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1 **Social differentiation of sun-protection behaviors: the mediating role of cognitive**
2 **factors.**

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24

25 **Abstract** (247/250 words max.)

26 **Introduction:** Adherence to sun-protection guidelines in developed countries is low,
27 especially among people of low socioeconomic status (SES). Mechanisms underlying this
28 social differentiation are poorly understood. This study aimed to examine the social
29 differentiation of sun-protection behaviors and of two cognitive factors (knowledge about sun
30 health and about behavioral risk factors for cancer); and to determine if these cognitive factors
31 mediate the association between SES and sun-protection behaviors.

32 **Methods:** Data came from the 2010 *Baromètre Cancer* survey (analyzed in 2014), a random
33 cross-sectional telephone survey conducted among the French general population (n=3359
34 individuals aged 15-75). First, bivariate associations between a composite individual SES
35 indicator (based on educational level, occupation, and income) and both sun-protection
36 behaviors and cognitive factors were tested with χ^2 tests and ANOVA. Then confirmatory
37 factor analysis and structural equation modeling were used to test the mediating role of
38 cognitive factors with a multiple mediation model including four latent variables.

39 **Results:** In bivariate analyses, the individual SES indicator was positively associated with
40 sun-protection behaviors and with both cognitive factors. Multiple mediation analyses showed
41 that both cognitive factors partially mediated the effect of individual SES on sun-protection
42 behaviors. The overall proportion of mediated effects was 48%. The direct effect of SES
43 remained significant.

44 **Conclusions:** These results suggest that interventions aimed at modifying the knowledge and
45 perceptions of persons with low SES might help to reduce social differentiation of sun-
46 protection behaviors. Further qualitative research is needed to understand these cognitive
47 factors better and develop suitable prevention messages.

48 **Introduction**

49 Avoiding sunburn and practicing sun protection are key messages for preventing skin cancer
50 and other UV radiation-related health effects.^{1,2} Beginning in summer 2004 and annually
51 since 2009, national prevention campaigns in France have advised the general population to
52 limit their exposure to the sun from noon to 4 p.m., wear protective clothing (T-shirts, hats,
53 and sunglasses), and use sunscreen.³

54 Although results across studies vary greatly, the international literature generally suggests that
55 fewer than half the people living in developed countries adhere to sun-protection guidelines
56 and that adherence rates are lower among people with low socioeconomic status (SES) (i.e.,
57 low educational, occupation, and/or income levels) than in the rest of the population.⁴

58 Significant positive associations between SES and sun-protection behaviors have been found
59 for some but not all kinds of protection.⁵⁻⁷ Sunscreen use in particular appears to be higher
60 among those with high SES.^{4,8-12}

61 The scientific literature amply demonstrates the existence of social inequalities in health
62 outcomes^{13,14} and in various health-related behaviors, including smoking, diet, and cancer
63 screening.¹⁵⁻¹⁸ Some studies provide support for the theoretical framework proposed by
64 Lynch et al.,¹⁹ according to which the social differentiation of cognitive factors (such as
65 perceptions and knowledge) is an important pathway in the development of SES differences
66 in such preventive health behaviors.^{20,21} Knowledge of the health effects of sun exposure and
67 of sun-protection behaviors – both associated with these behaviors^{4,22} – appears greater
68 among highly educated individuals than among those with low educational levels.^{6,23} No
69 study has yet explored, however, whether SES differences in such cognitive factors may
70 explain, at least partly, the SES differences in sun-protection behaviors: do cognitive factors
71 play a mediating role in the social differentiation of sun-protection behaviors?

72 In investigating individuals' perceptions of risks associated specifically with sun exposure, it
73 is also useful to consider their perceptions of other potential risk factors for cancer: in our
74 daily lives, we must all think about many different risks simultaneously, and our attitudes and
75 behaviors toward one specific risk may well depend on our perceptions of others.²⁴
76 Using data from a French nationwide general population survey (*Baromètre Cancer*, 2010),
77 this study sought to examine the associations of individual SES with 1) sun-protection
78 behaviors and 2) two cognitive factors: knowledge of sun health and of risk factors for cancer
79 more generally, and 3) determine whether these cognitive factors mediate the association
80 between SES and sun-protection behaviors.

81 **Materials and methods**

82 **Sampling design and data collection**

83 The 2010 *Baromètre Cancer* is a telephone survey of cancer-related knowledge, attitudes,
84 beliefs, and practices conducted by the national institute for prevention and health education
85 (INPES). It took place from April through August 2010 among a representative random
86 sample of the French general population (see Table 1).

87 Private households with landline telephones (listed and unlisted) were included in the sample,
88 as were people who had only mobile phones. A two-stage random sampling design was used:

89 1) household selection (by telephone number); and 2) random selection of one French-
90 speaking person aged 15-85 within each selected household, by the "next birthday"
91 method.²⁵ Residents of retirement homes, hospitals, and other institutions were excluded.

