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# Sun exposure and sun protection in young European children: an EORTC multicentric study

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**Abstract**

Most European children experience exposure to the sun during the summer holidays. The aim of this study was to examine the behaviour of European children when in the sun during their holidays. In 1995–1997, a total of 631 young children were recruited during a multicentric study in Belgium, Germany, France and Italy. For each holiday period from birth, parents gave detailed information on sun exposure and child behaviour. Predictors and trends over time of sun protection were investigated. Forty percent of children were exposed to sunlight in the first and 86% in the sixth year of life. At the same time, the number of children who experienced sunburns rose from 1 to 23%. In the whole period of 6 years, only 8% of children always wore trousers and shirt when in the sun, while 25% children always used a sunscreen. The proportion of sun-exposed children who used sunscreen was stable with age (~50%), while those who always wore trousers and shirts dropped from 46% (1st year) to 19% (6th year). Multinomial logistic regression showed that sunscreen use, but not the wearing of clothes was associated with sun-sensitivity. In summary, sun exposure increases steadily, while sun protection decreases in the first 6 years of life in our cohort of children. In this cohort, use of a sunscreen was much more frequent than the wearing of clothes and a reduction in sun exposure. 

*Keywords:* Sun; Sunscreens; Clothing; Sunburn; Child; Preschool; Epidemiology; Primary prevention

## 1. Introduction

Exposure to sunlight is a major determinant of risk for skin cancer (squamous and basal cell carcinoma, and melanoma) [1–4]. Contrasting trends in international mortality rates from melanoma have been recently linked to differences in the timing and implementation of preventive campaigns and, consequently, to differences in sun protection knowledge and practice [5].

Skin cancer prevention campaigns target young children because sun exposure reduction during childhood would have a greater impact on melanoma risk than reduction of sun exposure during adulthood [6]. Scientists agree that a global approach to sun protection should involve key actions such as reducing sun exposure and wearing protective clothes when in the sun. A Working Group of the International Agency for Research on Cancer (IARC) recently concluded that sunscreens should not be the first choice for skin cancer prevention and should not be used as the sole agent for protection against sun [7]. Furthermore, the Working Group concluded that sunscreen use during intentional sun exposure (i.e. sunbathing) might be harmful.

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We analysed the data from a large retrospective study we performed in 1995–1997 [8,9] to investigate whether sun protection behaviours of young children in Continental Europe complied with these recommendations.

## 2. Patients and methods

### 2.1. Setting

During the period from October 1995 through to February 1997, a study on sun exposure and sun protection in children was carried out in elementary schools of four cities in Continental Europe (228 in Brussels, Belgium; 147 in Bochum, Germany; 104 in Lyons, France and 152 in Rome, Italy). The detailed study design has been described elsewhere in Refs. [8,9].

### 2.2. Study population

Of the 1183 eligible 6- to 7-year old children whose parents were approached, a total of 631 (53%) participated in the study. The participation rate was approximately the same in all schools, and there was no difference in the sex distribution between the participants and non-participants.

### 2.3. Measurements

Home interviews of parents were performed by a trained research nurse (one for each city) using a structured questionnaire and concerned each holiday period longer than 5 days from birth until the interview. The mother was the responder for 93% of children. For each holiday period, information on duration, duration of sunny weather, and location was collected together with details on the hours spent by the child in the sun, use of sunscreens, wearing of trousers, shirt and hat. Every sunburn episode from birth (including those not experienced during a holiday period) was recorded.

Total duration of holidays (TDH), and the number of holidays periods (NHP) were directly derived from questionnaires. The total duration of sun exposure (TDSE) was computed as the sum of the duration of all the holidays weighted by the number of sunny days and the number of hours spent by the child in the sun during the period. TDSE was not corrected for wearing of clothes because the latter was a factor we wanted to study separately. The difference between latitude of holiday place and habitual place of residence (i.e. parent's usual home) was computed for each holiday period. Averages of wearing of trousers and shirt, wearing of hat, sunscreen use, and difference in latitude were weighted according to duration, number of sunny days and hours spent by the child in the sun during each holiday period. Natural sun sensitivity was estimated using the Fitzpatrick classification in phototypes [10].

