

Use of multiple correspondence analysis to explore associations between caregivers and sun protective habits during summer vacations

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Abstract

Background Childhood exposure to ultraviolet radiation (UVR) plays an important role in the development of keratinocyte carcinomas and melanomas. Therefore, sun protective measures ought to be implemented during early childhood. Young children are largely dependent upon adult care providers in order to achieve proper sun protection.

Objectives To develop effective photoprotection in children, it is necessary to understand caregivers' attitudes and knowledge about UVR exposure. This study aimed to explore the variables associated with sun protective behaviour in parents and grandparents during summer vacations.

Methods A multinational, cross-sectional study was conducted using a web-based online survey with a representative sample of parents and grandparents of children aged ≤ 12 years, who cared for their children/grandchildren for at least 2 weeks during the summer of 2021, in five countries (France, Germany, Spain, Italy and the USA). Multiple correspondence analysis (MCA) was used to explore in an unbiased way the possible relationships among all the variables and to identify specific profiles.

Results A total of 6190 adult participants responded to the questionnaire: 5104 parents (average age 42.0 years, 54.3% women) and 1086 grandparents (average age 64.2 years, 55.5% women). MCA allowed discrimination of two groups of respondents based on their answers: a profile with 'unprotected sun exposure habits' vs. those with 'protective sun exposure habits'. Parents fell in closer proximity to the 'unprotected sun exposure habits', and 'sunburn reported in youngest child'. Grandparents adopted more cautious behaviours than parents. Nevertheless, grandparents fell in proximity to 'having exposed the grandchild to the sun between 11 h and 17.00 h', 'not using an umbrella' and 'not using sunglasses'.

Conclusions Although grandparents appear to adopt more cautious behaviours than parents, many gaps in proper sun protection behaviour were observed in both groups of caregivers.

Keratinocyte carcinoma and malignant melanoma currently represent the most common types of cancer among fair-skinned populations and their incidence has been increasing steadily over the past decades.^{1–3} Rising individual exposure to ultraviolet radiation (UVR) has been identified as the primary driver of these increased incidence rates. This includes sun exposure behaviours during leisure-time activities, outdoor intentional and unintentional tanning, and the expanding popularity of tanning beds and salons driven by the popular belief that a tan is associated with improved appearance.¹ Although constitutional factors (pigmentary traits, melanocytic naevi, familial history of melanoma and genetic predisposition) play an important role in the risk of melanoma,^{2–4} it has been recently demonstrated that approximately 95% of all cutaneous melanoma cases and deaths in people in the USA are attributable to UVR.⁵ Moreover, epidemiological evidence indicates that childhood exposure to UVR and sunburn are strong determinants for all types of skin cancer

risk,^{6,7} and especially melanoma^{8–11} as children's skin is more sensitive to UVR.

The primary cornerstone of skin cancer prevention is the adoption of sun safety practices aiming at limiting UVR exposure. Recommended strategies for sun protection to reduce skin cancer risk include seeking shades when outdoors; wearing photoprotective clothing, hat and sunglasses; and using broad-spectrum sunscreens with sun protection factor (SPF) 30 or above.¹² There is a growing body of evidence suggesting a reduced risk of melanoma with sunscreen use.^{13–16} A randomized clinical trial conducted in Australia found that regular sunscreen use was associated with a lower risk of invasive melanoma (hazard ratio 0.27).¹⁴ Moreover, a population-based, case–control family study of 603 patients and 1088 controls using Australian Melanoma Family Study data found that both childhood sunscreen use and lifetime sunscreen use were significantly associated with a decreased risk of cutaneous melanoma among young adults.¹⁶ These