92 The interviews were conducted by professionals using a computer-assisted telephone
93 interview (CATI) system. All the data collected were anonymous and self-reported. The 52%
94 participation rate produced a sample of 3727 respondents with full interviews. Only
95 individuals with no cancer history and aged 75 years or younger were asked questions about
96 sun-health knowledge (n=3359).

97 The French National Commission for Computer Data and Individual Freedom (Commission
98 Nationale de l'Informatique et des Libertés, CNIL) approved the 2010 *Baromètre Cancer*.

99 **Measures**

100 Sun-protection behaviors

101 The questionnaire included six items — adapted from Glanz et al.²⁶— evaluating sun-
102 protection behaviors. Respondents were asked to report on a 5-point Likert scale (from *never*
103 to *always*, including a *don't know/no response* choice) the frequency with which they use
104 specific measures during the summer on a warm sunny day (at the seaside, in the mountains
105 or countryside) to protect themselves from the sun (see Table 2).

106 Cognitive factors

107 Sun-health knowledge was measured with five items asking respondents to report on a 5-point
108 Likert scale their level of agreement (from *strongly disagree* to *strongly agree*, including a
109 *don't know/no response* choice) with five sentences, all but one of which stated common
110 misconceptions about sun exposure (see Table 3).²² Sun-health knowledge also included
111 individuals' knowledge of the most dangerous time of day for sun exposure with an open-
112 ended question about those specific hours in France in the summer.

113 Knowledge of behavioral risk factors for cancer was measured with five items asking
114 respondents to report on a 5-point Likert scale (from *certainly not* to *certainly*, including a
115 *don't know/no response* choice) whether they thought the following behaviors could increase
116 a person's risk of developing cancer: tobacco smoking, drinking more than 2 (for women) or
117 3 (for men) glasses of alcohol per day, lack of physical activity, using a tanning lamp, and
118 cannabis smoking.

119 Demographic and socioeconomic characteristics and family/friend cancer history

120 Respondents' demographic and socioeconomic characteristics included gender, age,
121 educational level (less than high school, high school, some higher education), occupation (not

122 in the labor force, e.g., homemakers and people with disabilities; workers, e.g., farmers,
123 artisans, factory workers, and office/sales/service workers; professionals and managers,
124 including middle management and other intellectual work),²⁷ and equivalized household
125 income per month (EHI), which takes into account household size and composition.²⁸ The
126 EHI was calculated with the Organization for Economic Cooperation and Development's
127 (OECD) scale.

128 Respondents were also asked if they had at least one family member, friend or colleague with
129 a history of cancer (yes, no).

130 **Statistical analysis**

131 Data were weighted to match the sample more closely to the 2008 national census for age,
132 gender, educational level, geographic area, and size of town of residence, with a calibration
133 procedure.²⁹ All analyses were performed in 2014 with weighted data. Household income was
134 not reported (missing data) for 10% of participants. These individuals were more likely to
135 have less than a high school educational level and to be workers (results not shown). Missing
136 data for income were estimated by a single imputation procedure that used a multivariate
137 linear regression model including 15 sociodemographic characteristics (e.g., age, gender,
138 educational level, occupation, marital status, household composition, and health insurance
139 status).³⁰ Sensitivity analyses using the initial (not imputed) income variable with two
140 different parameter estimation methods^{31,32} confirmed the robustness of our findings (see
141 Supplemental Material Table S1).

142 Bivariate analyses were performed to describe the relations between SES and sun-protection
143 behaviors on the one hand and cognitive factors on the other (objectives 1 and 2). Linear
144 trends were tested with Cochran–Armitage tests for Chi² tests and analysis of contrasts for
145 ANOVA. For that purpose, an individual SES indicator based on respondents' educational
146 level, occupation, and EHI was calculated according to a methodology already published (see

147 Supplemental Material Box 1).^{33,34} A principal component analysis confirmed the validity of
148 this approach (see Supplemental Material Table S2). Three other scores (sun-protection
149 behavior, 6 items; sun-health knowledge, 6 items; and knowledge of behavioral risk factors
150 for cancer, 5 items) were also built by summing the responses to the corresponding items
151 described above. Higher scores indicated higher levels of sun protection and of knowledge
152 (see Supplemental Material Box 2). As recommended with use of a composite SES
153 indicator,³⁵ we also confirmed that all three SES variables were associated in the same
154 direction with sun protection and knowledge scores (see Supplemental Material Table S3).
155 Bivariate analyses between the SES indicator and the latent variables for sun-protection
156 behaviors and cognitive factors (see below) were also performed.