### 2.4. Analysis

Homogeneity across skin phototypes was tested using the Kruskal–Wallis test for TDH, NHP and TDSE and the chi-squared test for the difference in latitude. Trends of the variables over time were tested using the Generalised Estimating Equations (GEE) [11] to take into account the correlation of the values in the same children. Lastly, polytomous logistic regression [12] was used to study the mutual association of sunscreen use, sunburn occurrence, wearing of trousers and shirt and wearing a hat and their association with TDSE, difference in latitude and host characteristics (sex, eye colour and skin phototype). To avoid confounding, these variables were included simultaneously in the model. The Odds Ratios (ORs) provided by these models gave an estimate of these associations. In these models, TDSE, wearing of clothes and sunscreen use were categorised in tertiles, while the difference in latitude was categorised in quartiles.

## 3. Results

In their first 6 years of life, all children had at least one period (i.e. $\geqslant 5$ days) of holidays. The median total duration of holidays (TDH) was 19 weeks, spent on average during eight different periods (Table 1). After weighting for the presence of sunny weather, and for the child having been in the sun, the median total duration of sun exposure (TDSE) was 11 weeks. Sun exposure was not significantly different between the four skin phototypes, even if the most sun-sensitive children (Fitzpatrick phototype I: children who always burn and never tan) experienced less sun exposure than the others. Only 8% always wore trousers and a shirt when in the sun from birth to the sixth year of age, while 15% always wore a hat. Much greater proportions of children (25%) always used sunscreens and experienced sunburns (54%).

Table 2 shows variations in sun exposure and sun protection from birth to the sixth year of life. The median TDH increased from 0 weeks in the first year of life to 4 weeks in the sixth year of life ($P < 0.0001$), while the median TDSE increased from 0 to 2.4 weeks ($P < 0.0001$). Accordingly, the proportion of children who experienced sun exposure in a given year increased significantly with age, from 40 to 86% ($P < 0.0001$). In the first year of age, 12% of children who had TDSE $> 0$ spent holidays in places more than 8° south of their latitude of residence compared with 23% by the age of 6 years. However, this increase was not statistically significant.

Approximately 50% of children who were sun-exposed always wore clothes and a hat in the first year of life, but this proportion significantly decreased with age ($P<0.0001$) to 19% by the age of 6 years. The proportion of sun-exposed children who always used sunscreen did not change by age (approximately 50% each year). Only 1% of sun-exposed children experienced sunburns in the first year of age, but this number significantly increased to 23% in the sixth year of life ($P<0.0001$).

Tables 3 and 4 show the results from the logistic regression models. Neither sunscreen use nor wearing of clothes nor sunburn occurrence were found to be associated with gender. Sunscreen use was strongly positively associated with sun-sensitivity, and positively associated with wearing a hat and with the tendency to spend holidays in Southern latitudes. Sunscreen use was strongly negatively associated with the wearing of trousers and shirt.