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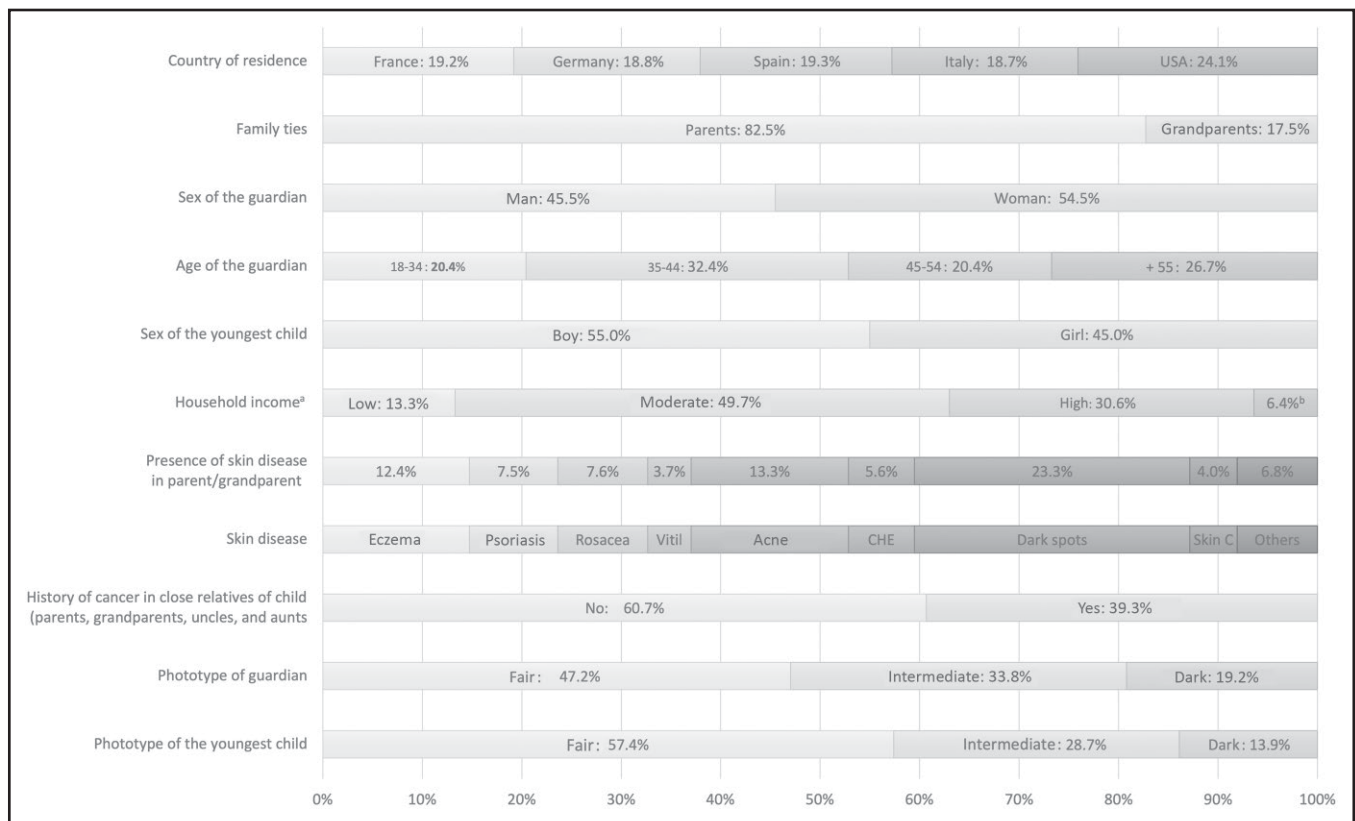


Figure 1 Description of the study population. ^aHousehold annual income defined as low (< 18 000 euros), intermediate (18 001–47 000 euros) and high (> 47 001 euros). ^bDo not wish to reply. CHE, chronic hand eczema; dark spots, consist of hyperpigmented spots such as lentigos, melasma; guardian, parents or grandparents; skin C, skin cancer; Vitiligo, vitiligo.

results emphasize the need to reach populations of all age groups with sun protection messages.

Although sun exposure occurs throughout a person's lifetime, a relatively higher cumulative amount of UVR is acquired in childhood and early adolescence compared with adulthood.^{17,18} Therefore, ideally, sun protective behaviours ought to be implemented during early childhood. Young children are largely dependent upon adult care providers' sun protective measures. Moreover, parents and other caregivers function as important role models for their children.¹⁹ Such behavioural patterns are likely to be maintained during adulthood.²⁰ Caregivers of children have therefore been one of the primary target groups in skin cancer prevention.^{21–23} However, the uptake of sun protection measures is far from ideal.^{24,25}

To develop effective skin cancer prevention interventions optimally, understanding caregivers' attitudes, knowledge concerning UVR exposure and protective behaviour is needed. This study aimed to explore the variables associated with sun protective behaviour in parents and grandparents during summer vacations.

