Title: Determinants of sunburn and sun protection of agricultural workers during occupational and recreational activities

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(a) Determinants of sunburn and sun protection of agricultural workers during occupational and recreational activities

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Manuscript Text:

Title: Determinants of sunburn and sun protection of agricultural workers during occupational and recreational activities

Running Title: Sunburn determinants in agricultural workers

ABSTRACT

Objective: The aim of this study was to identify determinants of occupational sunburn in agricultural workers and assess their occupational and recreational sun protection habits.

Methods: Specific surveys of agricultural workers in Switzerland and France were conducted (N=1,538). Multivariate logistic regressions identified occupational sunburn determinants. Occupational and recreational sun protection habits were estimated and correlated.

Results: One-year occupational and recreational sunburn prevalences were 19.8% and 11.5%, respectively. Occupational sunburn increased with having a recent recreational sunburn, highly sensitive skin, young age, high perceived skin cancer risk, using sunscreen and not wearing a hat. Correlation between protection habits during work and leisure was substantial (r_s 0.5-0.7). Skin health knowledge was high and pro-tanning attitude moderate.

Conclusions: Potentially modifiable sunburn determinants and sub-optimal recreational and occupational sun protection practices were identified in agricultural workers. Refining and tailoring sun protection messages targeting the agricultural sector are needed.

INTRODUCTION

Solar ultraviolet radiation (UVR) is the main environmental hazard that can lead to skin cancer, with individual risk increasing with the number of sunburns (1, 2). Sunburn (also known as erythema) is a readily observable inflammatory skin reaction occurring after acute overexposure to UVR (3). The dose of UVR received is significantly influenced by individual factors such as host pigmentation traits, sun-related behaviour, duration and type of activity, and environmental factors like altitude, latitude and cloud coverage (4-6).

Although there have been abundant investigations of sunburn occurrence during recreational activities (7-11), studies of sunburn prevalence and determinants during occupational activities, and of occupational sun protection behaviour are scant (12). Frequently and often unavoidably exposed to solar UVR, outdoor workers are at a high risk of sunburn during their occupational activities (13-16). Furthermore, there is growing evidence that knowledge about sun protection and levels of acceptance of sun protection measures are insufficient in outdoor workers, leading them to use inadequate sun protection measures despite their highly exposed circumstances (17, 18). Among outdoor workers, agricultural workers are among the populations most exposed to and least protected against solar UVR (19, 20).

Our study aims were to: (i) assess the prevalence of occupational and recreational sunburn in agricultural workers in Switzerland and France; (ii) identify determinants of their occupational sunburns; and (iii) evaluate the sun protection measures used during their occupational and recreational activities, their attitudes to tanning and their skin-health knowledge. Even though

exposure to UVR occurs in both occupational and recreational environments, the identification of sun protection measures common to both has rarely been reported. These findings could be most valuable in designing educational sun protection campaigns and interventions among outdoor workers.

Material and Methods

Two community surveys of agricultural workers in Switzerland and France were conducted as part of a larger project. The study design has been detailed previously (13, 21) and key elements of the recruitment procedures and questionnaires for both countries are summarised in **Table 1a** (supplementary material). The samples included winegrowers, fruit and vegetable growers, horticulturists, sylviculturists, farmworkers and arable/livestock farmers. Data were collected by self-administrated questionnaires (in Switzerland in 2009, N = 1,161 out of 4,000 questionnaires sent) or telephone interviews (in France in 2012, N = 640), and used a common set of questions.

The common information sought included sociodemographic data, participants' history of outdoor work, occurrences of occupational and recreational sunburn over the last year and the Fitzpatrick skin phototype (6) defined as type I = skin always burns, never tans; type II = skin burns quickly, tans slowly; type III = skin burns rarely, tans quickly; type IV = skin never burns, tans rapidly. The Swiss survey included additional questions on the use of five sun protection measures (seeking shade, wearing sunglasses, a hat, sunscreen or long sleeves) during occupational and recreational activities, tanning attitudes, perception of skin cancer risk, skin-health knowledge, and family or personal history of melanoma.

Agricultural workers were eligible for this study if they were aged 25–69 years, worked outdoors at least one day per week and cumulated at least one year of outdoor work over the past five years. For all analyses, sunburn was defined as experiencing at least one episode of severe sunburn, defined as painful and/or involving blistering, during the 12 months before the survey. We considered *a priori* that mild sunburn could sometimes occur accidentally without being a true reflection of workers' sun protection behaviour. Severe sunburn, however, was more likely to be accurately recalled and more relevant to our study objectives. Occupational and recreational sunburns were recorded separately.