Table 1
Sun exposure and sun protection in European children by sun sensitivity

| | Skin phototype according to Fitzpatrick | | | | |
|---|---|---|---|---|---|
| | I | II | III | IV | Total |
| Number of children | 32 (5%) | 154 (24%) | 238 (38%) | 207 (33%) | 631 |
| Median (ranges) total duration of holidays (TDH) in weeks[a] | 14 (2–68) | 20 (1–96) | 20 (1–120) | 18 (1–147) | 19 (1–147) |
| Median (ranges) number of holiday periods (NHP)[a] | 6 (1–18) | 8 (1–25) | 8 (1–23) | 7 (1–27) | 8 (1–27) |
| Number of children with NHP > 0 | 32 | 154 | 238 | 207 | 631 |
| Median (ranges) total duration of sun exposure (TDSE) in weeks[a] | 9.0 (2.0–45.6) | 11.8 (0.6–66.4) | 11.1 (0–93.4) | 10.4 (0–87.2) | 11.0 (0–93.4) |
| Number of children with TDSE > 0 | 32 | 154 | 235 | 206 | 627 |
| *n* (%) of children with average difference in latitude > 8° (south)[b,c] | 9 (28%) | 33 (21%) | 59 (25%) | 57 (28%) | 158 (25%) |
| *n* (%) of children who always wore trousers and a shirt[b,d] | 1 (3%) | 12 (8%) | 13 (6%) | 26 (13%) | 52 (8%) |
| *n* (%) of children who always wore a hat[b,d] | 6 (19%) | 28 (18%) | 34 (14%) | 25 (12%) | 93 (15%) |
| *n* (%) of children who always used sunscreen[b,d] | 13 (41%) | 38 (25%) | 58 (25%) | 48 (23%) | 157 (25%) |
| *n* (%) of children with at least 1 sunburn[d,e] | 23 (72%) | 108 (70%) | 157 (66%) | 52 (25%) | 340 (54%) |

[a] $P>0.1$ from Kruskal–Wallis tests for homogeneity of TDH, NHP and TDSE across the skin phototypes.
[b] Percentages were computed only over children with TDSE > 0.
[c] $P>0.1$ from Chi-squared test for the difference in latitude.
[d] Association with skin phototype tested in the polytomous logistic models presented in Tables 3 and 4.
[e] Given that sunburn episodes were reported also outside holiday periods, the percentages for this variable were not restricted to children with TDSE > 0.

Table 2
Sun exposure and sun protection in European children by year of age

| | Age (years) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 |
| 631 Children | | | | | | |
| Median (ranges) total duration of holidays (TDH) in weeks | 0 (0–34) | 2 (0–54) | 3 (0–20) | 3 (0–16) | 4 (0–16) | 4 (0–25) |
| Median (ranges) number of holiday periods (NHP) | 0 (0–4) | 1 (0–5) | 1 (0–5) | 1 (0–5) | 1 (0–5) | 2 (0–6) |
| Number (% over the total) of children with NHP > 0 | 294 (47%) | 406 (64%) | 450 (71%) | 494 (78%) | 538 (85%) | 561 (89%) |
| Median (ranges) total duration of sun exposure (TDSE) in weeks | 0 (0–32.2) | 0.6 (0–15.8) | 1.0 (0–20.0) | 2.0 (0–14.0) | 2.0 (0–13.0) | 2.4 (0–17.0) |
| Number (% over the total) of children with TDSE > 0 | 255 (40%) | 375 (59%) | 408 (65%) | 466 (74%) | 509 (81%) | 541 (86%) |
| *n* (%) of children with difference in latitude > 8° (south)[a,b] | 31 (12%) | 66 (18%) | 69 (17%) | 83 (18%) | 106 (21%) | 124 (23%) |
| *n* (%) of children who always wore trousers and a shirt[a,c] | 117 (46%) | 118 (31%) | 115 (28%) | 92 (20%) | 99 (19%) | 104 (19%) |
| *n* (%) of children who always wore a hat[a,c] | 145 (57%) | 177 (47%) | 155 (38%) | 145 (31%) | 128 (25%) | 108 (20%) |
| *n* (%) of children who always used sunscreen[a,b] | 106 (42%) | 196 (52%) | 191 (47%) | 219 (47%) | 236 (46%) | 244 (45%) |
| *n* (%) of children with at least 1 sunburn[c,d] | 8 (1%) | 21 (3%) | 49 (8%) | 76 (12%) | 1145 (18%) | 142 (23%) |

[a] Percentages were computed only over children with TDSE > 0.
[b] $P>0.1$ for test for trend by age (fitting Generalised Estimating Equations (GEE) to take into account the correlation of measures in the same children).
[c] $P<0.0001$ for test for trend by age (fitting GEE to take into account the correlation of measures in the same children).
[d] Given that sunburn episodes were reported also outside holiday periods, the percentages for this variable were not restricted to children with TDSE > 0.