Materials and methods

Study population

This multinational, cross-sectional study was conducted using a web-based online survey of a representative sample

of parents and grandparents of children aged ≤ 12 years, who cared for their children/grandchildren for at least 2 weeks during the summer of 2021, in five countries (France, Germany, Spain, Italy and the USA) (Figure 1). Individuals were recruited from a representative sample of the adult general population of each country using stratified proportional sampling with a replacement design. The survey was conducted at the end of August 2021 (between September and October 2021). Institutional review board approval were not required as the study did not involve any clinical examination and used anonymized data.

Questionnaire

The questionnaire elicited information about caregivers' sociodemographic characteristics, phototype and attitudes concerning sun exposure and protective behaviour. Information was only collected regarding the youngest child/grandchild looked after: age, sex, risk factors of the child (phototype, presence of a family history of skin diseases, melanocytic naevi, freckles, eye colour).

Phototype information was collected as follows.

- (i) Phototype I: You have very white skin, blond or red hair and blue/green eyes, often with freckles. Sunburns are systematic, your skin never tans and always reddens.
- (ii) Phototype II: You have fair skin, blond to chestnut hair and light to brown eyes with occasional freckles.

Sunburns are frequent, your skin tans hardly or very slowly.

- (iii) Phototype III: You have intermediate skin, chestnut to brown hair and brown eyes. Sunburns are occasional and your skin tans gradually.
- (iv) Phototype IV: You have dark skin and brown/black hair and eyes. You get sunburned occasionally, especially during intense exposure. Your skin tans well.
- (v) Phototype V: You have dark brown skin, black hair and eyes. Sunburns are rare, your skin tans a lot.
- (vi) Phototype VI: You have black skin, black hair and black eyes. Sunburns are very exceptional.

Phototypes I and II were labelled as 'fair phototype'. Phototype III was labelled 'intermediate' and phototypes IV, V and VI were labelled as 'dark phototypes'.

Statistical analysis

For descriptions of the study population, qualitative variables were reported as the number (percentage). Quantitative variables were reported as the median and/or the mean (SD) or were converted to qualitative variables.

In order to explore in an unbiased way the possible relationships among all the variables and to identify specific profiles we used multiple correspondence analysis (MCA).²⁶ MCA is a multivariate statistical analysis suited to categorical data. Associations between features are represented graphically. The graphs aim to visualize the similarities or differences in the profiles simultaneously, identifying those dimensions that contain most of the data variability. As a result, we reduced our variables of interest to two dimensions that explain the largest fraction of the variance observed in our dataset. Variables in our dataset were projected as vectors in a space

defined by those two dimensions. The position of the variable categories in this two-dimensional space reflects their mutual associations, with no a priori assumption on the underlying structure of the data. The percentage coordinates (*x*- and *y*-axis) of the graph enable the category points in a graph to be represented and established. Categories that plot close to each other will be significantly related statistically. If two categories present high coordinates and are close in space, this means that they tend to be directly associated. If two categories present high coordinates but are distant from each other, this means that they tend to be inversely associated. Inertia corresponds to the explained variance of dimensions. All analyses were conducted in RStudio (Integrated Development for R. RStudio, PBC, Boston, MA, USA) using R 4.1.3.

Results

Participant characteristics

A total of 6190 adult participants responded to the questionnaire: 5104 parents (average age 42.0 years, 54.3% women) and 1086 grandparents (average age 64.2 years, 55.0% women). Initial contact participation rates of the study were at 82.0% (6190/7550).

Parents and grandparents looked after 1.87 children and 1.88 grandchildren, respectively, for at least 15 days during the summer. Most respondents had a fair skin (2919/6190, 47.2%). Figure 1 describes the sociodemographic and personal characteristics of the parents and grandparents.

Table 1 describes the caregivers' attitudes and protective behaviour concerning UVR exposure.