157 To test whether cognitive factors mediate the association between SES and sun-protection
158 behaviors (objective 3), a multiple mediation model was fitted by using confirmatory factor
159 analysis (CFA) and structural equation modeling (SEM) to estimate the model parameters.
160 This analytic approach makes it possible to estimate the relations among variables and helps
161 to adjust for measurement error.³⁶ In the first step, a CFA model was evaluated to determine
162 whether the items mentioned above can measure the following four latent variables: i)
163 individual SES; ii) sun-protection behaviors; and two cognitive factors tested as potential
164 mediators: iii) sun-health knowledge, and iv) knowledge of behavioral risk factors for cancer.
165 In the second step, SEM enabled estimations of (see Figure 1):

- 166 • the effect of SES on each potential mediator (paths a_i),
- 167 • the effect of each potential mediator on sun-protection behaviors (paths b_i),
- 168 • the indirect effects of SES on sun-protection behaviors (i.e., the effect of SES
169 mediated by each mediator; paths a_i*b_i),
- 170 • the direct effect of SES on sun-protection behaviors (i.e., the SES effect not explained
171 by the potential mediators; path c'),

172 • and the total effect (i.e., the SES effect in the absence of both potential mediators; path
173 c).

174 Confidence intervals were obtained with 1000 bootstrap replications.³⁷ The proportion of the
175 total effect mediated by each potential mediator was obtained with the formula:

176 $a_i b_i / (\sum_i a_i b_i + c')$.³⁷ SEM analyses were adjusted for gender, age, and family/friend with a
177 history of cancer, because reporting a family member, friend or acquaintance with skin cancer
178 is positively correlated with sun-protection use.⁴

179 Model fit for both the CFA and SEM was assessed by the root mean square error of
180 approximation (RMSEA), comparative fit index (CFI), Tucker-Lewis index (TLI), and
181 standardized root mean square residual (SRMR). Models with CFI>0.90, TLI>0.90,
182 RMSEA<0.08, and SRMR<0.08 were considered to fit reasonably or well.³⁸ However, as
183 recommended by D. Kenny,³⁹ the CFI and TLI were not computed when the RMSEA of the
184 null model (i.e., a model where all structural paths are assumed to be zero, all measurement
185 paths from the latent to the observed variables are one, and the variance of the latent variables
186 are zero)³⁹ was <0.158.

187 All analyses were based on two-sided p values, with $p<0.05$ indicating statistical significance;
188 they were conducted with SAS 9.4 statistical software (SAS Institute, Cary, NC) and Mplus
189 7.2 for CFA and SEM.

190 **Results**

191 **Characteristics of the study population**

192 The study population included 3348 individuals; 51.0% were women, and 45.6% were aged
193 45-75 years. Most participants had less than a high school education (59.3%) or were workers
194 (54.0%). Overall, 27.6% were in the lowest category of the SES score and 20.2% in the
195 highest (Table 1).

196 **Sun-protection behaviors and cognitive factors**

197 More than 70% of the respondents reported *often/always* wearing a T-shirt, sunglasses, or
198 staying indoors during the hours the sun is strongest to protect themselves from the sun; less
199 than half reported *often/always* applying sunscreen hourly (Table 2). The mean score for sun-
200 protection behaviors was 16.4 (± 3.6 ; range: 6-24). Positive bivariate associations of the SES
201 score with all sun-protection behaviors (except for wearing a hat or a T-shirt), as well as with
202 the sun-protection score indicated greater sun protection among high-SES groups (Table 2).
203 The bivariate analyses also showed greater knowledge of both sun-health and behavioral risk
204 factors for cancer (except for cannabis smoking) among high-SES groups (Table 3). Bivariate
205 analyses between the SES score and the three latent variables produced similar results (Tables
206 2 and 3).

207 **Multiple mediation model**

208 The CFA fit the data well (RMSEA=0.034; SRMR=0.043); because the RMSEA of the null
209 CFA model (0.082) was less than 0.158, the CFI and the TLI were not computed.
210 The multiple mediation model also fit the data well (RMSEA=0.053; SRMR=0.046); the
211 RMSEA of the null model (0.102) was again less than 0.158. The total effect of the SES on
212 sun-protection behaviors was positive and significant (Figure 1, path c; $\beta=0.23$, $p<0.001$). The
213 direct effect was smaller but remained significant (path c'; $\beta=0.12$, $p<0.01$). SES was
214 significantly and positively associated with knowledge of both sun health (path a_1 ; $\beta=0.57$,
215 $p<0.001$) and behavioral risk factors for cancer (path a_2 ; $\beta=0.20$, $p<0.001$). These two
216 cognitive factors were also positively and significantly associated with sun-protection
217 behaviors (paths b_i). The positive, significant values of the indirect effects of SES (paths a_i*b_i)
218 indicated that both of these cognitive factors were significant mediators of the effect of SES
219 on sun-protection behaviors (Figure 1). The proportion of the mediated effects was 30% for
220 sun-health knowledge and 18% for knowledge of behavioral risk factors for cancer. The two
221 mediators were positively correlated ($r=0.34$; $p<0.001$).