Table 3
Determinants of sunscreen use and occurrence of sunburns (from multinomial polytomous logistic regression)[a]

| | | Outcome variables | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Sunscreen use | | Sunscreen use | | Sunburns | | Sunburns | |
| | | Medium versus low | | High versus low | | 1 versus 0 | | >1 versus 0 | |
| Predictors | | *n* | OR (95% CI) | *n* | OR (95% CI) | *n* | OR (95% CI) | *n* | OR (95% CI) |
| Sex | | | | | | | | | |
| Males | 317 | 109 | 1.0 Ref. | 98 | 1.0 Ref. | 108 | 1.0 Ref. | 59 | 1.0 Ref. |
| Females | 307 | 99 | 1.1 (0.7–1.6) | 115 | 1.4 (0.9–2.3) | 108 | 1.1 (0.7–1.6) | 62 | 1.1 (0.7–1.9) |
| Eye colour | | | | | | | | | |
| Dark | 211 | 64 | 1.0 Ref. | 64 | 1.0 Ref. | 67 | 1.0 Ref. | 29 | 1.0 Ref. |
| Hazel/green | 201 | 61 | 0.6 (0.4–1.1) | 71 | 0.6 (0.3–1.1) | 65 | 0.8 (0.5–1.2) | 44 | 0.8 (0.4–1.4) |
| Blue/grey | 212 | 83 | 0.7 (0.4–1.1) | 78 | 0.5 (0.3–0.9) | 84 | 0.8 (0.5–1.4) | 48 | 0.7 (0.4–1.3) |
| Phototype | | | | | | | | | |
| IV | 206 | 55 | 1.0 Ref. | 65 | 1.0 Ref. | 37 | 1.0 Ref. | 15 | 1.0 Ref. |
| III | 233 | 81 | 1.4 (0.8–2.4) | 80 | 1.8 (1.0–3.2) | 106 | 5.8 (3.6–9.4) | 48 | 6.4 (3.3–12.4) |
| II | 153 | 59 | 1.5 (0.8–2.9) | 51 | 1.7 (0.9-3.4) | 61 | 6.0 (3.4–10.6) | 47 | 10.6 (5.2–21.8) |
| I | 32 | 13 | 5.9 (1.2–27.9) | 17 | 15.8 (3.1–81.8) | 12 | 4.9 (1.8–13.3) | 11 | 10.0 (3.4–29.8) |
| Trousers and shirt (average use) | | | | | | | | | |
| Low | 249 | 76 | 1.0 Ref. | 108 | 1.0 Ref. | 85 | 1.0 Ref. | 42 | 1.0 Ref. |
| Medium | 162 | 62 | 0.9 (0.5–1.6) | 51 | 0.4 (0.2–0.7) | 60 | 1.0 (0.6–1.7) | 35 | 1.3 (0.7–2.4) |
| High | 213 | 70 | 0.5 (0.3–0.9) | 54 | 0.2 (0.1–0.3) | 71 | 0.7 (0.4–1.2) | 44 | 1.2 (0.7–2.2) |
| Hat (average use) | | | | | | | | | |
| Low | 202 | 67 | 1.0 Ref. | 46 | 1.0 Ref. | 67 | 1.0 Ref. | 36 | 1.0 Ref. |
| Medium | 208 | 72 | 1.5 (0.9–2.6) | 77 | 1.8 (1.0–3.2) | 64 | 0.8 (0.5–1.4) | 47 | 1.4 (0.8–2.7) |
| High | 214 | 69 | 1.8 (1.1–3.1) | 90 | 3.7 (2.1–6.6) | 85 | 1.1 (0.7–1.8) | 38 | 0.9 (0.5–1.8) |
| Sunburn | | | | | | | | | |
| 0 | 287 | 77 | 1.0 Ref. | 93 | 1.0 Ref. | – | – | – | – |
| 1 | 216 | 79 | 1.8 (1.1–2.9) | 82 | 1.3 (0.8–2.3) | – | – | – | – |
| >1 | 121 | 52 | 2.2 (1.2–4.0) | 38 | 1.1 (0.6- 2.2) | – | – | – | – |
| Sunscreens (average use) | | | | | | | | | |
| Low | 203 | – | – | – | – | 55 | 1.0 Ref. | 31 | 1.0 Ref. |
| Medium | 208 | – | – | – | – | 79 | 1.6 (1.0–2.6) | 52 | 2.2 (1.2–4.1) |
| High | 213 | – | – | – | – | 82 | 1.3 (0.8–2.2) | 38 | 1.3 (0.7–2.4) |
| TDSE | | | | | | | | | |
| ⩽7 weeks | 205 | 67 | 1.0 Ref. | 77 | 1.0 Ref. | 75 | 1.0 Ref. | 33 | 1.0 Ref. |
| 7.1–16 weeks | 205 | 68 | 0.9 (0.5–1.6) | 71 | 1.0 (0.6–1.8) | 79 | 1.1 (0.7–1.9) | 35 | 1.2 (0.6–2.3) |
| >16 weeks | 214 | 73 | 0.9 (0.5–1.6) | 65 | 1.0 (0.6–1.8) | 62 | 0.8 (0.5–1.3) | 53 | 1.7 (0.9–3.3) |
| Difference in latitude (average) | | | | | | | | | |
| <0° (north) | 140 | 58 | 1.0 Ref. | 28 | 1.0 Ref. | 44 | 1.0 Ref. | 25 | 1.0 Ref. |
| 0–4° | 170 | 43 | 0.5 (0.3–0.9) | 51 | 1.4 (0.7–2.7) | 49 | 1.1 (0.6–1.9) | 36 | 1.6 (0.8–3.2) |
| 4.1–8° | 157 | 59 | 1.3 (0.7–2.4) | 56 | 3.0 (1.4–6.1) | 61 | 1.9 (1.1–3.6) | 34 | 2.2 (1.0–4.7) |
| >8° | 157 | 48 | 1.4 (0.7–2.8) | 78 | 6.8 (3.3–14.3) | 62 | 1.6 (0.9–3.1) | 26 | 1.5 (0.7–3.3) |