Figure 2 depicts the incidence of sunburn in children 12 years or younger by country surveyed. This incidence of

Table 1 Parents and grandparents' attitudes and protective behaviour concerning ultraviolet radiation exposure

Question	<i>n</i>	%
During this summer, was the youngest child/grandchild somehow exposed to the sun during the following hours?	6158	
Morning before 11.00 h	3519	57.1
Between 11.00 h and 17.00 h	4595	74.6
After 17.00 h	3818	62.0
Never	120	1.9
On a typical day, for how long, on average, was the youngest child/grandchild exposed to the sun?	6040	
< 30 min	783	13.0
≥ 30 min and < 2 h	2933	48.6
≥ 2 h	2080	34.4
All day long	244	4.0
Was the youngest child/grandchild's exposure to the sun gradual (a little time at first, longer later)?	6040	
Yes	4300	71.1
No	1740	28.9
Did you protect your youngest child/grandchild from the sun?	6160	
Yes, at every outing regardless of the sunlight	3991	64.8
Yes, but only during intense sun exposure	1959	31.8
No	210	3.4
Did you use the following means to protect the youngest child/grandchild from the sun?	5952	
Sunscreen	5631	94.6
Shade	4726	79.4
Hat	4526	76.0
Umbrella	3832	64.4
Sunglasses	3784	63.6
Covering clothes	3287	55.2
Anti-ultraviolet clothing	1615	27.1
Food supplements	1119	18.8

(Continued)

Table 1 (Continued)

Question	n	%
What SPF do you usually use for your youngest child/grandchild?	5625	
6–10	225	4.0
15–25	747	13.3
30–40	1467	26.1
50	3192	56.7
Why do you use a sun protection product for your youngest child/grandchild?	5632	
To avoid sunburn	4537	80.6
To allow him/her to spend more time in the sun	2227	39.5
Due to his history of sunburns	726	12.9
To avoid the risk of skin cancer	3129	55.6
To prevent his/her skin from ageing too quickly	1649	29.3
Who recommended the sunscreen product you used for youngest child/grandchild?	5632	
A general practitioner	412	7.3
A paediatrician	984	17.5
A dermatologist	632	11.2
Another medical specialist	215	3.8
A pharmacist	1383	24.6
A consultant in a health store	262	4.7
I chose myself	2853	50.7
Someone else in his or her entourage	415	7.4
How many times during the day did you apply sunscreen on your youngest child/grandchild?		
On sunny days	5632	
Never	67	1.2
Once	975	17.3
Twice	2260	40.1
Three times	1319	23.4
Every 2 h	1010	17.9
On days when the sun was hidden by clouds	5632	
Never	1004	17.8
Once	1942	34.5
Twice	1432	25.4
Three times	682	12.1
Every 2 h	571	10.1
For what main reason(s) do you use sunscreen products?	5632	
To avoid sunburn	4537	80.6
To spend more time in the sun	2227	39.5
Because of a history of sunburns	726	12.9
As protection against the acceleration of skin ageing	3129	55.6
As protection against the risk of skin tumours	1649	29.3
When you think back to your childhood, do you feel like your parents protected you from the sun?	6160	
Not at all	1352	21.9
A little, but it wasn't really a concern	2596	42.1
A little, but still a concern	1041	16.9
Yes, they were very vigilant	1171	19.0
In the past year, have you had any indoor ultraviolet sessions?	6160	
Yes	813	13.2
No	5347	86.8
During the past summer, were you exposed to the sun during the hottest part of the day, between 11.00 h and 17.00 h?	5231	
Yes	4259	81.4
No	972	18.6
What SPF do you usually use?	4470	
6–10	183	4.1
15–25	891	19.9
30–40	1591	35.6
50	1805	40.4
When you think back to your childhood, do you remember if you had sunburn	5076	
No, never	822	16.2
Yes, from time to time	2961	58.3
Yes, regularly	897	17.7
Yes, often	396	7.8

SPF, sun protection factor.