222 **Discussion**

223 **Main results**

224 This study, based on a national survey of the French general population, showed a significant
225 positive association between a composite individual SES indicator and sun-protection
226 behaviors. This SES indicator was also positively associated with knowledge of both sun
227 health and behavioral risk factors for cancer. Multiple mediation analyses showed that these
228 two cognitive factors partially mediated the effect of individual SES on sun-protection
229 behaviors and that SES had a significant direct effect on them.

230 **Limitations of the study**

231 The results of this study should be interpreted with the following limitations in mind. First,
232 the cross-sectional design of the *Baromètre Cancer* prevents drawing definitive conclusions
233 about the directions of the relations between cognitive and behavioral variables⁴⁰ and about
234 causality. Second, this study shares the usual shortcomings of quantitative telephone surveys,
235 including a moderate participation rate (52%). As usual in epidemiological studies,^{41,42}
236 nonparticipants were probably less educated than participants; this most likely led to an
237 overestimation of sun-protection behaviors and knowledge scores. Weighting the data should
238 have limited the impact of this overestimate. However, weighting cannot overcome bias
239 introduced by the non-inclusion of specific subgroups (e.g., people with neither a landline nor
240 a cellular telephone, who nonetheless represent less than 1% of the population), and some
241 caution is required when extrapolating these results to the wider population. Moreover, there
242 is no reason to suspect that either sun-protection behaviors or cognitive factors were
243 correlated with nonparticipation, as the letter announcing the survey provided no details about
244 the topics to be investigated. Third, as in most previous studies assessing sun-protection
245 behaviors in large population surveys,⁴ these behaviors were measured by self-reports and
246 were probably overreported due to social desirability bias.²⁶ As social desirability seems to

247 affect people of low SES more than those of high SES,⁴³ this study might have
248 underestimated the strength of the association between SES and sun-protection behaviors.
249 Finally, people were asked about their sun-protection behaviors during summer exposure at
250 the seaside, or in the mountains or countryside. The possibility that some people, especially
251 those with a low SES who have outdoor occupations (e.g., construction or agricultural work),
252 responded about their occupational exposure instead cannot be ruled out.

253 **Social differentiation of sun-protection behaviors and cognitive factors**

254 Our findings are in line with previous studies showing that regularly applying
255 sunscreen,^{5,6,8,9,12,23} using sunglasses,^{6,11} and avoiding the sun or staying in the shade^{10,11,23} are
256 less frequently reported by people with low compared with high SES. Consistently with
257 previous reports,^{5,6,23,44} covering up did not vary according to individual SES in this study.
258 Our study also contributes further evidence to support the well-established positive
259 association between individual SES and knowledge of skin cancer and its risk factors,^{6,7,10} and
260 of risk factors for cancer more generally.^{45,46} Social differentiation of health literacy
261 (information seeking, and ability to appraise and understand information about health risks)
262 could contribute to these results.^{47,48} Some of these results may also reflect that people of low
263 SES share specific beliefs that standard prevention campaigns have so far failed to address
264 effectively. In particular, the misconception that *sunburns acclimate the skin by making it less*
265 *vulnerable to the sun* is an echo of the “risk-immune culture” prevailing among some groups
266 of manual workers.^{49,50} For example, workers in a pottery factory are reported to value early
267 exposure to risk because they believe it empowers them to overcome subsequent hazards, as a
268 sort of vaccination conferring immunity to accidents.⁴⁹ These results may also reveal the
269 instrumental relation that working-class people have with their bodies, which must be tough
270 and put into the test.⁵¹

271 **The mediating role of cognitive factors and its implications for prevention campaigns**

272 This evidence that cognitive factors (knowledge of sun health and of behavioral risk factors
273 for cancer) are significant mediators of the effects of SES on sun-protection behaviors,
274 mediating nearly 50% of the total effects, is a new result. It is consistent with the theoretical
275 model of Lynch et al. according to which individual SES influences cognitive factors, which
276 then influence behaviors.^{19,21} Both mediators were positively correlated, suggesting that
277 people tend to accumulate knowledge about risk factors for cancer in general and about health
278 risks related to sun exposure in particular, as already shown in various other health fields
279 (e.g., tobacco, alcohol, and nutrition).⁵² The effect of individual SES on sun-protection
280 behaviors remained significant after adjustment for both the mediators we studied (path c' on
281 Figure 1). This finding suggests the existence of other unobserved mediators. For example,
282 previous studies have suggested that less educated people are far less likely to perceive
283 themselves as at risk for melanoma or to perceive it as a serious disease,^{53,54} and these
284 perceptions strongly shape sun-protection behaviors.⁴ Other attitudinal factors, such as self-
285 efficacy, or future orientation, may also act as mediators.^{55,56} SES may also have a direct
286 effect on sun-protection behaviors. For example, as suggested in qualitative studies,⁵⁷ the
287 financial constraints of people with low SES may impede sunscreen use, because of its cost.
288 Moreover, they (especially those who work outdoors) are probably more frequently exposed
289 to the sun during their occupational activities (*versus* leisure ones) than those with a higher
290 SES. They may thus experience specific barriers to sun protection, including the impossibility
291 of working in the shade, forgetfulness, and the time-consuming application and sticky
292 consistency of sunscreens.⁵⁸