OR, Odds Ratio; 95% CI, 95% Confidence Interval; Ref, reference; TDSE, total duration of sun exposure.
[a] Excluded 3 children with missing eye colour and 4 with TDSE = 0.

The only predictor of sunburn occurrence was the natural sun sensitivity (i.e. skin phototypes I and II). Since TDSE tended to be lower in skin phototype I children, the effect of TDSE on sunburn occurrence was removed after introduction of the skin phototype in the logistic model. Results suggesting positive associations between sunburn experience and sunscreen use or difference in latitude were inconsistent. Wearing a hat was positively associated with wearing of trousers and shirt, with sunscreen use and less clearly with the difference in latitude (Table 4). Apart from the associations described above, wearing of trousers and a shirt was positively associated with difference in latitude.

## 4. Discussion

Our data indicated that, during the first years of life, important changes take place in the sun exposure behaviours of children living in Continental Europe. Over time, sunscreen use remained stable while the wearing of trousers, shirts and hats decreased dramatically. In addition, sunscreen use and the wearing of clothes were inversely correlated, indicating that sunscreens are not used as an adjunct to clothing, but as substitutes for clothing. It is thus possible that the increasing number of sunburns over time was due to the decrease in sun protection that paralleled the increase in sun exposure.

Table 4
Determinants of wearing of clothes (from multinomial polytomous logistic regression)[a]

| | | Outcome variables | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Wearing a hat | | Wearing a hat | | Wearing trousers and a shirt | | Wearing trousers and shirt | |
| | | Medium versus low | | High versus low | | Medium versus low | | High versus low | |
| Predictors | | *n* | OR (95% CI) | *n* | OR (95% CI) | *n* | OR (95% CI) | *n* | OR (95% CI) |
| Sex | | | | | | | | | |
| Males | 317 | 108 | 1.0 Ref. | 111 | 1.0 Ref. | 82 | 1.0 Ref. | 106 | 1.0 Ref. |
| Females | 307 | 100 | 0.7 (0.5–1.1) | 103 | 0.7 (0.5–1.1) | 80 | 1.2 (0.8–1.8) | 107 | 1.1 (0.7–1.7) |
| Eye colour | | | | | | | | | |
| Dark | 211 | 64 | 1.0 Ref. | 68 | 1.0 Ref. | 54 | 1.0 Ref. | 62 | 1.0 Ref. |
| Hazel/green | 201 | 65 | 0.9 (0.6–1.6) | 72 | 1.6 (0.9–2.7) | 53 | 1.1 (0.6–1.8) | 71 | 0.8 (0.5–1.4) |