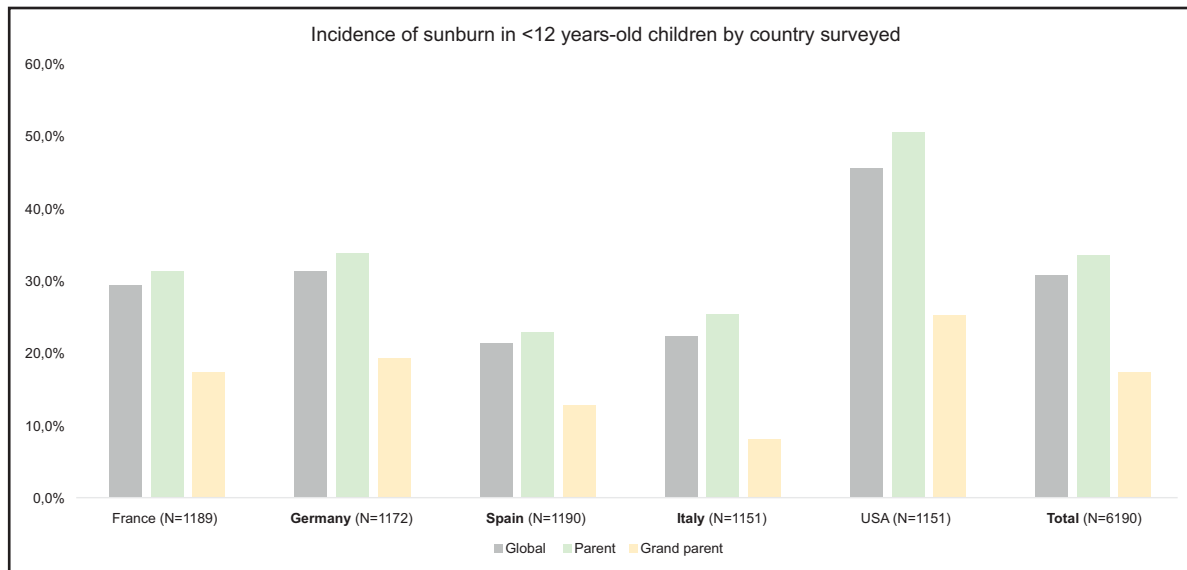


Figure 2 Incidence of sunburn in children 12 years and younger by country surveyed.

sunburn in children was the highest in the USA reaching 45.9% of surveyed parents and grandparents.

MCA was performed on data from 5832 parents and grandparents who had fully completed questionnaires. The descriptive data of the recoded variables are found in Table 2.

Figure S1 (see the Supporting Information) shows the position of each category in the plot and its contribution on the dimensions. For better visualization of the data, only the top contributing variable categories are represented in Figure 3. The perceptual map of the variables explained 20% of the variance (inertia) of the complete model. MCA allowed discrimination of two groups of respondents based on their answers: the x-axis of the figure opposes a profile 'unprotected sun exposure habits' (Q1_3, Q3_2, Q9_1) on the right vs. those with 'protective sun exposure habits' on the left (Figure 3, Table 3). The y-axis of the figure opposes parents above the y-axis and grandparents below the y-axis (Figure 3).

We observed that 'parents' fell in closer proximity to the 'unprotected sun exposure habits', to age < 45 years (Age_1), 'sunburn reported in youngest child' (Y_1), 'not using any means to protect the youngest child from the sun' (Q3_2), 'having had indoor UV tanning sessions in the past year' (Q2_1), 'using sunscreens with lower SPF (< 25)' (Q5_1 and Q6_1), 'applying sunscreen to allow the child to spend more time in the sun' (Q7_2), and 'having had the sunscreen product recommended by a dermatologist' (Q10_2).

We observed that 'Grandparents' fell in proximity to age ≥ 45 years (Age_2), 'no reported sunburn in grandchild (Y_0)', 'no history of sunburn during childhood' (Q8_1), 'not having protected the youngest grandchild from sun exposure' (Q1_3), 'having exposed the grandchild to the sun > 30 min' (Q8_2), 'having exposed the grandchild to the sun between 11.00 h and 17.00 h' (Q11_2), 'not using an umbrella' (Q12_2), 'not using sunglasses' (Q13_2). Moreover, 'Grandparents' fell in proximity to 'not having specified the SPF range of the sunscreen used' (Q6_3), and 'the means used to protect the child from sun exposure' (Q3_3).

