines 'Avoid the sun. Block the sun using SPF 15 + sunblock. Cover-up using hats and protective clothing. Speak out to family and friends regarding sun protection. Parental activities	Individuals' sunscreen use not measured	Individuals' other sun protection behaviour not measured

Table 14. Impact of large-scale commmunity interventions

Reference	Location	Study design and setting	Sample size	Population group	Duration of intervention	Strategy	Sunscreen use outcome	Other outcomes
Australia								
Hill *et al.* (1993)	Australia, Melbourne, 1987–89	Community Cross-sectional/ trends	1988 $n = 1655$ 1989 $n = 1397$ 1990 $n = 1376$	Melbourne residents 14–69 years	On-going community-wide intervention. Surveys of adult residents 1988, 1989, 1990	'Slip! Slop! Slap! school education programmes and annual summer public media campaign. Programme further developed into large-scale multi-component progamme 'SunSmart' (1988), with strategies including lobbying manufacturers to reduce sunscreen costs	1988–90 Increased sunscreen use if outside > 15 min 11:00–15:00: males, 10% to 14–15% ($p < 0.05$); females, 16% to 20–24% ($p < 0.001$)	1988–90 Fewer residents spending > 15 min outside 11:00–15:00: males 85% to 72–76% ($p < 0.001$); females, 69% to 54–66% ($p < 0.05$) Increased hat use among males and females ($p < 0.001$) Increased clothing coverage index: males, 0.68 to 0.65–0.72 ($p < 0.01$); females, 0.68 to 0.63–0.69 ($p < 0.01$)
Borland *et al.* (1990)	Australia, Victoria, 1988–89	Community Media Pre-post-intervention (repeated cross-sectional sample)	Pre-campaign $n = 560$ Post-campaign $n = 605$	Victoria residents $\geq$ 14 years	Summer campaign	'SunSmart' campaign	29% reported increased sunscreen use	22% hats 13% shirts 4% shade
Canada								
Rivers & Gallagher (1995)	Canada, 1991–93	Community Cross-sectional/ trends	$n = 1681$	Screening participants 2–87 years (median, 45 years)	On-going public and media campaign Surveys of screening participants 1991, 1992 and 1993	Annual media campaign and distribution of educational materials. 'Living with Sunshine' school curriculum. Community screening during 'Sun Awareness Week'	Sunscreen use increased in males and females Usual use of sunscreen by 60% of males and 77% of females in 1991 and 63% males and 79% of females in 1993	Other sun protection not measured

Table 14 (contd)

Reference	Location	Study design and setting	Sample size	Population group	Duration of intervention	Strategy	Sunscreen use outcome	Other outcomes
USA								
Miller *et al.* (1999)	USA, Massachusetts, Falmouth, 1994–97	Community Pre-/post-intervention	n = 401 pre-test n = 404 post-test	Households with children ≤ 13 years	Two random surveys of households at pre-test and and after 3 years of intervention	Multi-component community intervention (incorporated community activism, publicity campaign, distribution of sun protection educational materials and targeted interventions) Strategies include awareness raising, role modelling by parents and institutionalizing sun protection	At post-test more parents reported children used sunscreen For children aged 6–13, increase in use significant with regular use, when outside, at beach and continuous use at beach (36% to 53%, p < 0.001). For children aged < 6, increase significant only for continous use at beach (47% to 70%, p < 0.001) More parents bought and used sunscreen. Fewer parents sunbathed	Other sun protection behaviour generally consistent at both pre and post-test Increase in use of shirts at beach among children 6–13 years Decreased incidence of sunburn in children
Geller *et al.* (1997)	USA, 1995	Community Cross-sectional	58 cities n = 700 adults, 185 television stations, 54 newspapers	Residents ≥ 18 years	1994–95 post-test national survey of stations, newspapers and resident population	71% stations and 61% newspapers reported UVR index in 1994 and 1995	Regular sunscreen use associated with awareness of UVR index	64% aware of UVR index 38% changed sun protection 40% perceived UVR index helped choose when to tan
Robinson *et al.* (1997a)	USA, 1996	Community Cross-sectional/ trends	1986 n = 1012 1996 n = 1000	Residents ≥ 18 years	Public education programmes initiated in 1983; annual media campaign in May since 1985 Surveys of residents 1986 and 1996	Campaign includes print, television and radio messages on risks of sun exposure and benefits of sun protection	Sunscreen use increased from 35% to 54%	Increased regular use of tanning lamps/booths from 2% to 6%