| Blue/grey | 212 | 79 | 0.8 (0.4–1.3) | 74 | 1.2 (0.7–2.2) | 55 | 1.0 (0.6–1.7) | 80 | 0.6 (0.4–1.1) |
| Phototype | | | | | | | | | |
| IV | 206 | 79 | 1.0 Ref. | 61 | 1.0 Ref. | 51 | 1.0 Ref. | 63 | 1.0 Ref. |
| III | 233 | 74 | 0.7 (0.4–1.3) | 78 | 0.8 (0.5–1.4) | 62 | 1.4 (0.8–2.4) | 83 | 1.9 (1.1–3.3) |
| II | 153 | 45 | 0.8 (0.4–1.5) | 60 | 1.2 (0.6–2.3) | 41 | 1.5 (0.8–2.7) | 55 | 1.6 (0.9–3.1) |
| I | 32 | 10 | 1.0 (0.3–3.1) | 15 | 1.7 (0.6–5.2) | 8 | 1.3 (0.4–3.7) | 12 | 1.9 (0.7–5.2) |
| Trousers and shirt (average use) | | | | | | | | | |
| Low | 249 | 95 | 1.0 Ref. | 57 | 1.0 Ref. | – | – | – | – |
| Medium | 162 | 69 | 1.5 (0.9–2.6) | 45 | 1.6 (0.9–2.9) | – | – | – | – |
| High | 213 | 44 | 0.8 (0.5–1.5) | 112 | 4.2 (2.4–7.3) | – | – | – | – |
| Hat (average use) | | | | | | | | | |
| Low | 202 | – | – | – | – | 48 | 1.0 Ref. | 57 | 1.0 Ref. |
| Medium | 208 | – | – | – | – | 69 | 1.4 (0.8–2.3) | 44 | 0.7 (0.4- 1.1) |
| High | 214 | – | – | – | – | 45 | 1.5 (0.8- 2.7) | 112 | 3.8 (2.2–6.4) |
| Sunburns | | | | | | | | | |
| 0 | 287 | 97 | 1.0 Ref. | 91 | 1.0 Ref. | 67 | 1.0 Ref. | 98 | 1.0 Ref. |
| 1 | 216 | 64 | 0.8 (0.5–1.4) | 85 | 1.2 (0.7–2.0) | 60 | 1.1 (0.7–1.9) | 71 | 0.7 (0.4–1.1) |
| >1 | 121 | 47 | 1.4 (0.8–2.6) | 38 | 0.9 (0.5–1.8) | 35 | 1.2 (0.6–2.2) | 44 | 1.1 (0.6–2.0) |
| Sunscreens (average use) | | | | | | | | | |
| Low | 203 | 59 | 1.0 Ref. | 55 | 1.0 Ref. | 49 | 1.0 Ref. | 89 | 1.0 Ref. |
| Medium | 208 | 72 | 1.5 (0.9–2.6) | 69 | 2.1 (1.2–3.7) | 62 | 1.0 (0.6–1.7) | 70 | 0.5 (0.3- 0.9) |
| High | 213 | 77 | 2.0 (1.1–3.5) | 90 | 4.5 (2.5–8.1) | 51 | 0.4 (0.2- 0.7) | 54 | 0.2 (0.1–0.3) |
| TDSE | | | | | | | | | |
| ⩽7 weeks | 205 | 94 | 1.0 Ref. | 62 | 1.0 Ref. | 40 | 1.0 Ref. | 74 | 1.0 Ref. |
| 7.1–16 weeks | 205 | 57 | 0.5 (0.3–0.8) | 88 | 1.1 (0.7–2.0) | 63 | 2.7 (1.5–4.6) | 81 | 1.4 (0.9–2.4) |
| >16 weeks | 214 | 57 | 0.4 (0.2–0.7) | 64 | 0.7 (0.4–1.3) | 59 | 1.8 (1.0–3.1) | 58 | 0.8 (0.5–1.4) |
| Difference in latitude (average) | | | | | | | | | |
| <0° (north) | 140 | 30 | 1.0 Ref. | 40 | 1.0 Ref. | 27 | 1.0 Ref. | 35 | 1.0 Ref. |
| 0–4° | 170 | 52 | 1.8 (1.0–3.3) | 57 | 1.2 (0.7–2.2) | 39 | 1.8 (1.0–3.3) | 59 | |
| 4.1–8° | 157 | 64 | 3.3 (1.7–6.2) | 57 | 1.7 (0.9–3.2) | 50 | 4.0 (2.1–7.7) | 63 | 3.9 (2.0–7.5) |
| >8° | 157 | 62 | 2.8 (1.5–5.5) | 60 | 1.6 (0.8–3.1) | 46 | 3.5 (1.8–6.8) | 56 | 3.6 (1.8–7.0) |