Discussion

Almost a third of parents and grandparents reported a sunburn in their child/grandchild over the summer of 2021. It was highest in the USA reaching 45.9% of surveyed caregivers. This is alarming and highlights the need to continue raising awareness about sun exposure hazards, aiming at reducing the UVR dose received particularly by children. Key sun protection measures have been promoted through various national campaigns across the world; however, the success in behavioural modification and reduction of skin cancer rates has been variable.^{24,25,27} More-targeted education guidelines have been deemed to be necessary to ensure sun safety for all children. Because children are also looked after by their grandparents during the summer vacation, the sun protective strategies adopted by grandparents are particularly important for public health. Trends in social norms related to sun exposure have evolved in the past four decades and older adults are rarely targeted by sun safety interventions.²⁸ This study, conducted among national representative samples from five countries, offers an assessment of the sun protective habits of both parents and grandparents during the summer vacations.

Parents' and grandparents' sun protection behaviour towards children is probably affected by many factors, and these are likely to vary with the child's age and level of independence. In young children, sun protection depends chiefly upon the caregivers' behaviour and attitudes towards UVR exposure. As we sought to explore the caregivers' practices and decision making, children older than 12 years were not included, and when multiple children were cared for by the same participant, the questionnaire explored the sun protective behaviour towards the youngest child.

The findings of the study suggest that grandparents appear to adopt more cautious behaviours than parents. However, their sun prevention behaviour towards children is far from optimal. Important preventive messages to be targeted in grandparents are avoidance of sun exposure when UVR tend to be strongest (11.00–17.00 h), information on

Table 2 Description of the study population included in the multiple correspondence analysis

Variable	<i>n</i> (%) (<i>N</i> = 5832)
Caregiver	
Parent	4830 (82.8)
Grandparent	1002 (17.2)
Age of caregiver	
< 45 years	3114 (53.4)
≥ 45 years	2718 (46.6)
Caregiver sex	
Male	2698 (46.3)
Female	3134 (53.7)
Child sex	
Male	3224 (55.3)
Female	2608 (44.7)
Child age	
< 6 years	2525 (43.3)
≥ 6 years	3307 (56.7)
Sunburn (Y)	
Yes (Y_1)	1848 (31.7)
Q1 Did you protect your youngest child/grandchild from the sun?	
Q1_1, Yes, at every outing regardless of the sunlight	3783 (64.9)
Q1_2, Yes, but only during intense sun exposure	1860 (31.9)
Q1_3, No	189 (3.2)
Q2 Have you had indoor ultraviolet tanning sessions in the past year?	
Q2_1, Yes	789 (13.5)
Q2_2, No	5043 (86.5)
Q3 Did you use the following means to protect the youngest child from the sun?	
Q3_1, Yes	5335 (91.5)
Q3_2, No	308 (5.3)
Q3_3, Did not specify	189 (3.2)
Q4 Applying sun protection product to allow the youngest child to spend more time in the sun	
Q4_1, No	3206 (55.0)
Q4_2, Yes	2129 (36.5)
Q4_3, Did not specify	497 (8.5)
Q5 What SPF do you usually use for the youngest child?	
Q5_1, 6–25	944 (16.2)
Q5_2, 30–50	4391 (75.3)
Q5_3, Did not specify	497 (8.5)
Q6 For yourself, what SPF do you usually use?	
Q6_1, 6–25	1024 (17.6)
Q6_2, 30–50	3203 (54.9)
Q6_3, Did not specify	1605 (27.5)
Q7 Applying sunscreen to allow the child to spend more time in the sun	
Q7_1, No	3027 (51.9)
Q7_2, Yes	1200 (20.6)
Q7_3, Not specified	1605 (27.5)
Q8 Personal history of sunburn during childhood	
Q8_1, Never	1766 (30.3)
Q8_2, From time to time	2814 (48.3)
Q8_3, Yes	1252 (21.5)
Q9 How many times during the day did you apply sunscreen on your youngest child/grandchild?	
Q9_1, Not at all	563 (9.7)
Q9_2, 2–3 times a day	3049 (52.3)
Q9_3, ≥ 4 times a day	2220 (38.1)
Q10 Who recommended the sunscreen product you used for the youngest child?	
Q10_1, Other doctors	4727 (81.1)
Q10_2, Dermatologist	608 (10.4)
Q10_3, Others	497 (8.5)
Q11 During this summer, was the youngest child/grandchild exposed to the sun between 11.00 h and 17.00 h?	
Q11_1, No	1464 (25.1)
Q12 Did you use an umbrella to protect the youngest child/grandchild from the sun?	
Q12_1, Yes	3619 (62.1)
Q13 Did you use sunglasses to protect the youngest child/grandchild from the sun?	
Q13_1, Yes	3605 (61.8)

SPF, sun protection factor.