setting were effective in raising the perception of susceptibility to skin cancer of patients treated for non-melanoma skin cancer and their helpers, and this was associated with increased sunscreen use (Robinson, 1992; Robinson & Rademaker, 1995).

One intervention study among outdoor workers (Girgis *et al.*, 1994) and one among schoolchildren (Girgis *et al.*, 1993) affected sun protection behaviour, but sunscreen use was reported only as part of a composite solar protection score. The impact of one intervention at swimming pools in which clients were given incentives and role modelling of lifeguards is also unclear, although the authors reported that the sun protection score improved when two or more sun protection measures were taken together, with no change in the mean quantity of free sunscreen used at the pools (Lombard *et al.*, 1991).

Few studies of large-scale community interventions were reported. These represent long-term commitments from communities to the control of skin cancer, and the interventions were generally evaluated subsequently in cross-sectional population surveys. The programmes evaluated included the 'Slip! Slop! Slap!' and 'SunSmart' campaigns in Victoria, Australia (Borland *et al.*, 1990; Hill *et al.*, 1993), the 'Sun Awareness' programme in Canada (Rivers & Gallagher, 1995), UVR index forecasting in the USA (Geller *et al.*, 1997), the Melanoma Skin Cancer Detection and Prevention Program in the USA (Robinson *et al.*, 1997a) and the Falmouth Safe Skin Project in Massachusetts, USA (Miller *et al.*, 1999). The 'Sun Awareness' programme used strategies for improving community knowledge about skin cancer and sun protection, which included mass media, distribution of educational brochures and development of a school curriculum for sun protection. The UVR index forecasting and the Melanoma Skin Cancer Detection and Prevention Program are based on television and print media messages on sun protection. The Sun Awareness programme also included strategies aimed mainly at improving community knowledge of skin cancer and sun protection. In contrast, the Falmouth Safe Skin Project and the 'SunSmart' programme are multi-component programmes encompassing regular mass media campaigns and local interventions, involving working with various groups to institutionalize sun protection by creating supportive social and physical environments. Five of the large-scale community interventions had a positive impact on sunscreen use at a population level. No effect on sunscreen use was seen in a study in which the UVR index was reported on television and print media nationally in the USA, although sunscreen use was associated with increased awareness of the forecasts (Geller *et al.*, 1997).

Compensatory behaviour

As noted above, sun-protective behaviour to some extent involves choices among alternative behaviours, not all of which are completely effective in protecting the skin from UVR. Hence, to the extent that increased sunscreen use leads to reduced use of other forms of sun protection, net exposure to UVR may increase.

Sunscreens are designed primarily to prevent sunburn. Most sunburns in children and adults occur during intentional exposure to the sun (Hill *et al.*, 1992; McGee *et al.*, 1995; Melia & Bulman, 1995; Autier *et al.*, 1998). Although use of sunscreens during unintentional exposure can reduce the occurrence of sunburn (Hill *et al.*, 1993; Green et al., 1999a), the situation is different for intentional exposure, and usual use of sunscreens, or use of sunscreens with a higher SPF, during intentional exposure seems to have little impact on the occurrence of sunburn (Wulf *et al.*, 1997; Autier *et al.*, 1999; McCarthy *et al.*, 1999).