OR, Odds Ratio; 95% CI, 95% Confidence Interval; Ref, reference; TDSE, total duration of sun exposure.
[a] Excluded 3 children with eye colour not defined and 4 with TDSE = 0.

Thus, the families' propensity to protect their children by limiting sun exposure and by using clothes sharply decreased over time. Furthermore, as the child gets older it becomes easier for the family to spend longer holidays and in more distant and Southern areas and the children become less inclined to wear clothes in the sun.

Recall biases could account for a part of the reported changes in time-variations in sun exposure and sun protection habits. However, the time covered by the interviews was only 6 years, and mothers tend to remember quite well the care they provided to their child, as well as the negative health episodes experienced by their child. Participating families may have been more aware of the harmful effects of the sun, and probably had healthier habits than non-participants. In that respect, it is likely that the frequency of sun protection habits was somewhat overestimated.

Studies on sun exposure and protection including children aged less than 7 years were performed in Australia and New Zealand [13–16], North America [17–20] and a few in Europe [21,22]. The study by Miller and colleagues [19] reported two measures of sun exposure and sun protection before and after a prevention campaign. Some of these studies concentrated on the 'usual' sun protection [13,15], others on sun protection over a

short period of time [14,17,18,20–22]. Our study is one of the few studies to appraise sun exposure and sun protection in children during each year from birth until the sixth year of life.

Children had already significant sun exposure in their first year of life, and 12% of them spent their first holiday periods in places $\geqslant 8^{\circ}$ more southern than their habitual place of residence. This means that some children, resident for example in Northern Europe, in their first year of life spent some time in Southern Europe (i.e. Italy, Spain, Greece) or even in tropical countries and in these countries they spent some hours per day in the sun. Difference in latitude is not only an indicator of the intensity, but also of the spectral distribution of the sun exposure. The annual dose of ultraviolet radiation B (UVB, 280–315 nm) attaining Earth ground in Belgium (average latitude 50°) is equivalent to 1500 MEDs (Minimal Erythemal Doses, i.e. a dose of UVB necessary to trigger a perceptible erythemal reaction on unexposed skin). In Spain (average latitude 40°), the annual UVB irradiation is equivalent to 2500 MEDs [1]. Furthermore, seasonal variation in ultraviolet radiation (UVR) is significant in temperate regions, but less so in Southern regions and is more important for UVB [1]. Hence, compared with the UVB radiation, North to South and seasonal changes in the amounts of UVA radiation (315–400 nm) are much less significant.