293 In France, national prevention campaigns about the risks of sun exposure are conducted each
294 year in the summer, when prevention messages are broadcast on radios, TV and mobile
295 telephones (through weather applications); leaflets are also disseminated in several places
296 (e.g., tourist offices, preschool facilities, recreation centers, pharmacies, pediatricians' and

297 dermatologists' offices). Strategies should be tailored to reach low-SES people with
298 appropriate means and messages rather than with general campaigns that ignore social
299 differentiation. One possibility may be to reduce SES differences in sun-health knowledge by
300 ensuring that prevention messages are well understood by people of low SES and adapted to
301 their perceptions and ways of life.⁵⁹ To determine the best way to meet that aim, further
302 qualitative studies are needed to explore their perceptions of skin cancer, tanning, a tanned
303 appearance, preventive messages, and barriers to sun protection, as stressed in a recent
304 literature review.⁵⁷ Qualitative studies should also help to develop hypotheses about how
305 particular SES factors influence knowledge and behavior and which of these factors may have
306 the greatest influence.

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310

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- 530

531 **Table 1.** Demographic and socioeconomic characteristics of the study population, and of the
 532 French general population

	Study population ^a		French general population ^b (%)
	Weighted number	Weighted %	
Gender			
Female	1709	51.0	51.1
Male	1639	49.0	48.9
Age (years)			
15-25	638	19.1	18.4
26-34	533	15.9	15.4
35-44	653	19.5	19.3
45-54	628	18.8	18.8
55-75	896	26.8	28.0
Educational level			
Less than high school level	1984	59.3	59.1
High school level	598	17.9	18.0
Higher than high school level	766	22.9	23.0
Occupation			
Not in the labor force	170	5.1	/
Workers	1806	54.0	/
Managers, professionals, intellectual workers	1372	41.0	/
Equivalized household income (euros per month)			
≤1100	1393	41.6	/

[1101-1785]	1110	33.2	/
≥1786	845	25.3	/
Socioeconomic status (SES) score			
0-1 (Lowest SES)	923	27.6	/
2	731	21.8	/
3	558	16.7	/
4	460	13.7	/
5-6 (Highest SES)	677	20.2	/
Family/friend history of cancer			
Yes	2095	62.6	/
No	1253	37.4	/

533 ^a France, 2010 *Baromètre Cancer*, n=3348. Numbers and percentages are weighted for age,
 534 gender, educational level, geographic area, and size of town of residence. 11 respondents were
 535 excluded from the analyses because of missing data for educational level.

536 ^b France, 2008, Labor Force Survey conducted by the National Institute for Statistics and
 537 Economic Studies (INSEE), n=44,674,000.

538

Table 2. Bivariate associations between the socioeconomic status (SES) score and sun-protection behaviors (France, 2010 *Baromètre Cancer*, n=3348^a)

	Total sample	SES score					p trend ^b
		0-1	2	3	4	5-6	
Sun protection behaviors (%) ^c							
Stay inside when the sun is strongest	70.0	63.9	66.7	68.2	75.3	79.7	<.0001
Stay in the shade under an umbrella	59.0	57.5	56.3	57.9	58.1	65.4	0.0023
Apply sunscreen every hour	42.7	36.8	40.7	45.8	44.4	49.0	<.0001
Wear sunglasses	73.6	60.0	69.7	78.4	84.2	85.2	<.0001
Wear a hat	51.5	50.9	51.7	49.5	50.1	54.7	0.2901
Wear a T-shirt	75.8	77.6	74.5	73.6	73.2	78.5	0.9801
Score of sun-protection behaviors ^d (mean and SD)	16.4 (3.6)	15.8 (4.5)	16.2 (4.1)	16.5 (3.6)	16.8 (3.1)	17.1 (2.5)	<.0001
Latent variable for sun-protection behaviors ^e (mean and SD)	0.0 (0.8)	-0.2 (1.0)	-0.1 (0.9)	0.0 (0.8)	0.1 (0.7)	0.2 (0.6)	<.0001

^a Weighted data for age, gender, educational level, geographic area, and size of town of residence. 11 respondents were excluded from the analyses because of missing data for educational level.

^b Statistical significance of the linear trend among the five SES groups: Cochran–Armitage tests for Chi² tests for each sun protection behavior, and analysis of contrasts for ANOVA for sun-protection behavior score.

^c Percentage of respondents reported using each sun-protection measure *often* or *always* during the summer on a warm sunny day.

^d Higher score values indicate a higher level of sun protection (see Supplemental Material Box 2 for further details).

^e Latent variable built by confirmatory factor analysis using standardized items. Higher values indicate a higher level of sun protection.