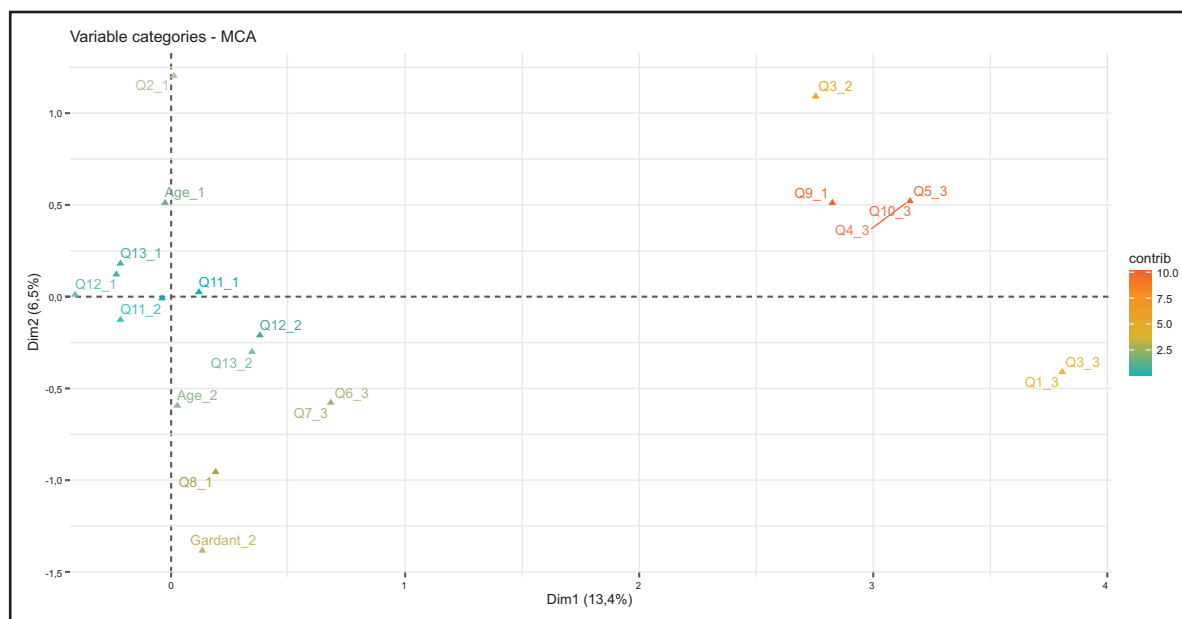


Figure 3 The x- and y-axes represent the first and second dimension (Dim1 and Dim2) of the multiple correspondence analysis (MCA) performed on data from 5832 parents and grandparents with fully completed questionnaires. The definitions and labels for each variable can be found in Tables 2 and 3. For example, Q1_3 refers to the answer 'no' for the question 'Did you protect your youngest child/grandchild from the sun?'. The x-axis of the figure represents a profile 'unprotected sun exposure habits' (Q1_3, Q3_2, Q9_1) on the right vs. those with 'protective sun exposure habits' on the left. The y-axis in the figure opposes parents (Gardant_1) above the y-axis and grandparents (Gardant_2) below the y-axis. 'Contrib' refers to the contribution of each variable to the second dimension (x-axis). The closer to the red end the higher the contribution of the variable to the 'unprotected sun exposure habits'. The closer to the blue end the lower the contribution of the variable to the 'unprotected sun exposure habits'.