A British study [21] reported in 1993 that the proportions of sun-exposed children who did not wear a shirt were 14, 52 and 83% in children aged $<1$, 1–2 and 3–4 years, respectively. The corresponding proportions of children who applied sunscreens at least once were 29, 59 and 65%, respectively. An American study by Robinson and colleagues [17] found that the proportion of children that used sunscreens was similar at different ages (approximately 50%). Mean duration of outdoor exposure was 5.04 h for children aged less than 2 years and 7.65 h for children aged 5–7 years. The proportion of children with sunburn experience was 7% in children aged less than 2 years and 11% in those aged 5–7 years. So, compared with our study, they found a higher sunburn experience in children aged less than 2 years and a lower one in children aged 5–7 years. Another study [19] on 222 American children aged less than 6 years showed that 58 and 49% of them wore a shirt and a hat respectively, proportions higher than those found in our study. Although many studies reported an insufficient level of sun protection in North American young children, the differences with our results suggest that the children's sun exposure is more cautious in North America than in continental Europe. The level of knowledge about the dangers of sun exposure is high in Australia and New Zealand where there is a national sun protection programme in schools [23]. The study by Rademaker and colleagues in New Zealand [15] showed that 65% of the 5–8-year-old children reported sunscreen use, 69% the use of protective clothing and 43% the use of shade. The study by Dixon and colleagues reported that in Australian children aged 5–12 years almost all of them wore a hat when in the sun [13].

Mortality for melanoma in the recent cohorts started to decline in Australia, North America, the UK and Sweden, while it has continued to increase in other countries of Continental Europe (Italy, France and Czechoslovakia) [5]. These differences are deemed to be the result of differences in the timing and implementation of skin cancer prevention campaigns. In the different countries of Continental Europe, the situation is far from homogeneous and short-term prevention campaigns are generally disseminated a few weeks before summer holidays. In addition, these campaigns focus particularly on the use of sunscreens and it is only recently that some prevention campaigns advocate sun protection mainly through a reduction in sun exposure and increased clothing.

The fact that skin phototype was not associated with the wearing of clothes and hats, but with sunscreen use suggests that the increased risk of harmful effects of sunlight in a fair-skinned child is recognised by the parents, but it is controlled only with the use of sunscreens. Sunscreens were primarily formulated for the prevention of sunburns. Their value in skin cancer prevention remains a controversial issue. Randomised studies have suggested that sunscreen use could moderately reduce the risk of skin squamous cell carcinomas [24], and could decrease the number of nevi in certain circumstances [25]. However, many epidemiological studies have suggested that sunscreen use during intentional sun exposure (i.e. when the aim is to acquire a tan) could increase the number of nevi, the risk of melanoma, and the risk of basal cell skin cancer [8,26–29]. Recent randomised studies have also suggested that sunscreen use could increase the time spent in the sun, a phenomenon probably responsible for the increased risk of melanoma and basal cell cancer found in many observational studies [30,31]. The relative role of UVB and UVA in melanoma and basal cell cancer occurrence is still under investigation. Therefore, for skin cancer prevention preference must be given to broad-spectrum sunscreen. However, the overall evaluation of sunscreens by the IARC Working Group [7] reported that sunscreens "probably prevent squamous cell carcinoma when used mainly during unintentional sun exposure, but no conclusion can be drawn about their cancer preventive effect against basal-cell carcinoma and cutaneous melanoma". In conclusion, there is an urgent need in Continental Europe for educational campaigns targeting families with young children in order to change children's behaviour when in the sun, and to encourage the adoption of global sun protection strategies, giving priority to a reduction in sun exposure and the increased wearing of clothes.

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