Statistical analyses were performed using a two-step approach. First, a global analysis was carried out with data available from the Swiss and French surveys in a common analysis. The Swiss subset of data on sun-related behaviour and sun protection measures used was analysed subsequently (sub-analysis). The possible responses for each sun protection measure were "systematically", "sometimes" or "never". We hereafter focus on the systematic use of sun protection measures. A sensitivity analysis grouping the "systematically" and "sometimes" responses was also performed.

Answers to multiple choice questions on tanning attitudes and skin-health knowledge were coded as scores. A pro-tanning attitude was defined by the participants agreement (yes vs no) with the following five statements: a) tanning is a sign of good health; b) tanning is a sign of attractiveness; c) tanning is a summer objective; d) tanning is good according to friends or e) family. A pro-tanning attitude score, ranging from 0 (disagreement with all statements) to 5 (agreement with all statements), was calculated for each worker, with one point given for each statement agreed with. A skin-health knowledge score was similarly constructed, based on disagreement with the following two false statements: a) tanning is a means to protect oneself from skin cancer; and b) tanning is something that requires sunburn. A skin-health knowledge score ranging from 0 (agreement with

both statements) to 2 (disagreement with both statements) was calculated for each worker, with one point given for each correct answer.

Statistical analyses were performed using Stata software, version 14 (StataCorp LP, College Station, Texas, USA). The Spearman's rank coefficient was computed to assess the correlation between the use of sun protection measures during occupational and recreational activities. The determinants of sunburn were identified and estimated using multivariate logistic regression models. Multivariate fractional polynomial analysis was used to model the influence of continuous variables on the outcome. Results were considered statistically significant if $p <= 0.05$. The models' goodness of fit was assessed using the Hosmer–Lemeshow chi-square statistic and residuals analysis (Pearson, chi-square, deviance and Pregibon statistics). The Wald test was used to estimate the *p*-values of categorical variables. Mean scores were compared using *t*-test statistics.

RESULTS

Out of 1,801 agricultural workers surveyed, 1,538 (60.4% Swiss; 39.6% French) were eligible for analysis **(Table 1)**. There were no statistically significant differences in gender, skin phototype, age and years of occupation between Swiss and French agricultural workers. The typical worker surveyed was a man (72.8%) in his late forties (mean age: 49.0; standard deviation (SD: 10.0)), with a skin that rarely burnt and tanned quickly (phototype III: 44.9%) and 27.5 years (SD: 12.6) of experience in an agricultural occupation. In the last 12 months, 19.8% reported experiencing at least one severe occupational sunburn, 11.5% at least one severe recreational sunburn, and 5.8% severe sunburn during both activities**.**

The multivariate analysis of the common analysis of the Swiss and French data set identified that recreational sunburn, gender, skin phototype and age had significant statistical associations with occupational sunburn **(Table 2)**. The odds ratios (OR) for occupational sunburn were statistically significantly decreased for men, skin phototype IV and workers aged 40 and above, whereas increased for recreational sunburn (nearly 10 times higher), women and being aged below 40. Of note, country of residence was not associated with occupational sunburn (OR 1.0).

The sub-analysis of agricultural workers in Switzerland showed moderate to strong correlations (r_s 0.5–0.7) between the systematic use of each type of sun protection measure during recreational and occupational activities **(Table 3)**. Agricultural workers protected themselves predominantly by wearing hats (48.6% during work vs 37.7% during leisure), followed by sunglasses (18.1% vs 31.5%), sunscreen (11.9% vs 25.9%), seeking shade (9.9% vs 18.4%) and wearing long sleeve clothes (6.8% vs 4.1%). Wearing hats and long sleeves were the only means of sun protection reported as more frequent for occupational than recreational activities. A sensitivity analysis combining “sometimes” and “systematically” response options for the use of sun protection measures confirmed the strong correlation between both activities (data not shown).

Multivariate analyses of the sub-anaylsis, including data on sun protection measures, pro-tanning attiude and skin health knowledge, identified recreational sunburn, skin phototype, age, perceived risk of skin cancer, wearing a hat and the use of sunscreen during outdoor work as significantly associated with occupational sunburn **(Table 4)**. The final model was also adjusted for two identified confounders: gender and family or personal history of melanoma. The lowest ORs for occupational sunburn were found for skin phototype IV, age above 40 and systematic hat-wearing during work. The highest ORs were found for recreational sunburn (13 times higher), followed by an above average perceived risk of skin cancer and systematic use of sunscreen during work. A pro-tanning

attitude (OR 1.1), skin-health knowledge (OR 0.9), seeking shade (OR 0.4) and wearing long sleeves (OR 0.5) or sunglasses (OR 0.6) were not identified as significantly associated with occupational sunburn.