Table 3 Description of the variables constituting the 'unprotected sun exposure habits' and 'protective sun exposure habits' profiles

Variable	Item definition	Variable labels	Unprotected sun exposure habits (on the left of the x-axis of Figure 3)	Protective sun exposure habits (on the right of the x-axis of Figure 3)
Q8	When you think back to your childhood, do you remember if you had sunburns	1: Never; 2: From time to time; 3: Yes	×	–
Guardian	GP: Grandparent, P: Parent	1: P; 2: GP	×	–
Age	Guardian age	1: < 45 years; 2: ≥ 45 years	×	–
Q2	In the past year, have you had any indoor UV sessions?	1: Yes; 2: No	×	–
Y	Sunburn (Yes vs. No)	1: Yes; 0: No	×	–
Q34	Which of the following phototypes do you feel closest to? Fair: phototypes 1 and 2; Intermediate: phototype 3; Dark: phototypes 4, 5 and 6	1: Fair; 2: Intermediate; 3: Dark	×	–
Q2r1	Family history of skin cancer	1: No; 2: Yes	×	–
Q10	Who recommended the sunscreen product you used for the youngest child?	1: Other doctors; 2: Dermatologist; 3: Others	–	×
Q1	Did you protect the youngest child from the sun?	1: Yes, every time outside; 2: Yes, but only during intense sun exposure; 3: No	–	×
Q9	How many times during the day did you put sunscreen on the youngest child	1: Not at all; 2: 2–3 times a day; 3: ≥ 4 times a day	–	×
Q5	What sun protection factor do you usually use for the youngest child?	1: 6–25; 2: 30–50; 3: Not specified	–	×
Q3	Did you use the following means to protect the youngest child from the sun?	1: Yes; 2: No; 3: Not specified	–	×
Q4	Applying sun protection product to allow the youngest child to spend more time in the sun	1: No; 2: Yes; 3: Not specified	–	×

UV, ultraviolet.

broad-spectrum sunscreens and the use of other strategies for sun protection such as seeking shade using umbrellas and wearing sunglasses. The latter is certainly of importance as evidence shows strong correlation between UVR exposure and eye diseases including cataract, uveal melanoma, photokeratitis and macular degeneration.²⁹

Our study shows that parents engaged in more unprotected sun exposure habits than grandparents, had indoor UV tanning sessions in the past year, reported not using any means to protect their child from the sun, using sunscreens with lower SPF (< 25) and applying sunscreen to allow the child to spend more time in the sun. The latter is consistent with previous reports indicating that when sun exposure is intentional, sunscreen use leads to longer duration of exposure possibility because of a false sense of protection.³⁰

Our findings indicate that both parents and grandparents might benefit from information regarding proper sunscreen use. Sunscreen is used as a primary strategy to prevent sunburn and later skin cancer. Strong evidence from previous studies have revealed the potential for sunscreen to reduce the risk of melanoma and squamous cell carcinoma when used as directed.^{14,31,32} However, observational studies have shown that in the real-world setting sunscreen users might not always apply sufficient amounts, or reapply sunscreen often enough, or may use it on some but not all sun-exposed skin.^{33–38} Therefore, photoprotection campaigns should focus on the correct application of sunscreen by targeting the various recognized factors leading to sunscreen failure. Health professionals could also play a key role to inform the population on sunscreen use. Parents were more likely to report having had the sunscreen product recommended by a dermatologist, whereas grandparents did not receive such information from any doctor. Primary care physicians are in an ideal position to initiate personalized conversations regarding sun protection with older adults.

Strengths of this study include nationally representative data on a comprehensive set of sun exposure related outcomes in a large number of parents and grandparents across five countries. Our data were self-reported, which could be subject to recall biases; however, this study was conducted at the end of August directly after the summer period to limit this bias.

Undoubtedly, establishing focused campaigns aimed at increasing awareness among grandparents and parents would be a suitable approach to enhance adherence to the recommendations. However, the measure with the most impact would involve incorporating sun protection education into schools. It is crucial to present this integration as an enjoyable and educational activity, avoiding any perception of it being punitive.

In conclusion, although grandparents appear to adopt more cautious behaviours than parents, many gaps in proper sun protection behaviour have been highlighted in both parents and grandparents. More qualitative research on the social contexts associated with sun protective behaviour could be informative to future prevention interventions.

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Conflicts of interest

C.B., N.P.C. and M.S.A. are employed by Pierre Fabre. The other authors declare no conflicts of interest.

Data availability

The data that support the findings of this work are available from the corresponding author upon reasonable request.

Ethics statement

Ethical approval: as the study used anonymized data and did not involve any clinical examination, institutional review board approvals were not required. Informed consent: all participants gave written, informed consent for participation and publication.

Supporting Information

Additional [Supporting Information](#) may be found in the online version of this article at the publisher's website.

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