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Table 3. Bivariate associations between the socioeconomic status (SES) score and knowledge of sun health and of behavioral risk factors for cancer (France, 2010 *Baromètre Cancer*, n=3348^a)

	Total sample	SES score					p trend ^b
		0-1	2	3	4	5-6	
Sun health knowledge (%) ^c							
Sunburns acclimate the skin	78.6	67.0	74.2	83.1	86.9	89.9	<.0001
Sunburns in childhood are harmless	59.5	49.2	55.0	61.1	64.3	73.7	<.0001
The sun causes the skin to age prematurely ^d	92.2	85.6	90.3	94.6	97.3	97.7	<.0001
1 application of sunscreen day is sufficient	91.4	85.8	89.8	92.7	96.4	96.4	<.0001
Sun lamps prepare the skin for sun exposure	75.1	74.2	72.2	76.9	76.7	76.7	0.0701
Knowledge of most dangerous hours ^e	51.8	41.7	49.4	55.8	57.7	60.6	<.0001
Score of sun health knowledge ^f (mean and SD)	19.3 (3.0)	18.2 (3.8)	18.9 (3.1)	19.7 (2.9)	20.0 (2.4)	20.5 (1.9)	<.0001
Latent variable for sun health knowledge ^g (mean and SD)	0.0 (0.8)	-0.5 (0.9)	-0.2 (0.8)	0.1 (0.7)	0.3 (0.5)	0.6 (0.5)	<.0001
Knowledge of behavioral risk factors for cancer (%) ^h							

Tobacco smoking	97.8	96.6	96.3	98.6	99.2	99.4	<.0001
Drinking more than 2 (for women) or 3 (for men) glasses of alcohol per day	76.3	69.7	73.5	80.2	80.1	82.8	<.0001
Lack of physical activity	62.0	53.4	57.0	69.2	67.6	69.6	<.0001
Tanning lamp sessions	88.3	83.3	88.7	90.8	90.1	91.1	<.0001
Cannabis smoking	79.7	80.2	80.9	82.5	80.6	74.9	0.0236
Score of behavioral risk factors for cancer knowledge ^f (mean and SD)	16.0 (2.5)	15.5 (3.2)	15.8 (2.7)	16.3 (2.3)	16.3 (2.2)	16.3 (1.7)	<.0001
Latent variable for behavioral risk factors for cancer knowledge ^g (mean and SD)	0.0 (0.8)	-0.2 (1.0)	-0.1 (0.9)	0.1 (0.7)	0.2 (0.7)	0.2 (0.5)	<.0001

^a Weighted data for age, gender, educational level, geographic area, and size of town of residence. 11 respondents were excluded from the analyses because of missing data for educational level.

^b Statistical significance of the test for linear trend among the five SES groups: Cochran–Armitage tests for Chi² tests for each knowledge item and analysis of contrasts for ANOVA for knowledge scores.

^c Percentage of respondents who disagreed *somewhat* or *strongly* with each item unless otherwise specified.

^d Percentage of respondents who agreed *somewhat* or *strongly*.

^e Percentage of respondents who answered “between noon and 4 p.m.” or indicated hours including the noon to 4 p.m. period to the following question: *In your opinion, during the summer in France, what are the dangerous hours during which it is better not to be exposed to the sun?*

^f Higher score values indicated a higher level of knowledge (see Supplemental Material Box 2 for further details).

^g Latent variable built by confirmatory factor analysis using standardized items. Higher values indicate a higher level of knowledge.

^h Percentage of respondents who answered that the behavior *probably* or *certainly* increases a person’s risk of developing cancer.