The distribution of scores for the pro-tanning attitude and skin-health knowledge is illustrated in **Table 5**. More than one third of agricultural workers in Switzerland agreed with none, and 1.6% agreed with all five pro-tanning statements. A total of 84.4% of agricultural workers disagreed with at least one of the two incorrect skin-health knowledge statement; 55.1% disagreed with both false statements. The higher the skin-health knowledge score, the lower the pro-tanning attitude was (mean skin-health knowledge scores: 1.32 (for pro-tanning attitude) vs 1.54 (for no pro-tanning attitude), $p < 0.0001$).

Most workers (67%) perceived their risk of skin cancer to be average, but 21% perceived it to be higher than the general population. There was no statistically significant difference in perceived risk of skin cancer risk with regard to gender or age (data not shown).

DISCUSSION

This study concomitantly measured agricultural workers' sunburn occurrence and sun protection behaviours in occupational and recreational activities. A high one-year occurrence of severe occupational sunburn was found, and a substantial correlation between workers' sun protection use during occupational and recreational activities. Recreational sunburn (OR 9.5) was the main occupational sunburn determinant, suggesting an overall sun-related behaviour rather than an occupation specific issue. Skin phototype, gender, age, perception of skin cancer risk, sunscreen use

and hat-wear during work also significantly influenced the occupational sunburn risk. These results are of concern as the study population was mainly made up of low sun-sensitivity individuals.

Women were found to be at higher occupational sunburn risk than their male counterparts, even after adjustment for sun protection behaviour. Several factors could explain this finding. In our study population, men and women presented different phototype distributions, probably due to a higher percentage of male seasonal workers from more Southern latitudes with darker skin complexion. Further, women are usually more health conscious and have a greater ease in communicating health issues compared to men, which might increase their reporting of sunburn. Additionally, several UVR measurement studies support an increased solar UVR dose in women compared to men in the agricultural sector (15, 22, 23). Some gender variation in labour activities influencing sun exposure might also contribute to this finding. Gender differences in pro-tanning attitude (mean pro-tanning attitude score: 1.36 in men vs 1.16 in women, $p = 0.15$) and in sun protection use have not been identified in this study, except for a higher systematic sunscreen application in women (35% vs. 8%, $p < 0.0001$), which has also been reported previously (25-27). Whether a general tendency for women to use more frequently sun protection measures and to have a more favourable pro-tanning attitude compared to men is also applicable to the occupational setting remains unclear (7, 24).

Young agricultural workers (below age 30) were found to be at higher risk of sunburn (OR 3.6), even after controlling for sun protection habits and personal risk factors. These findings corroborate previous studies which reported lesser use of sun protection by young people (below age 30) (20, 28). Young workers might also do more physical outdoor tasks and less administrative or in-vehicle work than more senior workers (29, 30). However the pro-tanning attitude was not found to be significantly associated with age ($p = 0.58$).

Overall, the skin-health knowledge was high (55% of workers having a maximum score). Workers who perceived their skin cancer risk above average or who had a sun-sensitive skin phototype were also found to have a significantly higher risk of occupational sunburn, despite an increased use of sun protection measures. However, translating this knowledge into appropriate sun protection behaviour appeared to be insufficiently adapted to the specific conditions of agricultural work (e.g. sweating, dust, a lack of shade) and to individuals' sun-sensitivity (17, 31, 32). Underestimating the potential consequences of sunburn, as well as a lack of appropriate and available information on effective sun protection use during agricultural activities could reduce the use of protection measures (16).

The strong association between the risks of occupational and recreational sunburn clearly suggests similar sun-related behaviours during work and leisure time. Wearing a hat was the most common sun protection behaviour reported and appears to have a high systematic use of almost 50%, compared to other studies (33, 34). The large differences in systematic use of sun protection means and the variable correlations between their use during leisure and work time, paralleled the specifities of recreational and occupational activities. The infrequent use of shade at work and the moderate shade-use correlation to leisure-time sun protection confirms agricultural workers' difficulty of implementing a shade-use strategy in their daily labour (12). In contrast, the systematic wear of long-sleeves, sunglasses and a hat was highly correlated between both activities, possibly emphasizing their easier use regardless of setting. We observed that the more systematically hats were worn, the lesser the occurrence of sunburn. Conversely, the more systematically sunscreen was applied, the higher the odds of getting sunburnt. Previous studies have shown that recreational sunscreen application can be intentional to lengthen sun exposure, notwithstanding that insufficient amounts are often applied and too infrequently (27). This is particularly relevant for occupational settings where sweating further reduces sunscreen effectiveness. Our results confirm that sunscreen

should not be advocated as the first line of sun protection, in particular in the agricultural sector (35-37).