A double-blind study of intentional exposure to the sun indicated that people who use high-SPF sunscreens stay in the sun longer than those who use lower-SPF products (Autier *et al.*, 1999). These investigators assigned French and Swiss volunteers aged 18–24 to use SPF 10 or SPF 30 sunscreen while on their summer holiday, assumed to consist of ≥ 15 days in a sunny region. The sunscreens were packaged identically, and 44 people were randomized to receive SPF 10 sunscreen and 43 to SPF 30 sunscreen. Analysis at the end of the summer revealed that the mean duration of the holidays was similar in the two groups, at 19 and 20 days, respectively. The number of skin reddening episodes was also comparable. However, those people randomized to the SPF 30 sunscreen had spent more hours per day in the sun (4.6) than those randomized to SPF 10 sunscreens (4.0). Similarly, the mean accumulated hours of exposure to the sun during the holiday was significantly greater for the subjects randomized to SPF 30 sunscreen (73 h) than those to SPF 10 (58 h). This study suggests that use of sunscreens by people who intentionally expose themselves to the sun reflects a desire to avoid sunburn rather than total exposure to UVR, and that guarding against skin cancer may be at best a secondary motive. The studies of beachgoers also lend support to the idea that sunbathers' use of sunscreens is driven by factors other than a desire to protect against skin cancer. It is possible that the increasing popularity of sunscreens will lead people who wish to be maximally protected to reduce their overall protection by over-reliance on sunscreens.

Cross-sectional surveys of comparable samples from the same population at different times indicate how people adjust various components of their sun protection behaviour. In Victoria, Australia, representative samples of 14–69-year-olds were interviewed during three successive summers covering a period when a major sun protection campaign was under way, and the point prevalence of sun protection behaviour was

measured (Hill *et al.*, 1993). Over this period, the use of sunscreens increased from 10% to 15% by men and from 16% to 28% by women. The prevalence of hat wearing rose from 23% to 32% among men and from 14% to 20% among women. The mean proportion of the body that was clothed did not decrease, but the proportion of people out of doors between 11:00 and 15:00 decreased. Surveys in Queensland, Australia, using the same method, four years apart (Baade *et al.*, 1996) showed an increase in sunscreen use (odds ratio, 1.7) at the same time as increases in shade seeking (odds ratio, 1.3) and hat wearing (odds ratio, 1.5), and both the proportion of people who went outside and the average time spent outside between 11:00 and 15:00 decreased. Likewise, in a Canadian study of screening participants in an on-going public education campaign (Rivers & Gallagher, 1995), increased sunscreen use was found, but other protective behaviour did not appear to have been measured.

In an evaluation of a community intervention in the USA (Miller *et al.*, 1999), children aged 6–13 years were reported by their parents to have increased sunscreen use but engaged in less sunbathing. At the beach, however, they were less likely to wear a shirt but more likely to use a sunscreen. An intervention study at swimming pools in the USA showed changes in children's non-sunscreen protective behaviour but no change in the amount of freely available sunscreen taken from dispensers (Lombard *et al.*, 1991). An inverse correlation between sunscreen use and the wearing of clothes was found for European children engaged in intentional exposure to the sun (Autier *et al.*, 1998). One year after an educational intervention in an elementary school in the USA, increases were reported in the use not only of sunscreens but also of hats, long-sleeved shirts, long trousers and sunglasses (Gooderham & Guenther, 1999).

Australian coastal lifeguards studied 8 years apart reported increased use of SPF ≥ 15 sunscreens while on duty (Fig. 24) and increased use of shade and hats (Dobbinson *et al.*, 1999). In a study in the USA, young women who were shown motivational material on photo-ageing increased their use of sunscreens without changing the amount of time spent outside (Novick, 1997).

In a study of intentional exposure to the sun by people aged ≥ 40 who were randomized to apply an SPF ≥ 15 sunscreen or a placebo moisturizer (Cockburn *et al.*, 1997), the levels of other sun protection behaviour, including time spent outdoors, were similar among those given sunscreen and those not given sunscreen. This result contrasts with the pattern reported in the study of Autier *et al.* (1999) and suggests that the way in which different sun protection behaviours are 'balanced' by individuals depends on personal characteristics and motivations.

Figure 24 T-shirt and sign advertising the 'SunSmart Campaign' on a beach in Australia