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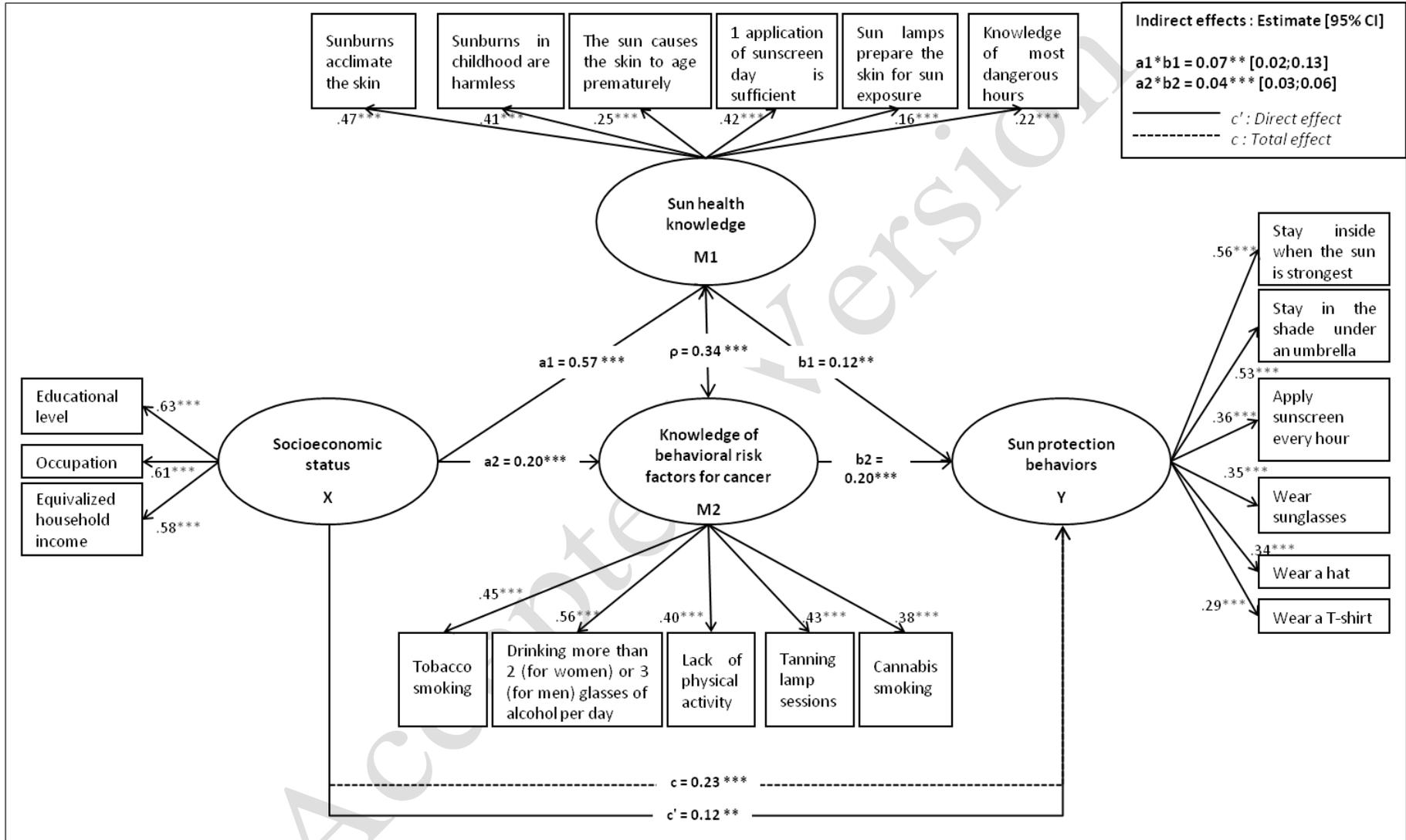


Figure 1. Unstandardized effects (β and standard errors) of paths a_i , b_i , a_i*b_i , c and c' of multiple mediation model^a on sun-protection behaviors (France, 2010 *Baromètre Cancer*, $n=3348^b$).

** $p \leq 0.01$; *** $p \leq 0.001$

^a The model was adjusted for gender, age, and relative's history of cancer.

^b Weighted data for age, gender, educational level, geographic area, and size of town of residence. 11 respondents were excluded from the analyses because of missing data for educational level.

Path a_i : SES effect on each potential mediator.

Paths b_i : Effect of each potential mediator on sun-protection behaviors.

Path a_i*b_i : Indirect effects of SES on sun-protection behaviors (i.e., the effect of SES mediated by each mediator).

Path c' : Direct effect of SES on sun-protection behaviors (i.e., the effect of SES not explained by the potential mediators).

Path c : Total effect of SES (i.e., the effect of SES in the absence of the potential mediators).

Path ρ : Correlation between both potential mediators.

Supplemental Material

Box 1

The individual socioeconomic (SES) score was calculated from the respondents' educational level, occupation, and equivalized household income (EHI), according to a methodology already published.^{1,2} For each SES indicator, respondents were assigned between 0 (educational level less than high school level, not in the labor force, lowest EHI respectively) and 2 points (educational level higher than high school level, intellectual worker, highest EHI respectively); the SES score was calculated by summing respondents' points, and ranged from 0 (lowest SES) to 6 (highest SES). Because only few respondents had an SES score of 0 or 6, they were grouped with the categories 1 and 5 respectively.

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2. Stamatakis E, Wardle J, Cole TJ. Childhood obesity and overweight prevalence trends in England: evidence for growing socioeconomic disparities. *Int J Obes* 2005. 2010;34(1):41-7.

Box 2

The score of sun-protection behaviors was built by summing the responses to the six related items coded as follows: *never*= 1, *rarely*= 2, *often*= 3, *always*= 4.

The score of sun health knowledge was built by summing the responses to the five related items and to the item assessing knowledge of the most dangerous hours. The first five items were coded as follows: *strongly agree*= 1, *somewhat agree*= 2, *somewhat disagree* = 3, *strongly disagree* = 4; with the exception of the item *the sun causes premature aging of the skin*, which was coded in reverse order. Based on the French guidelines, knowledge of the most dangerous hours was coded as follows: 1= *none between noon and 4 p.m.*, 2= *at least one hour between noon and 4 p.m.*, 3= *several hours including the noon to 4 p.m. period*, 4= *between noon and 4 p.m.*

The score of knowledge of behavioral risk factors for cancer was built by summing the responses to the five related items coded as follows: *certainly not*= 1, *probably not*= 2, *probably*= 3, *certainly*= 4.