Agricultural workers experienced severe sunburn almost twice as often during work than during leisure (19.8% vs 11.5%, respectively, and 5.8% during both). Our results confirmed previous observations indicating that subjects at the highest risk of sunburn also experience more sunburn episodes despite their more frequent use of sun protection measures (9, 14, 38). Less sun-sensitive (skin phototypes III and IV) agricultural workers were found to be at lesser risk of occupational sunburn in spite of reporting more favourable pro-tanning attitude and using sun protection less frequently than more sun-sensitive workers (skin phototypes I and II).

The study's main limitations are its reliance on self-reported data and the potential for social desirability bias in answering questions, even anonymously. Agricultural workers might have recognised, remembered or reported sunburn differently and sunburn could have potentially occurred in situations where the reported sun protection habits did not apply. To our knowledge, there is no evidence that these limitations focus on any specific subgroup and thus induce any systematic differences that would bias the results of our analyses. Furthermore, our restriction to severe sunburn episodes, clearly defined as painful and/or involving blistering, should have reduced subjectivity in reporting sunburn.

The study's main strengths are its population approach with results potentially applicable to outdoor workers in the agricultural sectors in Switzerland and France, and its large population size. National statistics data (Switzerland: https://www.bfs.admin.ch/bfs/fr/home/statistiques/agriculture-sylviculture.html, France: http://statistiques.msa.fr/sw_course_tag/demographie-agricole/) indicate that the composition of our study

samples (gender, phototype) was largely comparable to the whole population of agricultural workers in these two countries. The robust statistical modelling approach (residuals analysis) enabled the identification of sunburn determinants most valuable for more effective and sector-specific sun prevention messages. As the country where workers were employed had no significant effect on the risk of sunburn, the determinants identified should be valid for the entire study population.

In conclusion, these results highlight the need to tailor awareness raising campaigns and sun protection messages to the agricultural sector and its everyday working conditions, i.e. using shade during lunch breaks, systematically wearing long sleeves and a wide-brimmed hat, rotating activities (indoor–outdoor), and providing information on short and long-term solar UVR exposure effects and skin damage due to sunburn. As perspectives of our study, these results could serve as a basis for increasing outdoor workers´ awareness towards their high risk of solar UVR-induced cutaneous damage by focusing on the modifiable identified sunburn determinants and improving their personal estimation of long term solar UVR exposure. The study results suggest policy enforcement and education in the agriculture sector integrating well-accepted primary protection measures against solar UVR exposure, specifically targeting outdoor workers (39).

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Table 1: Characteristics of the study population of agricultural workers in Switzerland and France, and their prevalence of occupational and recreational sunburn

Characteristics	N*	%
Total	**1538**	
Country		
Switzerland	929	60.4
France	609	39.6
Gender		
Male	1118	72.8
Female	418	27.2
Age in years (mean; IQR)	49.0; 41-57	
Less than 40	305	19.8
40–49	481	31.3
50–59	485	31.5
60 and above	267	17.4
Skin phototype		
I	86	5.6
II	349	22.7
III	691	44.9
IV	395	25.7
Years of occupation (mean; IQR)	27.5; 20–35	
Sunburn occurrence last 12 months (% yes)		
Occupational	296	19.8
Recreational	163	11.5
Both	89	5.8

*Subtotals may not add up to 1,538 due to missing values.
IQR: Interquartile range

Study	Country	
	Switzerland	**France**
Questionnaire design	Questions adapted from previously validated European studies questionnaires (ie. Cremsol, EUROSUN) with addition of a few context-specific questions.	Questions partly derived from the Swiss questionnaire with a common set of questions.
Recruitment procedure	From cantonal farming association's entry list; Systematic sending out of questionnaires in four French-speaking Swiss cantons (Neuchâtel, Jura, Valais and Vaud; 1000 for each canton).	By random digit dialing; Interviews through computer-assisted telephone interviews (company ENOV Research); Quotas applied by major French regions (France, including Corsica); Over-sampling of agriculture workers (via a business list).
Response	Out of 4000 questionnaires sent, 1161 agricultural workers responded.	Out of 24,110 contacted people, 7942 accepted being interviewed. 1443 were occupationally exposed to solar UVR at least one day per week. 640 agricultural workers were included in this sample.

Table 1a: Study design and recruitment process of Swiss and French agricultural workers study sample.

Table 2: Multivariate logistic regression analyses for occupational sunburn among agricultural workers in Switzerland and France (N = 1405)*

Factors	**Adjusted OR [95% CI]	p-value
Recreational sunburn		
Yes	9.53 [6.43, 14.12]	< 0.0001
No	1.00	
Gender (Men vs Women)		
Men	0.64 [0.44, 0.92]	< 0.0001
Women	1.00	
Skin phototype		0.0133
I	3.76 [1.73, 8.17]	
II	4.89 [2.84, 8.44]	
III	3.48 [2.07, 5.85]	
IV	1.00	
Age		< 0.0001
25–29 years	3.60 [1.74, 8.80]	
30–39 years	2.26 [1.25, 4.07]	
40–49 years	1.17 [0.75, 1.85]	
50–59 years	1.00	
60–69 years	1.10 [0.58, 2.02]	
Country		
Switzerland	0.99 [0.68, 1.45]	0.9754
France	1.00	

*Cases with missing information on occupational or recreational sunburn were excluded (N = 133).

**All factors were adjusted for all other variables in the model and duration of occupation Hosmer-Lemeshow goodness-of-fit statistic: chi-square (8 df) = 5.67; p = 0.68.

Table 3: Systematic use of sun protection measures by agricultural workers in Switzerland during their occupational and recreational activities, and their correlation (N = 799)*.

	Sun protection measure used (%)				
	Hat	Long sleeves	Sunglasses	Sunscreen	Shade
Outdoor activity					
Occupational	48.6	6.8	18.3	11.9	9.9
Recreational	37.7	4.1	31.5	25.9	18.4
	Spearman correlation factor (r_s)				
Occupational/ recreational	*0.69*	*0.74*	*0.64*	*0.48*	*0.48*

*Cases with missing information on occupational or recreational sunburn were excluded (N = 130).

Table 4: Multivariate logistic regression analysis for occupational sunburn among agricultural workers in Switzerland (N = 799)*

Factors	Column (%)	** Adjusted OR [95% CI]	p-value
Recreational sunburn			
Yes	14.4	13.38 [8.00, 22.38]	< 0.0001
No	85.6	1.00	
Skin phototype			0.0444
I	2.3	3.87 [0.96, 15.58]	
II	21.2	2.06 [0.87, 4.86]	
III	51.3	2.86 [1.33, 6.17]	
IV	17.9	1.00	
Age (in years)			0.0201
25–29	4.4	3.01 [1.14, 7.92]	
30–39	19.8	2.01 [1.10, 3.70]	
40–49	36.2	0.97 [0.55, 1.70]	
50–59	27.9	1.00	
60–65	11.8	1.00 [0.41, 2.46]	
Perception of skin cancer risk			0.0182
Above average	20.7	2.82 [1.17, 6.80]	
Equal to average	67.0	1.33 [0.59, 3.00]	
Below average	11.4	1.00	
Don't know	1.0	1.44 [0.13, 15.43]	
Occupational use of sunscreen			0.0009
Systematic	11.9	2.77 [1.58, 4.85]	
Sometimes	55.1	2.42 [1.10, 5.31]	
Never	32.3	1.00	
Occupational use of a hat			0.0295
Systematic	48.6	0.50 [0.26, 0.96]	
Sometimes	35.9	0.60 [0.32, 1.11]	
Never	15.1	1.00	

*Cases with missing information on occupational or recreational sunburn were excluded (N = 130).

**All factors were adjusted for all other variables in the model and gender and family or personal history of melanoma.

Hosmer-Lemeshow goodness-of-fit statistic: chi-square (8 df) = 9.58; p = 0.30.

Table 5: Skin-health knowledge and pro-tanning attitude scores among agricultural workers in Switzerland (N = 799)*

	Score	%
Skin-health knowledge		
No	0	15.6
Middle	1	29.3
High	2	55.1
Pro tanning attitude		
No	0	34.3
Slight	1	25.0
Moderate	2	22.1
Important	3	11.9
	4	5.0
	5	1.6

*Cases with missing information on occupational or recreational sunburn were excluded (N = 130).