N.B.: “*don't know/no response*” (<2% for all items) was coded 2.5.

Table S1. Unstandardized effects (β and standard errors) of paths a_i , b_i , a_i*b_i , c and c' of multiple mediation model^a on sun-protection behaviors according to different strategies for dealing with missing income data (France, 2010 *Baromètre Cancer*)

Path	Single imputation process n=3348 ^b	Maximum likelihood (exclusion of missing data) n=3013 ^b	Full information maximum likelihood n=3348 ^b
SES -> Sun health knowledge (a1)	0.57 ***	0.58 ***	0.58 ***
SES -> Knowledge of behavioral factor risks for cancer (a2)	0.20 ***	0.21 ***	0.21 ***
Sun health knowledge -> Sun protection behaviors (b1)	0.12 **	0.15 **	0.12 **
Knowledge of behavioral factor risks for cancer -> Sun protection behaviors (b2)	0.20 ***	0.21 ***	0.20 ***
a1*b1	0.07** [0.02;0.13]	0.09** [0.04;0.15]	0.07** [0.02;0.13]
a2*b2	0.04*** [0.03;0.06]	0.04*** [0.03;0.07]	0.04*** [0.03;0.06]
SES -> Sun protection behaviors (c)	0.23 ***	0.21 ***	0.22 ***
SES -> Sun protection behaviors (c')	0.12 **	0.08 *	0.11 **
Index fit	RMSEA = 0.053 SRMR = 0.046	RMSEA = 0.053 SRMR = 0.047	RMSEA = 0.052 SRMR = 0.046

* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

^a The model was adjusted for gender, age, and relative's history of cancer.

^b Weighted data for age, gender, educational level, geographic area, and size of town of residence.

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Table S2. Results from principal component analysis on individual socioeconomic characteristics (France, 2010 *Baromètre Cancer*, n=3348^a)

Variable	Coordinates on axis 1 ^b
Educational level	0,77
Occupation	0,79
Equivalentized household income	0,74

^a Weighted data for age, gender, educational level, geographic area, and size of town of residence. 11 respondents were excluded from the analyses because of missing data for educational level.

^b The first axis explained 58% of the total variance (eigenvalue=1.75) while the second explained 22.0% (eigenvalue=0.66).

Table S3. Bivariate associations between each of the three socioeconomic measures, and score of sun-protection behaviors, and both cognitive factors scores (France, 2010 *Baromètre Cancer*, n=3348^a)

	Total sample	Occupation			p trend ^b
		Not in the labor force	Workers	Managers, professionals, intellectual workers	
Score of sun-protection behaviors ^d (mean and SD)	16.4 (3.6)	16.1 (4.3)	16.1 (4.0)	16.9 (3.0)	0.0050
Score of sun health knowledge ^f (mean and SD)	19.3 (2.3)	18.2 (3.3)	18.8 (3.4)	20.0 (2.4)	<.0001
Score of behavioral risk factors for cancer knowledge ^f (mean and SD)	16.0 (2.5)	15.5 (3.4)	15.8 (2.8)	16.3 (2.0)	0.0018

	Total sample	Educational level			p trend ^b
		<High school	High school	>High school	

Score of sun-protection behaviors ^d (mean and SD)	16.4 (3.6)	16.2 (4.2)	16.6 (3.4)	17.0 (2.6)	<.0001
Score of sun health knowledge ^f (mean and SD)	19.3 (2.3)	18.8 (3.5)	19.7 (2.6)	20.4 (2.0)	<.0001
Score of behavioral risk factors for cancer knowledge ^f (mean and SD)	16.0 (2.5)	15.8 (2.9)	16.2 (2.3)	16.4 (1.8)	<.0001
Equivalized household income					
	Total	(euros/month)			p trend^b
	sample	≤ 1100	[1101-1785]	≥ 1786	
Score of sun-protection behaviors ^d (mean and SD)	16.4 (3.6)	15.9 (4.2)	16.6 (3.3)	17.0 (3.0)	<.0001
Score of sun health knowledge ^f (mean and SD)	19.3 (2.3)	18.5 (3.5)	19.6 (2.7)	20.1 (2.3)	<.0001
Score of behavioral risk factors for cancer knowledge ^f (mean and SD)	16.0 (2.5)	15.8 (2.9)	16.1 (2.4)	16.1 (2.0)	0.0158

^a Weighted data for age, gender, educational level, geographic area, and size of town of residence. 11 respondents were excluded from the analyses because of missing data for educational level.

^b Statistical significance of the test for linear trend (analysis of contrasts) among the three groups.

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